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Transport-Land Use Synergy and Its Influence on the Physical Development of Spontaneous City

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Abstract
Dhaka is among the world's most densely populated cities, characterized by rapid and largely spontaneous urban growth in which transportation and land use co-evolve without formal planning oversight. This study investigates the synergic relationship between transport and land use in Kamrangirchar—a spontaneously developed enclave within Dhaka comprising Wards 55, 56, and 57—and quantifies how that relationship drives its physical development trajectory. Primary data were collected through a structured household survey of 309 valid responses (from 399 administered), supplemented by a Traffic Volume Survey; secondary land use data were obtained from the Detailed Area Plan (DAP) and Dhaka South City Corporation (DSCC). Land use analysis reveals a profound structural shift: residential coverage declined from 66.94% in 2010 to 50.87% in 2020 and is projected to contract to a residual 1.05% by 2051, while industrial land is forecast to expand from 9.22% to 37.52% and commercial land from 7.70% to 31.08% over the same horizon. These transformations are mirrored in observed travel demand: Wards 56 and 57, which concentrate industrial and mixed-use activities, already generate the highest daily trip volumes—638 and 615 trips per day respectively—and attract corresponding inflows, while Ward 55, still predominantly residential, generates comparatively fewer work-oriented trips. Trip production is strongly stratified by income, rising from 1.17 trips per person per day in low-income households to 2.19 in the highest-income cohort, with Leguna and auto-rickshaws serving as the dominant modes. External trip attraction is concentrated at New Market (388 generated, 377 attracted daily), Dhanmondi, and Babu Bazar, reflecting the pull of employment and commercial destinations beyond Kamrangirchar's boundaries. Future trip generation, projected via the least-squares parabola method and compound annual growth rates, indicates sustained demand growth as households increase toward 2051. Gravity model simulations of trip distribution confirm that the densification of industrial and mixed-use land in Wards 56 and 57 will intensify both internal circulation and external trip flows, reinforcing those wards as the dominant mobility hubs. Crucially, the analysis identifies a bidirectional feedback mechanism: diversified land use generates higher and more varied travel demand, which in turn signals accessibility improvements that attract further industrial and commercial investment, perpetuating Kamrangirchar's transformation away from a residential settlement toward a multifunctional urban-economic hub. These findings underscore the critical need for integrated land use and transport planning in spontaneously developed urban contexts to manage this feedback proactively and steer growth toward more sustainable and equitable outcomes.

Keywords: Transport-Land Use Synergy; Spontaneous City; Trip Generation; Gravity Model; Feedback Mechanism.

1. Introduction

Rapid urbanization and economic transformation in developing countries are reshaping cities at an unprecedented pace, placing immense strain on transportation networks and urban infrastructure (Kitamura et al., 2018). As populations expand, the mismatch between land use change and transport capacity results in chronic congestion, rising travel costs, and declining accessibility (Goetz, 2019). Transportation and land use interact in a mutually reinforcing cycle: while transport infrastructure shapes urban growth, evolving land use patterns simultaneously influence mobility behaviors (Ewing & Cervero, 2010; Litman, 2022).

In contrast, many cities across South Asia, Africa, and Latin America are experiencing organic, unregulated growth in what has been termed *spontaneous cities*—dense, informally developed areas that evolve outside of formal planning systems (Rahman, 2019). A spontaneous city generally refers to an urban settlement that grows without formal planning, often driven by rapid population growth, informal housing, and unregulated economic activities. According to UN-Habitat (2003), spontaneous cities emerge as "self-organized urban forms" shaped by residents' needs and informal practices rather than state-led planning or structured development frameworks. Dhaka's growth has produced dense, mixed-use neighborhoods with weak infrastructure, traffic congestion, and environmental stress, but also with vibrant economic activity and community-driven adaptation (Islam, 2012).

Dhaka exemplifies this phenomenon through neighborhoods such as Old Dhaka and Kamrangirchar, where organically developed street networks, high-density housing, and overlapping commercial and residential activities reflect decades of incremental, need-based growth. Improved accessibility in such environments often accelerates land use transformation, creating feedback loops where transport changes drive further densification, and intensified land use generates new transport demand (Rahman et al., 2019). Although prior studies have documented how compact, mixed-use environments reduce car dependence (Cervero & Kockelman, 1997; Frank & Pivo, 1994) and how transport investments shape urban form (Ewing, 1997; Litman, 2022), few have explored the two-way, dynamic feedback between transport and land use in informal or spontaneous contexts. As a result, policy and planning in these environments are hindered by a lack of empirical insights, leaving rapidly urbanizing areas vulnerable to congestion, inequity, and environmental degradation.

This research addresses this gap by investigating transport–land use interactions in Kamrangirchar, one of Dhaka's most densely populated and organically developed neighborhoods. The study asks: *How does the transport–land use synergy influence the physical development of a spontaneous city?* To answer this question, the paper pursues two objectives: (1) to assess the existing land use patterns and travel demand of Kamrangirchar, and (2) to simulate the interaction between transportation and land use in order to understand feedback mechanisms shaping future development. By situating this work in a spontaneous city, the research makes both empirical and

theoretical contributions. Empirically, it provides rare, case-based evidence on mobility dynamics in an informal context. Theoretically, it extends established transport–land use models—often applied in structured, planned urban systems—into unregulated, high-density settlements. This reframing highlights how models such as the four-step travel demand framework and the gravity model can illuminate feedback loops even in cities where informality dominates.

The significance of this study lies not only in documenting Dhaka's unique development trajectory but also in offering lessons for other rapidly urbanizing cities worldwide. While the findings are context-specific, the underlying dynamics—dense, mixed-use growth without adequate infrastructure and the resulting feedback between land use and transport—are common across many spontaneous cities. By articulating both the challenges and opportunities of transport–land use synergy under such conditions, this paper advances understanding of how unplanned urban systems evolve and provide actionable insights for planners and policymakers seeking to guide growth toward more sustainable, inclusive outcomes.

2. Literature Review and Analytical Framework

Urban studies have long attempted to explain how cities evolve spatially and how mobility interacts with land use. Early monocentric models such as Burgess's concentric zone theory and Hoyt's sector model emphasized the dominance of a central business district (CBD). The Ullman and Harris multiple nuclei model later acknowledged that several sub-centers may emerge, though it still positioned the CBD as the urban core. More recent scholarship, particularly from the Los Angeles School of Urbanism in the 1980s–2000s, challenged this monocentric view. Based on research in Los Angeles, they argued that large contemporary cities evolve in polycentric ways, with multiple specialized hubs for commerce, industry, and residence spreading without a uniform pattern (Florida, 2013). This perspective, tied closely to the debate on urban sprawl, highlights that modern metropolitan areas often exhibit dispersed land use, weakening the dominance of a single CBD. For developing and spontaneously grown cities, the polycentric model offers a lens to understand how multiple smaller nodes emerge to accommodate diverse functions across the urban fabric.

