Spatial Analysis of Transport Mode Choice and Travel Behaviour in Indo-Burman Border: A Case Study of Aizawl City, Mizoram

Abstract

This study investigates the spatial determinants of transport mode choice and travel behaviour in Aizawl City, located in the Indo-Burman border region of Northeast India. As a hill city constrained by rugged topography and limited developable land, Aizawl presents unique challenges to urban mobility and accessibility. Using Multinomial Logistic Regression (MNLR), this research examines how spatial attributes, such as elevation, slope, population density, road density, traffic congestion, and proximity to transport facilities, affect the probability of commuters adopting specific modes of travel, including public transport, private vehicles, and walking. Primary data from household surveys were integrated with geospatial layers using ArcGIS to derive spatial variables. Results indicate that proximity to bus stands, slope gradients, and road density are the most influential factors shaping travel behaviour. Steeper slopes and greater elevation discourage non-motorized mobility, while high road density and moderate population density support higher transport diversity. Areas distant from transport facilities exhibit stronger reliance on private vehicles and intermediate modes, especially two-wheeler taxis. The findings emphasize that urban form and terrain directly condition accessibility and mode choice in hilly environments. The study contributes to spatial transport modelling literature by illustrating how built environment and topographical constraints influence daily mobility in small but growing border cities. Recommendations highlight the need for terrain-sensitive planning, improved public transport accessibility, and non-motorized connectivity enhancement for sustainable mobility in similar hill city contexts.

Keywords

Aizawl City; Built environment; Multinomial Logistic Regression; Spatial mobility; Transport mode choice; Indo-Burman border; Urban geography

Introduction

The geography of Aizawl City, the capital of Mizoram, profoundly shapes its transportation dynamics. Situated in the Indo-Burman border region of Northeast India, Aizawl lies along steep ridgelines and escarpments that constrain both settlement and movement. Urban development has evolved linearly along hilltops, producing fragmented connectivity and uneven access to public transport. The city's terrain, limited level land, and elongated morphology result in a transport system dominated by two-wheelers, taxis, and private vehicles. Public bus operations are challenged by narrow, winding roads and varying gradients, creating accessibility inequalities for peripheral communities.

In many hill cities, the built environment is not merely a passive background but an active determinant of mobility (Ewing & Cervero, 2010). Topographical constraints, slope-based settlements, and population concentration along ridgelines generate spatial inequalities in transport access. Aizawl typifies this dynamic, where geography dictates the form, direction, and intensity of movement. This study seeks to model how built environment factors influence travel mode choice through a Multinomial Logistic Regression (MNLR) framework, enabling a quantitative assessment of how urban form and spatial variables affect commuting behaviour.

The research builds on the premise that spatial accessibility, network connectivity, and physical barriers jointly shape the travel decisions of residents. Understanding these relationships is essential for designing inclusive, terrain-responsive transport policies suited to the challenges of hilly urban environments such as those across the Indo-Burman range.

Literature Review

Urban mobility research has long emphasized the interaction between land use and transport systems. Cervero and Kockelman (1997) introduced the “3Ds” framework, density, diversity, and designas fundamental dimensions linking the built environment with travel behaviour. Later studies expanded this framework to include destination accessibility and distance to transit (Ewing & Cervero, 2010).

In hilly cities, these relationships acquire distinct spatial signatures. Terrain, gradient, and elevation alter route connectivity, impose physical strain on walking or cycling, and affect vehicle operation (Rastogi & Rao, 2003). Limited flat terrain leads to compact linear development, restricting road expansion and efficient public transport provision (Singh, 2015). Hill cities such as Gangtok, Shillong, and Aizawl face similar topographical limitations, where accessibility is largely governed by slope and ridge-road proximity.

Empirical studies using Multinomial Logistic Regression (MNLR) demonstrate that built environment factors significantly influence modal choice (Zhao et al, 2021). Proximity to bus stops, road density, and traffic congestion correlate with the probability of choosing specific modes, while population with moderate densityaccessibility to public transit (Badoe& Miller, 2000). However, the spatially embedded nature of these relationships remains underexplored in smaller urban contexts within developing regions.

Saitluanga and Hmangaihzela (2022) examined the transport mode choice of off-campus students in Aizawl, a rapidly growing hilly city in Northeast India, and highlighted how travel behaviour is influenced by socio-economic background, demographics, housing location, and transport availability. Their study revealed that walking and public buses are the dominant commuting modes, with female students living near colleges preferring to walk, while male students from higher-income families often use private vehicles from more distant residences. The authors argue that improving on-campus hostel capacity and enhancing public transport accessibility are essential strategies for addressing the mobility challenges of off-campus students and promoting sustainable urban transport in hilly environments.

In the Indo-Burman context, Aizawl offers a rare opportunity to examine mobility under severe topographical constraints and limited multimodal transport options. The application of MNLR allows for estimating mode-specific probabilities as functions of multiple spatial and environmental variables, thus providing a nuanced understanding of mobility determinants in this geographically unique city.

Study Area and Data

Aizawl is the administrative and economic centre of Mizoram. It serves the capital city of the landlocked state of North East India, Mizoram, which has internal borders with Manipur, Assam, and Tripura in the north and 722 kilometres of international borders with Myanmar and Bangladesh in the south. At 21,087 km2, it is the fifth-smallest state in India (8,142 sq. mile area). It is located between 23º39'47"-23º48'47" north latitudes and 92º39'47"-92º46'52" east longitudes in the northern part of the state of Mizoram. The city occupies an elongated ridge aligned north–south, with elevations ranging from 800 to 1250 meters above sea level (Pachuau,1994). The settlement pattern follows the topographic contours, producing a linear city form characterized by narrow roads and steep slopes.

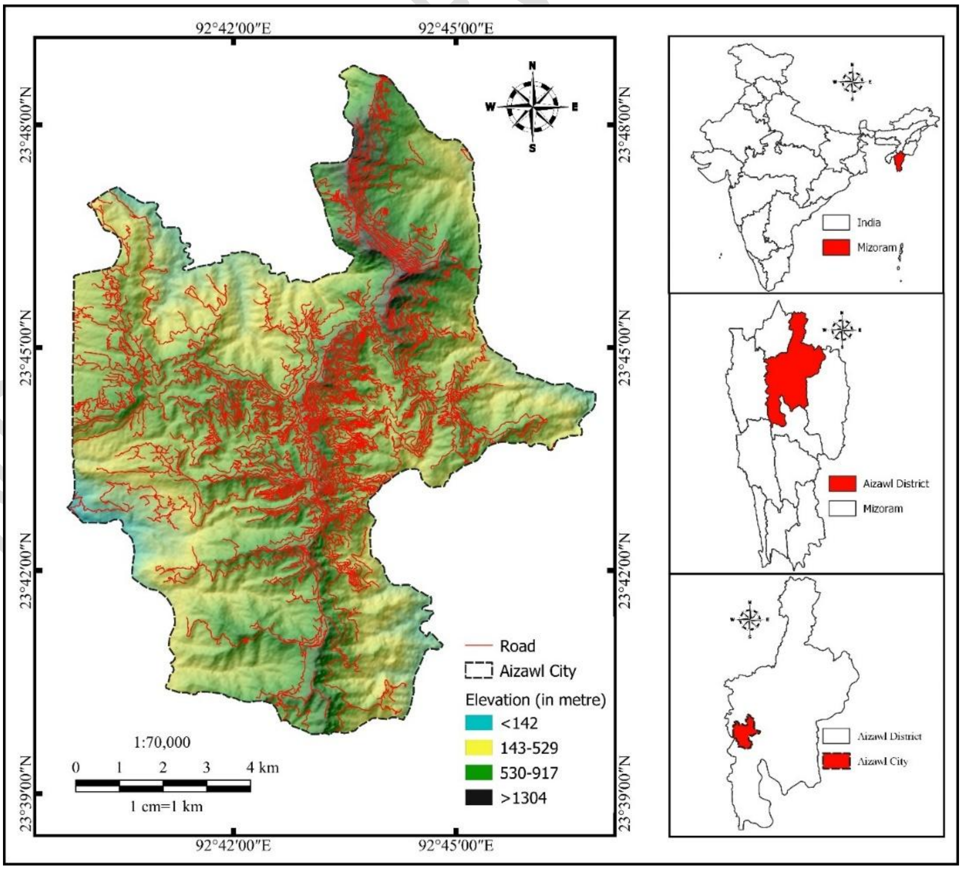


Figure 1: Location map of the study area

A stratified random sampling framework was employed to capture the heterogeneity of travel behaviour across Aizawl City's diverse socio-spatial and topographic contexts. Three principal criteria informed the stratification; Administrative divisions (municipal wards), Physiographic zones based on elevation and slope gradients, and Socio-economic characteristics derived from secondary demographic datasets. This ensured that the sampling captured intra-urban variations in accessibility, modal choice, and trip purposes across the inner core, outer core, inner periphery, and outer periphery. Within each stratum, respondents were selected using simple random sampling to minimise selection bias and maintain statistical representativeness.

Table1: Distribution of Sample Size

Residential Zones	No of Households	No. of Samples
Outer Periphery	13217	275
Inner Periphery	12045	194
Outer Core	6890	109
Inner Core	2444	113
Total	**41023**	**691**

The primary data for this study were collected through structured household surveys covering different wards of the Aizawl Municipal Corporation (AMC). Respondents provided information on travel frequency, mode choice, purpose, and socio-economic characteristics. Spatial variables were derived using ArcGIS 10.4 and included distance from bus stands, taxi stands, and the Central Business District (CBD); road density; elevation; slope; traffic congestion; and population density. Each variable was categorized into ordinal classes to facilitate inclusion in the MNLR model.

Secondary data sources included AMC base maps, road network layers, and topographic sheets from the Survey of India. All spatial datasets were standardized to a common coordinate system to ensure spatial consistency across analysis layers.

Table 2: Sources of data collection

Type	Data	Source	Utilization
Primary Data	Household socio-economic and trip data	Household questionnaire survey (691 households)	Analyse socio-economic factors and mode choice patterns
	Geo-tagging	GPS-enabled devices during survey (2023)	Spatial mapping of trips and locations
	Topographic map	ALOS PALSAR DEM	Elevation, slope, terrain analysis

Secondary Data	Road data	Esri OSM extract from https://extract.bbbike.org/	Road density and connectivity analysis
	Population and Households data	Census 2011 & AMC data 2022	Demographic and householddistribution analysis

Methodology

Analytical Framework

This study employs the Multinomial Logistic Regression (MNLR) model to estimate the likelihood of commuters choosing a particular transport mode relative to a reference mode as a function of the built environment and spatial variables. MNLR is suitable for modeling nominal dependent variables with more than two categories without assuming proportional odds among choices(Train & McFadden, 1978).