Alongside land use theories, transport demand research provides the analytical basis for understanding how urban form shapes mobility. The theory of travel demand management emphasizes strategies to influence travel behavior, moving beyond infrastructure supply alone. Central to this study is the four-step travel demand model, a widely applied framework in transport planning (Button, 1977; Ahmed, 2012). It includes: (1) trip generation, estimating how many trips are produced and attracted in each zone based on socio-economic and land use factors; (2) trip distribution, allocating these trips between origins and destinations using models such as the

gravity model; (3) mode choice, predicting how trips are divided among transport modes; and (4) traffic assignment, allocating trips to specific network routes. While this study focuses on the first three steps, they collectively capture how activities translate into mobility needs. Trip generation is closely linked to household size, income, and automobile ownership (McNally, 2007; Ortúzar & Willumsen, 2011). Trip distribution, often operationalized through the gravity model, generates OD matrices reflecting flows between zones (Zainab, 2012). Mode choice analysis incorporates trip, household, zonal, and network characteristics to estimate the likelihood of using cars, buses, or informal modes (Zhang, 2023).

The gravity model is particularly relevant here. Inspired by Newtonian physics, it assumes that interaction between zones increases with their size or attractiveness and decreases with greater distance or cost. Bouchard and Pyers (1965) emphasized that spatial separation functions and friction factors capture the deterrence effect of distance, making the model sensitive to accessibility constraints. This simple but powerful framework has been widely applied to analyze travel flows and calibrate forecasts against observed data. In the Kamrangirchar case, it helps identify the spatial distribution of trips and the extent to which nearby commercial or employment zones attract demand.

Land use–transport interaction (LUTI) models formalize the feedback loop between spatial development and mobility. Wegener (2004) showed how land use patterns determine trip origins and destinations, while transport accessibility influences location decisions and subsequent land use change. This cyclical relationship explains phenomena such as suburbanization and job decentralization following highway expansion (Moynihan, 1960; Muller, 1986). Although this study does not implement a full LUTI model, it adopts its principles by linking land use trends to observed and projected mobility through the four-step model and gravity distribution. Variables include household size, income, land use categories (residential, industrial, commercial, mixed), and modal choice, analyzed with SPSS, Excel, and ArcGIS. By combining these, the study integrates theoretical models with practical data analysis, offering a framework suitable for spontaneous urban contexts where unregulated growth produces dense, mixed-use land patterns.

The relationship between transportation and land use has long been established in urban studies. High-density, mixed-use developments reduce automobile dependency and encourage public and non-motorized transport (Cervero & Kockelman, 1997; Ewing & Cervero, 2010). Conversely, sprawling urban forms foster car dependency and increase travel costs (Handy, 2005). The feedback loop between transport infrastructure and land use is well documented: infrastructure investment improves accessibility, which spurs land use change, which in turn alters travel demand (Iacono et al., 2008).

The framework (Figure 1) operates in two integrated steps: first, it assesses and projects historical and future land use changes using GIS classification and trend interpolation. Second, it models mobility by assessing current travel demand and forecasting future trips based on household growth, utilizing components of the four-step model. A Gravity Model is then applied to simulate the distribution of these future trips, identifying key areas of attraction. The novelty of this framework lies in its application of these established models to an unplanned urban context; by integrating the land use patterns from the first step with the travel demand simulations from the second, it produces a network analysis that visualizes the synergy, offering clear, empirical evidence of how this interaction shapes physical development.

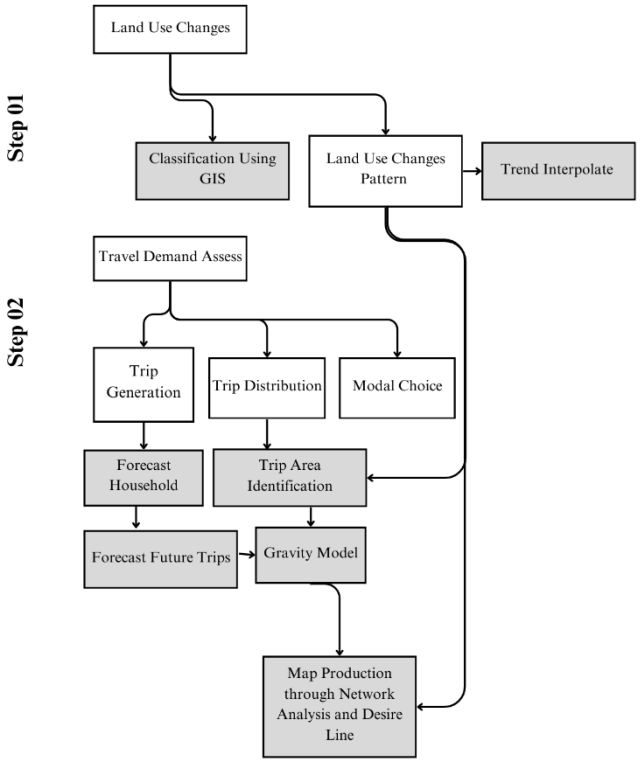


Figure 1 Analytical Framework of the Study

3. Methodology

3.1 Research Approach

The study employed a quantitative, deductive approach aligned with its objectives. The first objective—assessing land use patterns and travel demand—was addressed through descriptive statistical analysis and spatial data processing. The second—simulating the transport–land use interaction—was addressed by applying the four-step travel demand model and the gravity model. This approach was chosen for its ability to quantify relationships, project future outcomes, and align with international best practice in transport planning (Creswell & Creswell, 2018; Ortúzar & Willumsen, 2011).

3.2 Study Area

Kamrangirchar (Wards 55, 56, and 57) was selected for its dense population of 372,294 (BBS, 2022), rapid spontaneous growth, and mixed land uses (residential,

industrial, commercial). These characteristics make it a representative case for spontaneous cities. Figure 2 (Source: Author, 2024) shows the study area's location and urban form. The area's unplanned development, riverine setting, and transport challenges make it an ideal context to study transport–land use synergy.

3.3 Data, Sampling, and Analysis

The sample size was determined using Slovin's formula, yielding a requirement of 398 households out of 97,573.

$$n = \frac{N}{1 + N * e^2}$$

Where,
n = sample size
N = population size
e = margin of error (expressed as a decimal)

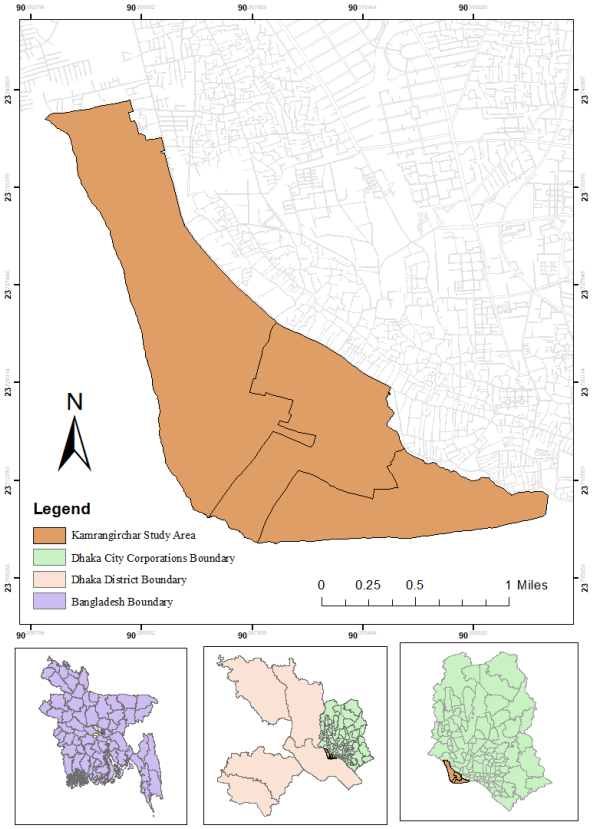


Figure 2 Map of Study Area

The study surveyed 399 households, with 309 valid responses after cleaning. Data were evenly distributed across wards (103 per ward), ensuring representativeness. A purposive sampling strategy was adopted to capture socio-economic diversity. Although Slovin's method provided a useful guideline, no external validation of the projection was undertaken—this remains a methodological limitation.

Data came from both primary and secondary sources. Secondary data included land use records from the Detailed Area Plan (DAP) and Dhaka South City Corporation (DSCC). Primary data were collected through structured questionnaires administered to households, supported by a traffic volume survey (TVS). Questionnaires captured household socio-demographics and travel behavior (trip generation, trip distribution, modal choice). Data collection took place between 19–23 September 2024 with the help of 12 enumerators. The survey was digitized using Google Forms to improve data quality and efficiency. Table 1 (Source: Author, 2024) outlines the collection methods.

Analysis combined statistical and spatial techniques. Land use data were processed using ArcGIS and analyzed with trend interpolation in MS Excel to identify temporal changes. Household survey data were analyzed in SPSS and Excel. In SPSS, descriptive statistics (frequencies, means, cross-tabulations) were used to summarize socio-demographic and travel variables. Regression models tested the relationship between household characteristics and trip generation. Pivot charts in Excel were used to visualize trip generation, trip distribution, and modal shares. Table 1 (Source: Author, 2024) summarizes the analytical tasks, approaches, and tools.

Table 1 Data Index

Objective	Components	Variables / Data	Type	Source	Collection Method / Tools	Tasks / Approaches
1. To assess the land use patterns and travel demand of a spontaneous area.	**1.1 Land Use**	-Structure of buildings (residential, commercial, mixed, industrial, open space) Waterbody - Road Network	Secondary	DAP Data, DSCC Data	Data extraction	- Land use change analysis - Pattern analysis (Trend interpolate) Tools: ArcGIS, Excel, SPSS
	1.2 Travel Demand	- Household size - Total number of trips - Trip origin-destination - External-Internal trips - Modal choice - Trip purpose	Primary & Secondary	Household survey responses, TVS, RSTP Reports, DSCC Data	Survey tools (Questionnaire, Traffic Volume Survey)	- Trip generation (Pivot Chart) - Trip distribution (OD Matrix, Pivot Chart) - Modal choice (Pivot Chart)
2. To simulate the interaction between transportation and land use, aiming to understand the feedback mechanism for future physical development.	**Integrated (Land Use + Travel Demand)**	- All variables from 1.1 and 1.2 combined - Land use trend - Traffic Volume Survey (TVS) data	Primary & Secondary	Household survey, TVS, DAP & DSCC Data, RSTP reports	Surveys, GIS & statistical analysis	- Future trip generation (Forecasting household growth) - Future trip distribution (Gravity Model) - Map production (Network Analysis)

3.4 Application of Models

The four-step travel demand model was central to the study. Trip generation estimated the number of trips produced by each household based on size and income. Trip distribution employed the gravity model, which assumes that trips between two zones are proportional to their activity levels and inversely proportional to distance or travel cost. The gravity model was justified due to its simplicity, theoretical robustness, and widespread application in contexts lacking detailed behavioral data (Bouchard & Pyers, 1965).

$$T_{ij} = G \cdot \frac{A_i \cdot Bj}{dij^n}$$

Where:
T_{ij} = Trips from zone I to zone j.
A_i = Trips generated in zone i.
B_j = Trips attracted to zone j.
d_{ij} = Distance between zone i and zone j
G = Calibration constant
n= Friction factor

Source: (Voorhees, 1956)

Mode choice analysis applied descriptive statistics to estimate modal shares and identify determinants of choice, rather than full logit models, given data limitations. The fourth step, traffic assignment, was excluded because the study did not simulate detailed route-level flows.

The OD matrix was developed to represent trip flows between Kamrangirchar and external zones such as Newmarket, Dhanmondi, Hazaribagh, Mohammadpur, Motijheel, Babu Bazar, Keraniganj, and Gabtoli. This provided the foundation for gravity model calibration and distribution analysis. Network analysis in GIS was then used to visualize flows, producing desire-line maps that highlighted zones of high trip generation and attraction. These spatial outputs helped validate the statistical findings by showing consistent patterns between modeled and observed data.

Future household numbers were projected up to 2051 using the least squares parabola method, minimizing squared deviations to estimate long-term growth. This method was selected because it can capture non-linear growth trends more effectively than a straight-line projection, making it suitable for urban contexts where household growth may accelerate or decelerate over time. Its ability to smooth irregular fluctuations in historical data provides a more stable long-term forecast. Household growth was combined with observed trip rates to forecast future trip generation, applying compound annual growth rates (CAGR) to project year-by-year growth. The straight-line trend method was applied to analyze temporal changes, expressed as

$$\sum Y = n\,a + b\sum x$$

$$\sum XY = a\sum x + b\sum x^2$$

The straight-line trend can be expressed using the equation $Y_t = a + bt$ where Y_t represents the trend values, a is the Y-intercept (the value of Y when x=0), and b is the slope of the line, indicating how much the Y variable will change with each unit increase or decrease in x (time period). To find the constants a and b, two equations known as the normal equations must be solved.

And, the growth rate was calculated following CAGR (Compound Annual Growth Rate) formula.

$$\text{Growth Rate} = \left(\frac{Future\ Value}{Present\ Value}\right)^{\frac{1}{n}} - 1$$

Forecasts of trip distribution applied the gravity model to projected data, and the resulting OD matrices were visualized through GIS-based network analysis. These simulations provided long-term insights into how land use and transport demand may evolve in Kamrangirchar.

4. Land Use and Travel Demand

4.1 Land Use Pattern

Kamrangirchar, comprising Wards 55, 56, and 57, exhibits a complex mix of residential, commercial, industrial, and mixed-use development that reflects its spontaneous growth trajectory. According to the Detailed Area Plan (DAP), residential use dominates the landscape with 50.87% of total land. Mixed-use areas account for 13.71%, industrial land 9.22%, and commercial use 7.70%. Smaller shares are devoted to open space (6.76%), road networks (6.01%), and water bodies (3.38%).