Y denote the travel mode choice, and let $X_1, X_2, \ldots, X_p$ represent the independent variables (e.g., age, income, and travel distance, etc.). The general form of the MLR model is:

$$log\left(\frac{P(Y=j)}{P(Y=K)}\right) = \beta_{j0} + \beta_{j1} + \beta_{j2} + \cdots + \beta_{jp} X_p$$

for j=1,2,...,K-1, where category $K$is the reference category.

The model estimates a set of coefficients for each non-reference category that describe the log-odds of choosing category j relative to the reference category.

$$\log\left(\frac{P(\text{car})}{P(\text{walk})}\right) = \beta_{C0} + \beta_{C1} \cdot \text{Age} + \beta_{C2} \cdot \text{Income} + \beta_{C3} \cdot \text{Distance} \ldots$$

$$\log\left(\frac{P(\text{Bus})}{P(\text{walk})}\right) = \beta_{B0} + \beta_{B1} \cdot \text{Age} + \beta_{B2} \cdot \text{Income} + \beta_{B3} \cdot \text{Distance} \ldots$$

$$\log\left(\frac{P(Bike)}{P(\text{walk})}\right) = \beta_{k0} + \beta_{k1} \cdot \text{Age} + \beta_{k2} \cdot \text{Income} + \beta_{k3} \cdot \text{Distance} \ldots$$

Once coefficients are estimated, the predicted probabilities for each travel mode can be calculated as:

$$P(Y=j) = \frac{e^{\beta_{j0} + \sum_{i=1}^{p} \beta_{ji} Xi}}{1 + \sum_{l=1}^{k-1} e^{\beta_{l0}} + \sum_{i=1}^{p} \beta_{li} X_i} \; for\ j = 1,2,\ldots,k-1$$

$$P(Y = K) = \frac{1}{1 + \sum_{l=1}^{k-1} e^{\beta_{l0} + \sum_{i=1}^{p} \beta_{li} X_i}}$$

The dependent variable represents transport mode choice with six categories: owned car, owned two-wheeler, public bus, two-wheeler taxi, walking, and four-wheeler taxi (reference). Independent variables represent spatial characteristics such as elevation, slope, population density, road density, traffic congestion, and distance to transport facilities.The model was estimated using SPSS software. Multicollinearity among independent variables was tested through the Variance Inflation Factor (VIF), ensuring values below 5.0. The significance of coefficients was tested at a 95 per cent confidence level ($p < 0.05$). Goodness-of-fit was assessed using McFadden's R^2 and likelihood ratio tests.

Interpretation of results focused on the direction and magnitude of coefficients, representing how changes in spatial variables influence the probability of adopting specific transport modes.

Table3: Descriptive statistics

Parameters	Overall (%)	Pvt. Car(%)	Pvt. 2-wheeler(%)	4-Wheeler taxi(%)	2-Wheeler taxi(%)	Pubic Bus(%)	Walk(%)
Dist. from Bus stand (m)							
Very near	21.1	26	18.9	14.3	17.4	11.8	30.2
Near	33.9	28.8	35	39.3	30.4	55.9	28.6
Moderate	21.1	19.2	20.2	35.7	39.1	14.7	22.2
Far	14.2	14.7	15.8	3.6	8.7	8.8	12.7
Very far	9.7	11.3	10.1	7.1	4.3	8.8	6.3
Elevation(metre)							
< 862	1.7	1.1	1.6	3.6	13	5.6	4.3
862 – 963	14.5	13	14.8	17.9	8.7	11.8	18.1
963 – 1031	26	25.4	24.9	28.6	35.8	26.5	27.6
1031– 1120	43.6	41.8	46.2	48	36.2	37.3	33.2
>1120	14.2	18.6	12.6	1.9	6.2	18.8	16.8
Population density							
Low	31.4	22.6	35.5	39.3	28.4	17.6	36.5
Moderately Low	19	23.7	15.6	32.1	24.1	17.6	17.5
Medium	19.4	15.3	19.4	7.1	25.1	26.5	30.2
Moderately High	18.5	26	16.7	17.9	17.4	20.6	7.9
High	11.7	12.4	12.8	3.6	5	17.6	7.9
Dist. from 4-wheeler taxi stand (m)							
Near	60.2	56.5	60.4	67.9	60.9	52.9	69.8
Moderate	25	24.3	26	17.9	26.1	32.4	20.6
Far	9.4	13	9.3	3.6	8.7	2.9	6.3
Very Far	5.4	6.2	4.4	10.7	4.3	11.8	3.2
Dist. from 2-wheeler taxi							