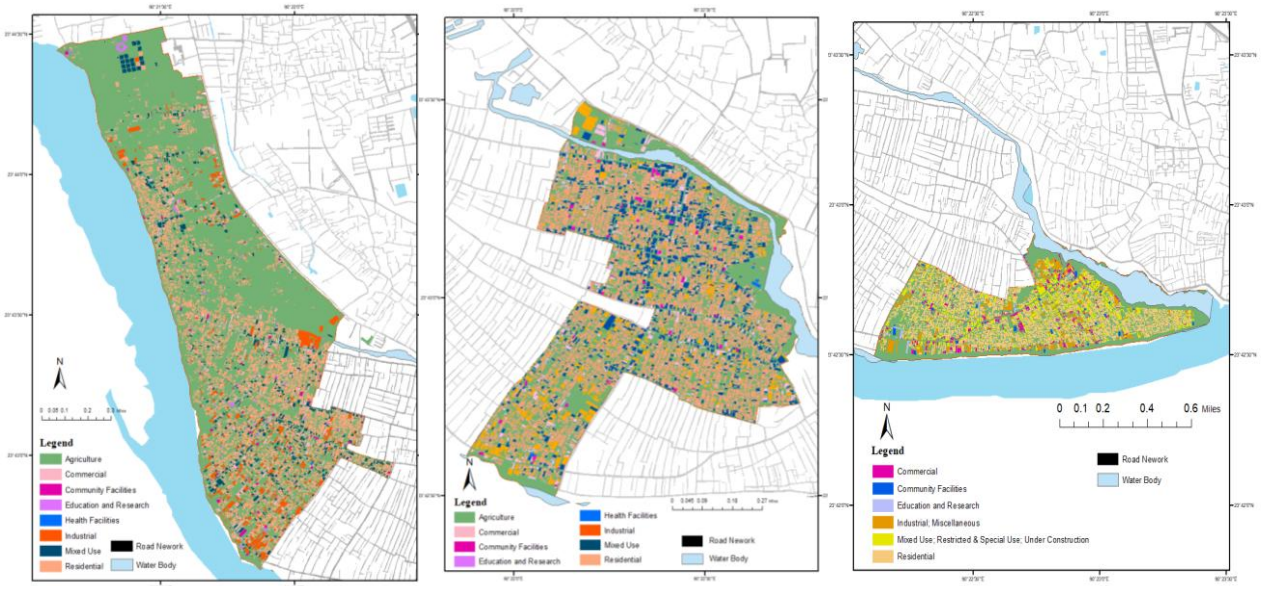


Figure 3 Ward wise Land use Map

Educational, community, and health facilities occupy marginal shares, and agricultural land is virtually absent. This distribution highlights the area's transition from a residential settlement toward a multifunctional urban hub.Ward-level patterns reveal further variation. Ward 55 remains largely residential (57.04%) but contains 20% unused land, suggesting potential for future development. Ward 56 has the highest proportion of residential land (70.03%) with notable mixed-use and commercial activities, reflecting balanced diversification. Ward 57 is the most heterogeneous, with strong integration of industrial (11.15%), mixed-use (15.83%), and commercial (6.97%) functions, though healthcare facilities are absent. Comparatively, Wards 56 and 57 demonstrate greater urban intensity and economic activity, while Ward 55 retains a more residential character with latent development capacity.

Table 2 Trend of Land use pattern of Kamrangirchar from 2010 to 2051

Year	**2010**	**2020**	**2031**	**2041**	**2051**
Agricultural Use	0%	0.01%	0.01%	0.01%	0.10%
Residential	66.94%	50.87%	33.19%	17.12%	1.05%
Commercial	0%	7.70%	16%	23.54%	31.08
Community Facilities	0%	1.13%	2%	2.79%	3.59
Industrial	0%	9.22%	19%	28.59%	37.52
Educational	0.60%	1.13%	1.71%	2.24%	2.77%
Health Facilities	0.04%	0.07%	0.10%	0.13%	0.16%
Mixed Use	6%	13.71%	21.78%	28.86	34.46
Open Space	3.93%	6.76%	5.79%	4.82%	3.85%
Water Body	7.94%	3.38%	0.30%	0.00%	0.00%
Flood Flow Zone	3.80%	0.00%	0%	0.00%	0.00%
Road Network	4.34%	6.01%	8%	9.50%	11.19%

Source: Author, 2024

Historical data show that in 2010 Kamrangirchar was predominantly residential (66.94%), with negligible industrial or commercial land and limited road infrastructure (4.34%). By 2020, residential land had decreased to 50.87%, while industrial, commercial, and mixed-use functions expanded significantly. Projections up to 2051 indicate a dramatic transformation: industrial land is expected to reach 37.52%, commercial land 31.08%, and mixed-use 34.46%. Conversely, residential use is forecast to shrink to just 1.05%. The road network will nearly triple in coverage, while open space, water bodies, and flood zones will decline sharply, signaling major environmental trade-offs. Table 2 (Source: Author, 2024) summarizes these land use trends. The trajectory demonstrates Kamrangirchar's evolution toward an industrial-commercial hub, but at the cost of ecological resilience and residential stability.

4.2 Current Travel Demand Pattern

The transformation of land use has directly shaped travel demand, increasing the number and diversity of trips. Household survey results from 309 respondents highlight socio-economic characteristics, trip production, trip purposes, and modal choices.

4.2.1 Socio-economic Characteristics of Trip Makers

Respondents were 56.03% male and 43.97% female, with the majority belonging to the middle-middle income group (49.19%), followed by the lower-middle group (27.18%). Average household size was 4.48 persons. Only 20.39% of households owned motor vehicles—predominantly motorcycles—while 79.61% relied on public or informal modes. Table 3 (Household Survey, 2024) details these characteristics. This demographic profile reflects a predominantly non-motorized, low-to-middle income population dependent on shared or informal transport.

Table 3 Socio-economic characteristics of the participants

Variables		***Frequency***	***Percentage***
Gender	Male	776	56.03%
	Female	609	43.97%
Monthly Income	Low Income (6000 to 14999)	16	5.18%
	Lower-middle Income (15000-29999)	84	27.18%
	Middle-middle Income (30000-69999)	152	49.19%
	Upper-middle Income (70000-149999)	35	11.33%
	Higher Income (150000+)	22	7.12%
Family Size	Mean	4.48	
	Std. Dev.	1.52	
Automobile Ownership	Yes	63	20.39%
	Bike	35	
	Car	20	
	Both (Car & Bike)	8	
	No	246	79.61%

Source: (Household Survey, 2024)

4.2.2 Trip Production and Household Income

Trip production correlates strongly with household income. Low-income households generated 1.17 trips per person, rising steadily to 2.19 trips per person in the highest-income group. This reflects greater economic flexibility and participation in diverse activities among higher-income groups. Figure 4 (Household Survey, 2024) illustrates this trend, emphasizing how rising incomes increase mobility demand.

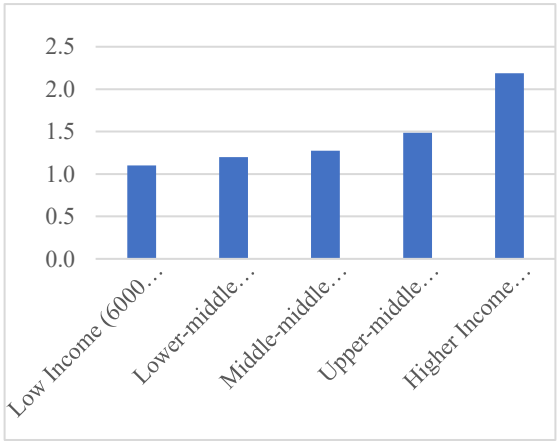


Figure 4 Number of Trips and Trip Rate by Household Income

4.2.3 Trip Generation and Attraction by Area

Table 4 Number of Generation and Attraction Trips by Area

Area	Generation (Trips/day)	Attraction (Trips/day)
Ward 55	600	576
Ward 56	615	607
Ward 57	638	621
New Market	388	377
Dhanmondi	351	345
Mohammadpur	287	276
Hazaribagh	194	201
Motijheel	45	38
Babu Bazar	192	207
Keraniganj	101	112
Gabtoli	21	23

Internal zones (Wards 55, 56, 57) generated the highest number of trips: 600, 615, and 638 respectively per day. External zones attracted substantial flows, especially New Market (388 generated, 377 attracted) and Dhanmondi (351 generated, 345 attracted), highlighting their role as key employment, education, and shopping destinations. Mohammadpur, Hazaribagh, and Babu Bazar also attracted significant trips. The OD matrix (Table 4, Source: Author, 2024) confirms the importance of proximity in shaping travel behavior.

Figures 5 shows that trips concentrate around industrial sites, markets, and riverside work areas internally, and extend outward to adjacent commercial centers.

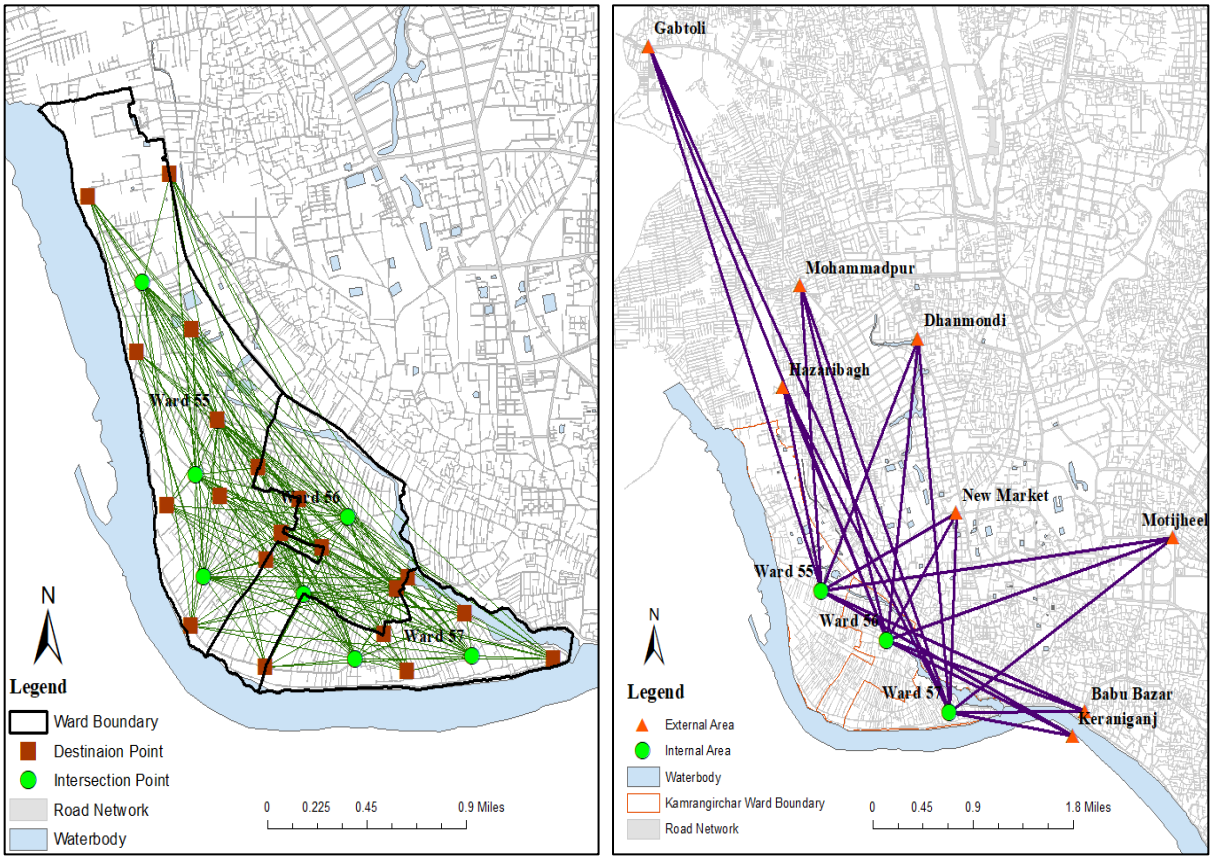


Figure 5 Trip Distribution Map

4.2.4 Trip Purpose

Work trips dominate across all wards, with Wards 56 and 57 each generating 103 daily work trips, and Ward 55 slightly fewer (100). Educational trips are the second largest category, followed by shopping trips. Recreational, medical, and social trips are minimal, reflecting limited local provision of such facilities. Figure 6 (Household Survey, 2024) illustrates these ward-level variations, underscoring the role of employment and education as the primary mobility drivers in Kamrangirchar.

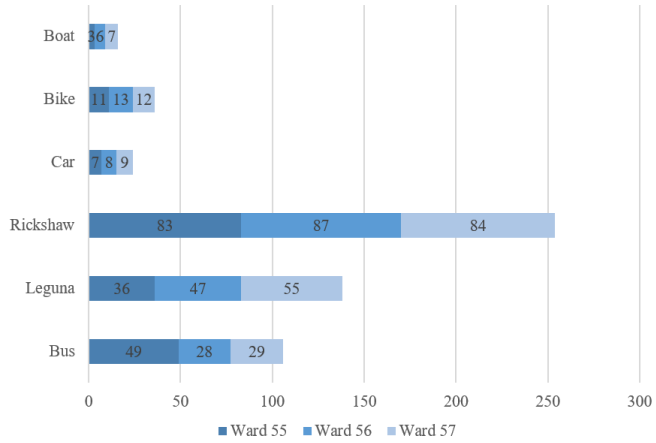


Figure 6 Trips by Purpose (Ward Wise)

4.2.5 Modal Choice

Auto-rickshaws emerged as the dominant mode, accounting for 254 trips across the three wards, due to their ability to navigate narrow, congested roads. Legunas (informal shared vehicles) followed with 138 trips, while buses were used for 106 trips, mostly on longer external routes. Private vehicle use remained marginal, with only 24 car trips and 36 bike trips recorded. A small number of boat trips (16) were reported, reflecting the riverine geography. Figure 7 (Household Survey, 2024) shows that auto-rickshaws and legunas dominate both internal and external trips, particularly toward Mohammadpur, Gabtoli, New Market, and Babu Bazar. The reliance on informal modes highlights both the adaptability of residents and the absence of sufficient formal public transport.