stand(m)							
Near	55.9	52	58.2	57.1	47.8	52.9	57.1
Moderate	21.3	24.3	21	17.9	26.1	11.8	19
Far	13	12.4	11.7	14.3	13	23.5	15.9
Very Far	9.8	11.3	9	10.7	13	11.8	7.9
Dist. from CBD (m)							
Very Near	16.9	18.1	17.8	7.1	13	14.7	15.9
Near	25.9	20.9	27.6	35.7	30.4	29.4	22.2
Moderate	19	20.9	17.8	10.7	17.4	23.5	22.2
Far	18.4	18.1	18.6	17.9	26.1	11.8	19
Very Far	19.8	22	18.3	28.6	13	20.6	20.6
Traffic congestion							
Very High	19	20.9	16.4	3.6	8.7	26.5	34.9
High	21	25.4	19.1	17.9	30.4	23.5	15.9
Moderate	19.5	17.5	21.3	17.9	17.4	14.7	19
Low	40.5	36.2	43.2	60.7	43.5	35.3	30.2
Slope							
<14	18.1	17	18	10.7	30.4	17.6	20.6
14-28	29.4	28.4	29.2	42.9	30.4	32.4	25.4
28-42	31.7	34.1	32	27.8	26.1	32.4	27
42-56	15.2	14.2	15.6	16.9	8.7	8.8	20.6
>56	5.5	6.3	5.2	1.7	4.3	8.8	6.3
Road density							
Low	6.4	7.3	5.5	17.9	8.7	2.9	4.8
Medium	55.7	50.3	58.5	57.1	49.2	52.9	57.1
High	32.7	35.6	31.1	21.4	39.1	35.3	34.9
Very High	5.2	6.8	4.9	3.6	3	8.8	3.2

Results and Discussion

Spatial determinants of transport mode choice

The MNLR model demonstrates that built environment attributes substantially influence transport mode choice in Aizawl City. Among the explanatory variables, distance from bus stands, elevation, slope, road density, and traffic congestion emerged as significant predictors across multiple modes.

Table 4: Multinomial Logistic Regression for Mode Choice

Mode Choice	Variable	Coeff	Std.Err	z value	p value	Conf. Low	Conf. High
Pvt. 2-wheeler	(Intercept)	2.475	0.804	3.079	0.002	0.900	4.051
	bus_dist.near	-1.109	0.377	-2.944	0.003	-1.848	-0.371
	bus_distmod.	-1.079	0.338	-3.193	0.001	-1.741	-0.417
	bus_dist far	-0.833	0.35	-2.381	0.017	-1.518	-0.147
	4w_dist.far	-4.891	1.255	-3.896	0.000	-7.352	-2.430

	2_dist.far	3.644	1.219	2.990	0.003	1.255	6.033
	elev.862.2 - 963.8m	-0.826	0.261	-3.164	0.002	-1.337	-0.314
	elev.963.8 - 1031.9m	-1.357	0.220	-6.171	0.000	-1.787	-0.926
	traffic_low	0.625	0.250	2.494	0.013	0.134	1.116
	traffic_high	0.983	0.349	2.813	0.005	0.298	1.667
	cbd_dist<1353m	1.421	0.309	4.602	0.000	0.816	2.026
	cbd_dist2503-3950m	1.081	0.277	3.895	0.000	0.537	1.624
	cbd_dist3951-6168m	0.882	0.344	2.561	0.010	0.207	1.556
	pop_dens.low	-1.481	0.433	-3.424	0.001	-2.329	-0.633
	pop_dens.mod.low	-2.428	0.430	-5.645	0.000	-3.272	-1.585
	slope28-42	0.803	0.230	3.488	0.000	0.352	1.254
	road_denslow	-1.929	0.361	-5.343	0.000	-2.636	-1.221
	road_densmedium	-0.885	0.229	-3.858	0.000	-1.334	-0.435
	road_dense.high	-1.455	0.484	-3.003	0.003	-2.404	-0.505
Pvt.Car	(Intercept)	2.686	0.802	3.349	0.001	1.114	4.258
	bus_distmod.	-0.976	0.347	-2.815	0.005	-1.655	-0.296
	4w_distnear	-1.391	0.464	-2.995	0.003	-2.301	-0.481
	4w.taxi_dist.mod.near	-1.767	0.464	-3.811	0.000	-2.675	-0.858
	4w_dist.far	-5.506	1.250	-4.403	0.000	-7.957	-3.055
	2_dist.far	3.241	1.222	2.653	0.008	0.847	5.636
	elev.963.8 - 1031.9m	-0.971	0.230	-4.228	0.000	-1.421	-0.521
	traffic_high	1.223	0.337	3.625	0.000	0.562	1.884
	cbd_dist<1353m	1.559	0.320	4.866	0.000	0.931	2.188
	cbd_dist2503-3950m	1.431	0.286	5.006	0.000	0.871	1.991
	cbd_dist3951-6168m	1.260	0.354	3.564	0.000	0.567	1.953
	cbd_dist>6169m	1.168	0.342	3.419	0.001	0.499	1.838
	pop_dens.low	-1.956	0.444	-4.402	0.000	-2.827	-1.085
	pop_dens.mod.low	-2.057	0.432	-4.756	0.000	-2.904	-1.209
	slope28-42	1.146	0.236	4.861	0.000	0.684	1.608
	road_denslow	-1.299	0.365	-3.562	0.000	-2.013	-0.584
	road_densmedium	-0.957	0.233	-4.103	0.000	-1.414	-0.500
	road_dense.high	-0.876	0.466	-1.882	0.060	-1.789	0.036
Public Bus	(Intercept)	3.872	0.857	4.517	0.000	2.192	5.551
	bus_dist.near	-2.289	0.430	-5.329	0.000	-3.131	-1.447
	bus_distmod.	-1.793	0.379	-4.731	0.000	-2.536	-1.050
	2w_dist.near	-1.646	0.342	-4.813	0.000	-2.316	-0.976
	2w_dist.mod.near	-2.052	0.418	-4.914	0.000	-2.871	-1.234
	elev.963.8 - 1031.9m	-0.835	0.233	-3.579	0.000	-1.293	-0.378
	traffic_mod.	-0.816	0.338	-2.415	0.016	-1.477	-0.154
	traffic_high	1.447	0.341	4.240	0.000	0.778	2.117
	cbd_dist2503-3950m	1.051	0.288	3.648	0.000	0.486	1.616
	pop_dens.low	-2.496	0.448	-5.577	0.000	-3.373	-1.619
	pop_dens.mod.low	-3.114	0.446	-6.986	0.000	-3.988	-2.241
	pop_dens.mod	-0.976	0.417	-2.340	0.019	-1.793	-0.159
	slope28-42	1.091	0.249	4.387	0.000	0.603	1.578
	road_denslow	-2.268	0.409	-5.543	0.000	-3.069	-1.466
	road_densmedium	-1.261	0.238	-5.296	0.000	-1.728	-0.794
2-wheeler	(Intercept)	-3.538	3.800	-0.931	0.352	-10.985	3.910