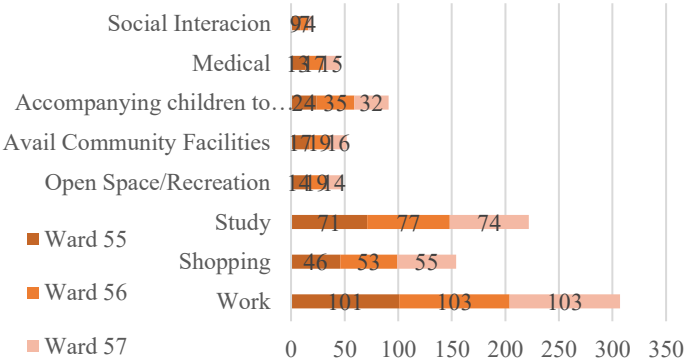


Figure 7 Ward Wise Modes of Transport

5. Interaction of Land Use and Travel Demand

5.1 Forecasting Future Trip Rate

5.1.1 Household Growth Rate

Household expansion provides the foundation for forecasting future travel demand. Using household data from the Bangladesh Bureau of Statistics (2001, 2011, 2022), future growth was projected with the least squares parabola method. This technique was chosen because it effectively captures non-linear trends, smoothing irregular

fluctuations and reflecting potential acceleration or deceleration of growth in rapidly urbanizing areas. The resulting equation (Yt = 49454.8 + 3169.78x) projects approximately 112,850 households by 2031. Between 2022 and 2031, the average annual household growth rate is estimated at 1.59%. This growth signals steadily rising demand for mobility, particularly as residential expansion is accompanied by intensified industrial and commercial activity.

5.1.2 Future Trip Generation

Table 5 Predicted Trip Numbers

Ward No/Trip Year	2024	2031	2041	2051
Ward 55	600	664	770	907
Ward 56	615	689	800	941
Ward 57	638	715	829	976
Total	1853	2068	2399	2824

Forecasts indicate a sharp increase in daily trip generation, rising from 1,853 trips in 2024 to 2,824 by 2051—a 52% increase. Ward-level projections reflect varied growth trajectories aligned with land use intensity. Ward 57, with its concentration of industries, emerges as the leading trip generator, growing from 638 trips in 2024 to 976 in 2051. Ward 56, with balanced mixed-use and commercial functions, follows with an increase from 615 to 941 trips. Even Ward 55, primarily residential, demonstrates significant growth from 600 to 907 trips. These results highlight how rising household numbers and land use diversification directly amplify mobility demand. Table 5 (Source: Author, 2024) summarizes projected trip numbers across wards.

5.1.3 Trip Distribution Using the Gravity Model

Table 6 Trip Generation and Attraction by Gravity Model

From / To	Ward 55	Ward 56	Ward 57
Ward 55		193.11	72.12
Ward 56	198.54		475.01
Ward 57	203.12	468.45	
Newmarket	14.33	24.60	32.78
Dhanmondi	10.16	12.85	9.98
Hazaribagh	36.98	24.26	17.48
Mohammadpur	7.08	5.69	5.11
Gabtoli	0.21	0.21	0.19
Motijheel	0.44	0.51	0.46
Babu Bazar	5.04	9.76	18.00
Keraniganj	1.29	1.72	3.51

Trip distribution was modeled using the gravity framework, which accounts for both the size of trip-generating and trip-attracting zones and the impedance of travel distances. Results demonstrate the dominance of Wards 56 and 57 as internal trip hubs, with strong interconnections reflecting their industrial and commercial character. Flows between Ward 56 and Ward 57 are particularly high, with 475.01 and 468.45 trips respectively, underscoring significant intra-area economic linkages. Ward 55, being more residential, generates fewer inter-ward trips but contributes to outbound flows to nearby employment zones.

External destinations remain crucial in the travel network. New Market attracts 32.78 trips from Ward 57 and 24.60 from Ward 56, confirming its role as a regional commercial hub. Hazaribagh attracts 36.98 trips from Ward 55, reflecting spatial proximity and employment opportunities. Babu Bazar is also a notable attractor, particularly from Ward 57 (18.00 trips). Other external zones such as Dhanmondi, Mohammadpur, and Keraniganj play moderate but important roles. Table 6 (Source: Author, 2024) presents the detailed distribution outcomes.

5.1.4 Areas of Attraction

Analysis highlights Wards 56 and 57 as the most prominent trip generators and attractors within Kamrangirchar, reflecting dense clusters of industrial and commercial land uses. Among external zones, New Market, Hazaribagh, Babu Bazar, and Keraniganj emerge as key attractors due to their provision of employment, shopping, and educational services not fully available locally.

Traffic volume surveys conducted at Company Ghat (Ward 55) and Beribadh Ghat (Ward 56) indicate a Level of Service (LOS) F, signifying severe congestion. This condition highlights the inability of existing infrastructure to accommodate projected growth in trip activity, especially near industrial clusters and markets. Figure 8 (Field Survey, 2024) illustrates these LOS conditions. Figures 8 further highlight Ward 56's emergence as a critical commercial hub, where the spatial clustering of shops, markets, and factories generates high volumes of both intra- and inter-ward trips.

Company Ghat Bridge

Morning Peak		Morning Peak	
PCU/Hour	745.43	PCU/Hour	506.44
V/C Ratio	1.5693 26316	V/C Ratio	1.06618 9474
LOS	F	LOS	F
Afternoon Peak		**Afternoon Peak**	
PCU/Hour	847.71	PCU/Hour	540.06
V/C Ratio	1.7846 52632	V/C Ratio	1.13696 8421
LOS	F	LOS	F
Evening Peak		**Evening Peak**	
PCU/Hour	849.25	PCU/Hour	585.29
V/C Ratio	1.7878 94737	V/C Ratio	1.23218 9474
LOS	F	LOS	F
Total LOS –F		**Total LOS –F**	