Taxi	bus_dist.very near	1.479	0.414	3.573	0.000	0.668	2.291
	bus_dist.near	1.493	0.438	3.408	0.001	0.634	2.352
	bus_distmod.	1.399	0.392	3.571	0.000	0.631	2.167
	bus_dist far	1.344	0.490	2.743	0.006	0.384	2.304
	4w_distnear	-1.692	0.500	-3.382	0.001	-2.672	-0.712
	4w.taxi_dist.mod.near	-1.506	0.495	-3.041	0.002	-2.477	-0.535
	4w_dist.far	-5.632	1.282	-4.394	0.000	-8.145	-3.120
	2w_dist.near	-0.882	0.390	-2.262	0.024	-1.646	-0.118
	2w_dist.mod.near	1.185	0.401	2.956	0.003	0.399	1.971
	2_dist.far	3.033	1.236	2.454	0.014	0.610	5.455
	elev.862.2 - 963.8m	-1.096	0.281	-3.895	0.000	-1.647	-0.544
	elev.963.8 - 1031.9m	-0.912	0.233	-3.907	0.000	-1.369	-0.454
	traffic_mod.	-0.937	0.350	-2.674	0.007	-1.624	-0.250
	traffic_high	-0.826	0.388	-2.127	0.033	-1.587	-0.065
	cbd_dist<1353m	1.266	0.317	3.987	0.000	0.643	1.888
	cbd_dist3951-6168m	-0.843	0.375	-2.248	0.025	-1.578	-0.108
	slope<14	1.424	0.291	4.889	0.000	0.853	1.995
	slope28-42	0.512	0.247	2.074	0.038	0.028	0.996
	road_denslow	-1.166	0.374	-3.117	0.002	-1.900	-0.433
	road_densmedium	-0.846	0.228	-3.703	0.000	-1.294	-0.398
Walking	(Intercept)	-0.759	0.873	-0.870	0.384	-2.471	0.952
	bus_dist.very near	-1.364	0.378	-3.606	0.000	-2.105	-0.623
	4w_dist.far	-5.587	1.281	-4.362	0.000	-8.097	-3.076
	2_dist.far	4.245	1.222	3.473	0.001	1.849	6.640
	elev.963.8 - 1031.9m	-1.155	0.238	-4.849	0.000	-1.622	-0.688
	traffic_high	2.368	0.341	6.951	0.000	1.700	3.035
	cbd_dist<1353m	1.352	0.337	4.013	0.000	0.692	2.012
	cbd_dist2503-3950m	2.146	0.300	7.151	0.000	1.558	2.734
	cbd_dist3951-6168m	1.723	0.369	4.675	0.000	1.001	2.446
	cbd_dist>6169m	1.938	0.358	5.408	0.000	1.235	2.640
	pop_dens.mod.low	-1.229	0.450	-2.729	0.006	-2.112	-0.346
	slope28-42	0.893	0.249	3.587	0.000	0.405	1.381
	slope42-56	0.770	0.285	2.704	0.007	0.212	1.328
	road_denslow	-2.777	0.437	-6.352	0.000	-3.634	-1.920
	road_densmedium	-0.632	0.241	-2.627	0.009	-1.104	-0.161

The reference category is Four-wheeler taxi

Proximity to Bus Stands

Proximity to bus stands strongly affects travel choice. Residents living closer to bus stands are significantly more likely to use public transport and walking as their main modes. The coefficients for “near” and “moderate” distances show strong negative associations with two-wheeler and private car use ($p < 0.05$), indicating that improved accessibility to bus services reduces dependency on private transport. This distance-decay pattern confirms the pivotal role of public transit accessibility in influencing modal choice.