Company-ghat Market ↕ Company-Ghat Leguna Stop

Buriganga Bridge

Morning Peak		Morning Peak	
PCU/Hour	844.96	PCU/Hour	997.75
V/C Ratio	0.88016 66667	V/C Ratio	1.03932 2917
LOS	D	LOS	F
Afternoon Peak		**Afternoon Peak**	
PCU/Hour	695.96	PCU/Hour	885.05
V/C Ratio	0.72495 83333	V/C Ratio	0.92192 70833
LOS	D	LOS	E
Evening Peak		**Evening Peak**	
PCU/Hour	658.76	PCU/Hour	597.14
V/C Ratio	0.68620 83333	V/C Ratio	0.62202 08333
LOS	C	LOS	C
Total LOS –D		**Total LOS –F**	

Buriganga Bridge Road ↕ Paka Bridger Dhal

Figure 9 LOS of Designated Area

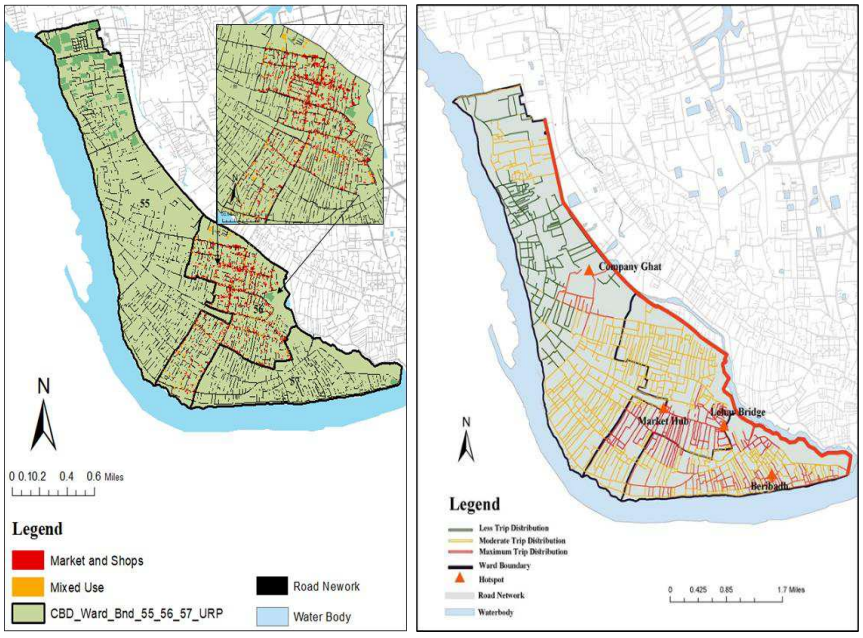


Figure 8 Locational Hotspots

Desire line analysis (Figure 10) reinforces these patterns, illustrating strong outbound flows from Ward 56 to major external destinations such as New Market, Hazaribagh, Keraniganj, and Babu Bazar. These flows are driven by employment and educational needs and underscore the mounting pressure on Ward 56's transport infrastructure. The findings confirm that future physical development in Kamrangirchar will be shaped by the interplay of intensifying land use and rising travel demand, reinforcing the need for targeted infrastructure investment and improved public transport to manage growth sustainably.

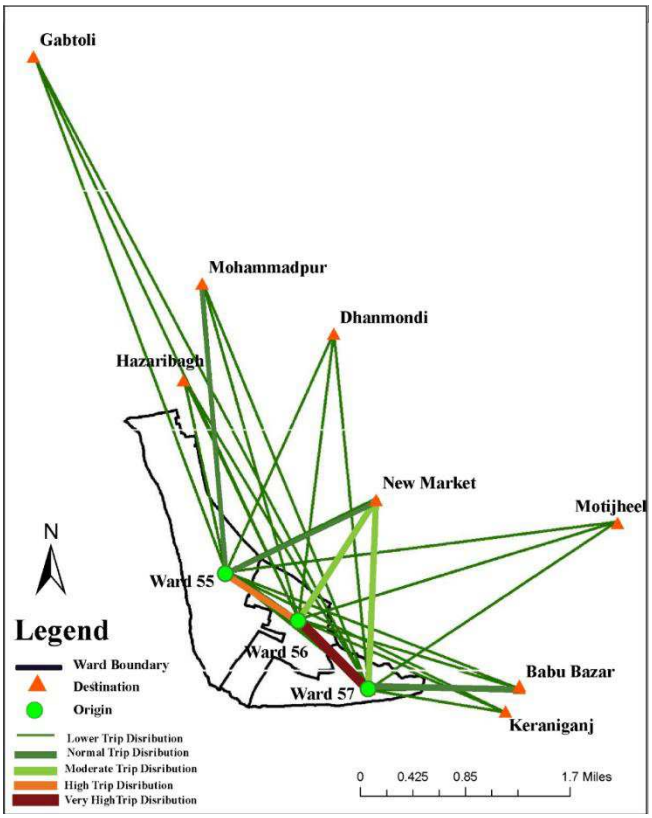


Figure 10 Desire line

6. Discussion and Conclusion

6.1 Discussion

This research has examined the transport–land use relationship in Kamrangirchar, Dhaka, through a case study approach that combines empirical evidence and theoretical insights. The findings highlight the dynamic transformation of Kamrangirchar from a predominantly residential area into one characterized by industrial and mixed-use developments, particularly in Wards 56 and 57. This shift has substantially influenced trip generation and attraction, creating an increasingly complex travel demand structure. The study also underscores how socio-economic characteristics, such as income levels and household size, directly shape trip rates, modes of transport, and overall mobility patterns.

The use of the four-step model—particularly trip generation, trip distribution, and modal choice—combined with the gravity model provided a robust analytical framework for understanding the spatial distribution of trips. While the empirical findings reveal that Wards 56 and 57 generate and attract the majority of trips due to their industrial and commercial dominance, the theoretical contribution lies in demonstrating how such land use transitions intensify the transport–land use feedback cycle. The results confirm that spontaneous cities, despite lacking planned infrastructure, exhibit a self-reinforcing mechanism: growing industrial and mixed-use

activities increase travel demand, which in turn further stimulates additional land use transformation.

From a methodological perspective, this study validates the applicability of traditional transport models such as the gravity model and four-step framework in spontaneously developed urban contexts. These tools, though designed for more structured environments, can be adapted to capture the unique complexities of unplanned areas when carefully contextualized with local land use and socio-economic data. This constitutes a theoretical contribution, expanding the scope of LUTI (Land Use Transport Interaction) frameworks into informal and spontaneous urban settings, which are often underrepresented in mainstream urban studies.

Although the research is context-specific to Kamrangirchar, the findings hold broader relevance for other spontaneously growing cities in South Asia and beyond. Similar settlements—characterized by rapid, unplanned urbanization, mixed land use, and high reliance on informal transport—can draw lessons from this case. The observed feedback loop suggests that unchecked growth in industrial and commercial functions without commensurate transport investment leads to severe congestion, as evidenced by LOS F at major gateways. Other cities with similar characteristics can generalize from this case to anticipate comparable challenges and design integrated policies that simultaneously regulate land use, provide adequate transport infrastructure, and manage travel demand.

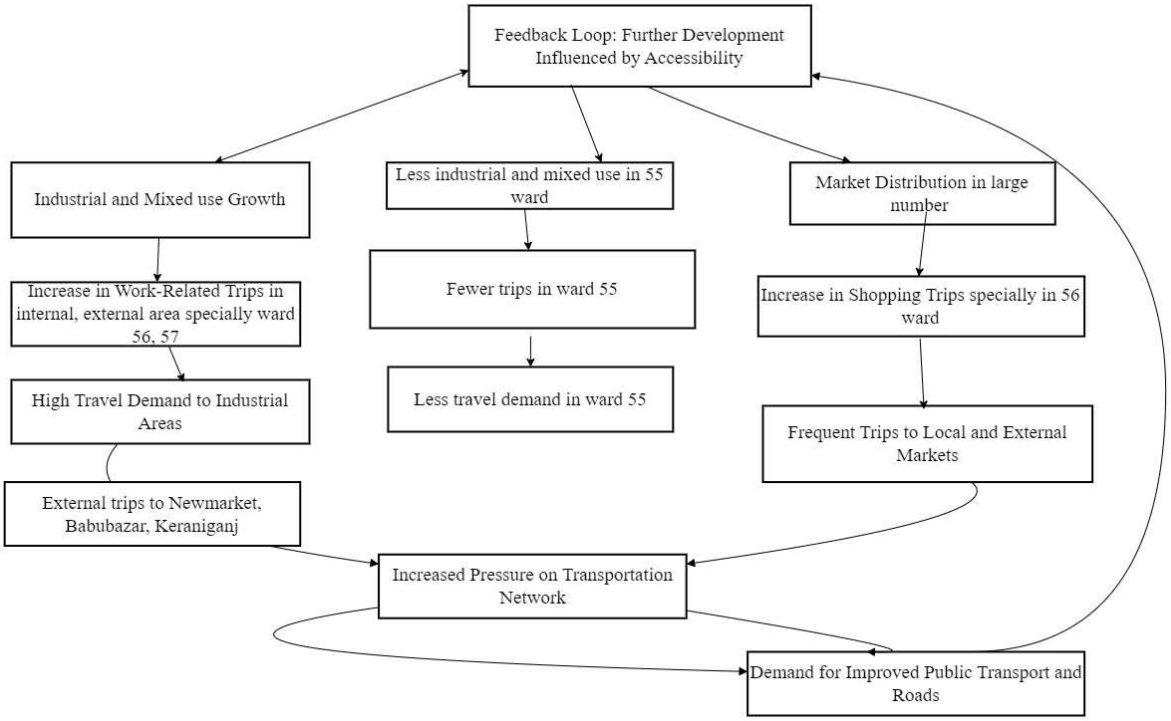


Figure 11 Transport-Land Use Feedback Mechanism

The discussion also reveals key policy implications. First, zoning strategies are needed to separate incompatible land uses and mitigate residential displacement caused by industrial expansion. Second, investment in formal and affordable public transport is critical to reduce dependence on informal modes such as Legunas and auto-rickshaws. Third, long-term redevelopment strategies must balance densification with environmental sustainability, given Kamrangirchar's loss of open spaces and water bodies. These lessons provide actionable insights not only for Dhaka but also for rapidly urbanizing cities across the Global South.

6.2 Conclusion

This study concludes that the transformation of Kamrangirchar's land use from residential to industrial and mixed functions is directly shaping its travel demand patterns. Using a combination of empirical surveys, spatial analysis, and transport models, the research demonstrates that industrial and mixed-use hubs—particularly Wards 56 and 57—emerge as dominant generators and attractors of trips, creating heavy reliance on informal transport and causing severe congestion at entry points.

Beyond its empirical contribution, the study offers theoretical advancement by extending the applicability of LUTI frameworks and transport demand models to spontaneous urban environments. It shows that even in unplanned settlements, transport–land use relationships follow identifiable patterns, governed by feedback loops between household growth, land use change, and mobility demand. This contributes to the broader literature by bridging the gap between formal urban models and the realities of spontaneous city growth.

While Kamrangirchar served as the case study, the findings are generalizable to other rapidly growing, unplanned cities facing similar conditions of mixed land use, informal transport reliance, and limited infrastructure. The lessons from this study highlight that sustainable redevelopment in such areas requires integrated planning approaches that coordinate transport investments with land use management.

Data Availability Statement

All data supporting the findings of this study are available within the main manuscript and its Supplementary Information. Additional anonymized data derived from the household surveys are not publicly available because the original participant consent agreements restricted the public dissemination of individual responses. Such data may be made available by the corresponding author on reasonable request for legitimate scientific research purposes, subject to ethical approval, institutional permission, and compliance with the original consent agreements.

Author Contributions

Conceptualization: Shafiqul Hassan Shawon, Kasphia Nahrin; Methodology: Shafiqul Hassan Shawon, Kasphia Nahrin; Data Curation: Shafiqul Hassan Shawon; Investigation: Shafiqul Hassan Shawon; Formal Analysis: Shafiqul Hassan Shawon;

Visualization: Shafiqul Hassan Shawon; Writing – Original Draft: Shafiqul Hassan Shawon; Writing – Review & Editing: Shafiqul Hassan Shawon, Kasphia Nahrin; Supervision: Kasphia Nahrin.

Use of Artificial Intelligence (AI)

During the preparation of this manuscript, the authors used ChatGPT (OpenAI) to improve the language, readability, organization, and academic presentation of the manuscript. The AI tool was not used to generate, analyze, or interpret the research data, nor to formulate the study's findings or conclusions. All outputs were carefully reviewed, revised, and verified by the authors, who take full responsibility for the accuracy, originality, and integrity of the final manuscript.

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Conflict of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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Clinical Trial Registration

Not applicable. This study is not a clinical trial. It is based on field survey data, secondary data, and numerical modelling and simulation.

Ethics, Consent to Participate, and Consent to Publish

Ethical approval was not required for this study in accordance with the institutional and national guidelines, as the research involved a non-invasive questionnaire-based field survey and secondary data analysis. Participation in the household survey was entirely voluntary. Prior to data collection, all participants were informed about the purpose of the research, the confidentiality of their responses, and their right to decline or withdraw from the survey at any stage without any consequences. Verbal informed consent was obtained from all participants before the interviews commenced. No personally identifiable information was collected, and all data were anonymized prior to analysis.

Consent for publication: Not applicable. The manuscript does not contain any individual person's identifiable data, images, or personal information requiring consent for publication.

Ethics Statement

This study was conducted as part of a compulsory undergraduate thesis under the Department of Urban and Regional Planning, Jahangirnagar University, Bangladesh. The study protocol, questionnaire, and data collection procedures involving human participants were reviewed by the Ethical Review Board, Department of Urban and Regional Planning, Jahangirnagar University, and the research was conducted in accordance with the ethical requirements and guidelines of the Ethical Review Board. Participation was voluntary, and informed consent was obtained from the participants. Confidentiality and privacy of the participants were maintained throughout the research process.

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