Elevation and Slope

Elevation exerts a critical impact on mobility patterns. Moderate elevation zones (862–1030 m) show higher use of motorized modes, while extremely high elevations (>1120 m) discourage both public and private modes due to road limitations. Slope gradients between 28° and 42° have positive and significant coefficients for walking and two-wheeler use, reflecting adaptability in moderate terrains. Extremely steep slopes (>56°) drastically reduce the probability of all modes, highlighting terrain as a major physical constraint in Aizawl's transport system.

Population and Road Density

Population density influences modal preferences through accessibility and congestion effects. Moderate-density zones record higher public transport use, while very low-density areas depend more on private vehicles. Road density displays strong positive relationships with motorized modes and walking, indicating that better-connected areas foster modal diversity. Low road density significantly reduces the likelihood of public bus use ($p < 0.001$), confirming that limited network reach restricts formal transport accessibility in peripheral wards.

Traffic Congestion

Traffic congestion levels alter the attractiveness of different modes. Areas with heavy congestion demonstrate reduced private car use and greater reliance on public buses and walking. Two-wheeler taxis maintain relatively high usage across congestion levels, indicating their flexibility and adaptability in narrow, high-traffic corridors typical of Aizawl's core areas.

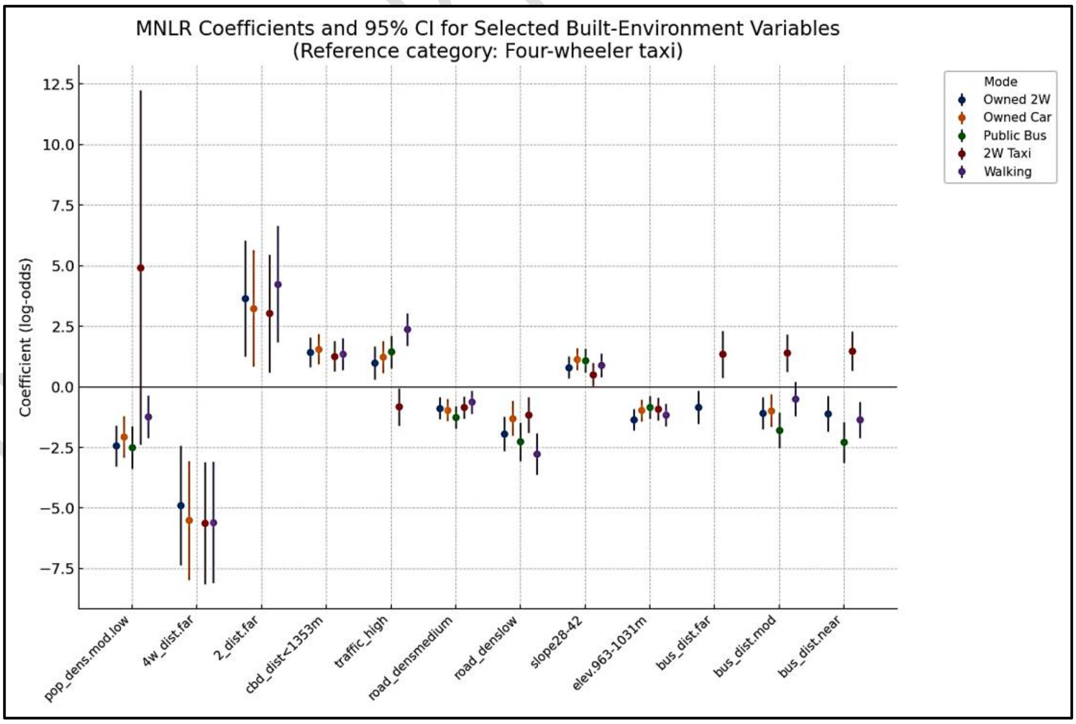


Figure 2: MNLR coefficient plot

Distance to the Central Business District (CBD)

Distance from the CBD exhibits a consistent negative influence on public transport and walking. Peripheral residents tend to rely on private and semi-formal modes, reflecting reduced transit service coverage. Mid-range distances (2–4 km) display the highest probability for bus use, indicating concentration of services in intermediate zones. This finding underscores the monocentric structure of Aizawl and the dominance of the central ridge in shaping commuting flows.

The MNLR results confirm that travel behaviour in Aizawl is shaped by an intricate interaction between the built environment and topography. The model identifies road density, slope, elevation, and proximity to transport nodes as statistically significant determinants. Notably, socio-economic variables such as income and occupation, though not analyzed in this model, are likely to further mediate these relationships. The results illustrate that accessibility in Aizawl is primarily spatial, determined by physical geography and infrastructure distribution rather than mere distance.

Distance to Two-Wheeler Taxi Stand

Distance to two-wheeler taxi stands is positively associated with the use of this mode, indicating that even when commuters live farther from designated stands, they continue to rely on two-wheeler taxis. This suggests that the service operates flexibly and informally, filling the accessibility gap in areas where public transport coverage is limited. The finding highlights the adaptive nature of two-wheeler taxis in hilly environments such as Aizawl, where narrow roads and dispersed settlements make fixed-route services impractical. Strengthening the regulatory and infrastructural support for this mode could enhance overall urban mobility resilience.

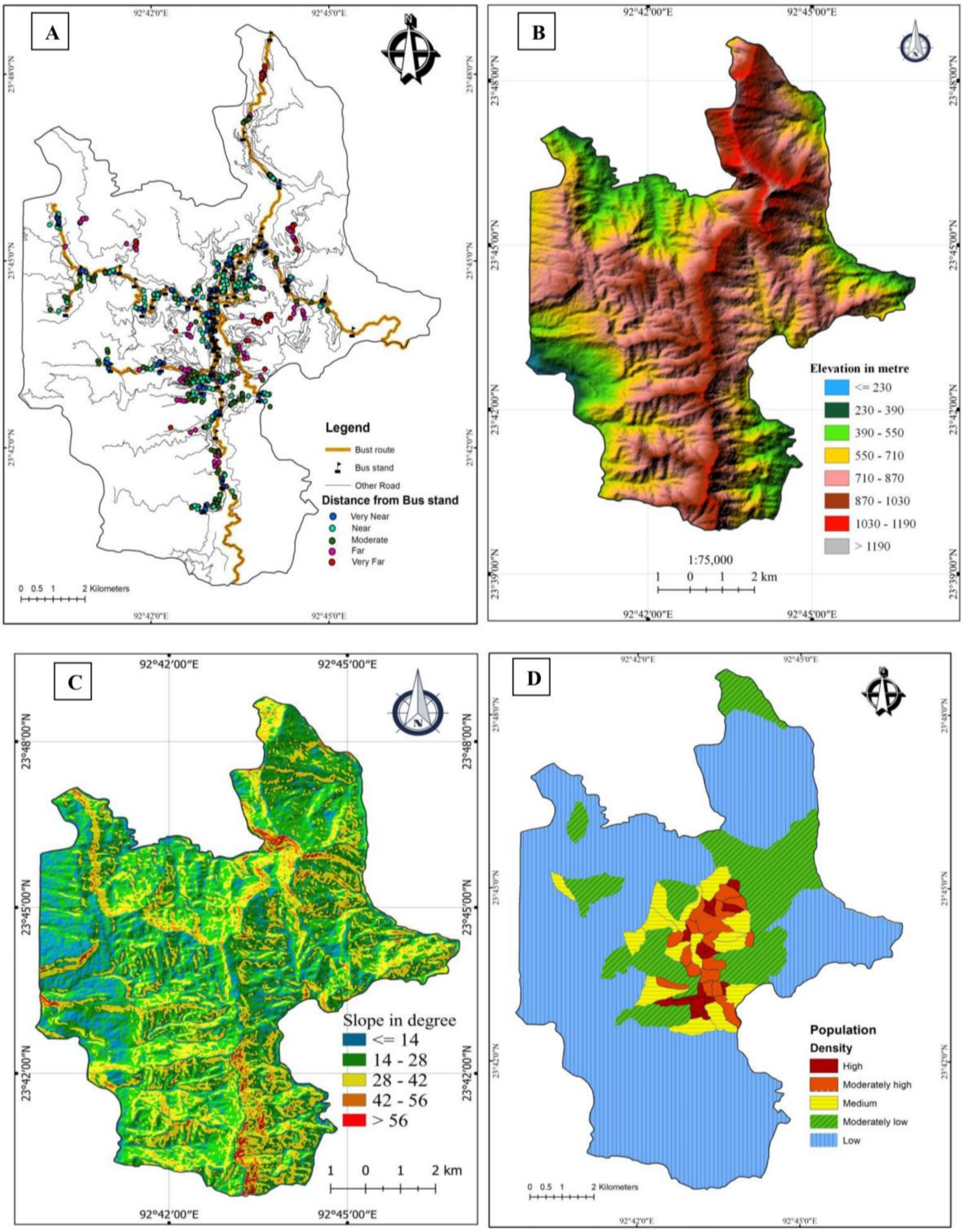
Distance to Four-Wheeler Taxi Stand

The variable representing distance to four-wheeler taxi stands shows a negative relationship with two-wheeler and public bus modes. This implies that as the distance to formal taxi stands increases, commuters are more likely to use smaller and more flexible modes, such as two-wheelers or two-wheeler taxis, to compensate for the reduced accessibility of four-wheeler services. The result reflects how modal substitution operates spatially in a constrained environment, where proximity to larger vehicle stands is often limited by road width, gradient, and parking capacity.

Conclusion

This study reveals that transport mode choice in Aizawl City is primarily shaped by its hilly terrain and built-environment characteristics. The Multinomial Logistic Regression analysis identifies proximity to bus stands, two-wheeler and four-wheeler taxi stands, elevation, slope, and road density as the most influential factors. Closer access to bus stands encourages public transport use and reduces two-wheeler dependency, while greater distance from formal transit points increases reliance on flexible modes such as two-wheeler taxis. Steeper gradients and higher altitudes restrict walking and two-wheeler use, whereas moderate slopes and denser road networks enhance overall accessibility and modal diversity.

The findings underscore that transport behaviour in Aizawl is driven more by spatial and topographical constraints than by socio-economic attributes. Sustainable mobility planning must therefore be terrain-sensitive, integrating topographic realities with transport design. Improving public transport accessibility in elevated and peripheral wards, enhancing road connectivity, and integrating intermediate modes into the formal system are vital strategies. Overall, the study contributes to understanding the spatial dynamics of mobility in hilly Indo-Burman cities and provides a framework for developing inclusive, geography-responsive transport policies.


A
92°42'0"E
92°45'0"E
Legend
Bust route
Bus stand
Other Road
Distance from Bus stand
Very Near
Near
Moderate
Far
Very Far
0 0.5 1 2 Kilometers
B
92°42'00"E
92°45'00"E
23°48'00"N
23°45'00"N
23°42'00"N
23°39'00"N
Elevation in metre
<= 230
230 - 390
390 - 550
550 - 710
710 - 870
870 - 1030
1030 - 1190
> 1190
1:75,000
1 0 1 2 km
C
92°42'00"E
92°45'00"E
23°48'00"N
23°45'00"N
23°42'00"N
Slope in degree
<= 14
14 - 28
28 - 42
42 - 56
> 56
1 0 1 2 km
D
Population
Density
High
Moderately high
Medium
Moderately low
Low
0 0.5 1 2 Kilometers

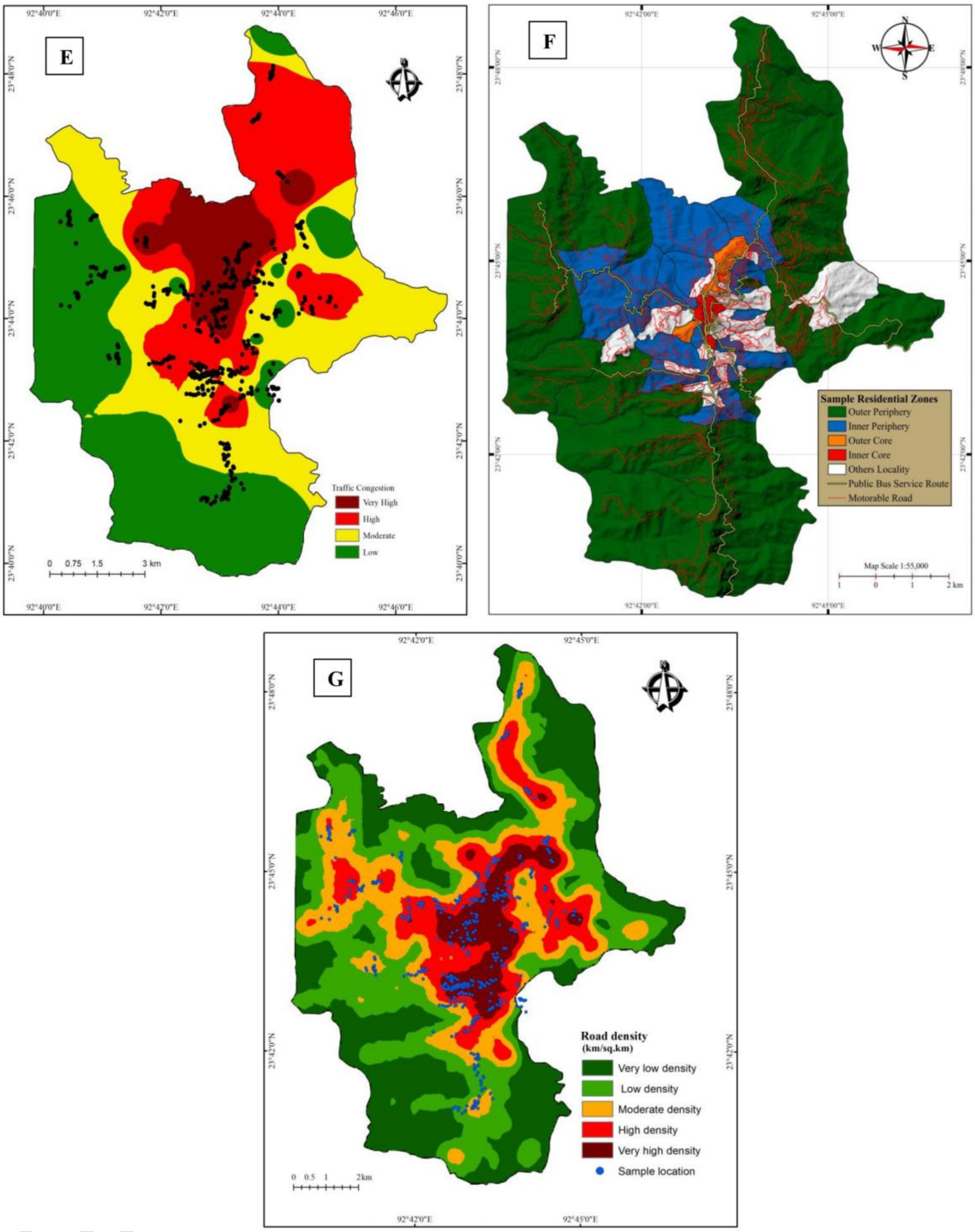


Figure 3: Map of determinants of mode choices

(A) Distance from transit point
(B) Elevation (m) map of AMC
(C) Slope map of AMC
(D) Population density map of AMC
(E) Traffic congestion map of AMC
(F) Residential map of AMC
(G) Road density map of AMC

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