



Geospatial Assessment of Urban Road Network Connectivity and Intersection Traffic Performance: A GIS Based Case Study of Court Bazar, Rajshahi, Bangladesh

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ARTICLE INFORMATION

Received date: 15 June 2026
Revised date: 08 Oct 2026
Accepted date: 10 Oct 2026

Keywords

Geospatial analysis
Traffic volume survey
Manual counting method
Level of service (LOS)
Peak Hour Factor (PHF)
Speed Based Method

ABSTRACT

The distinct influence of transportation modes and networks is considered an effective factor in the formation of transportation planning and development. This study addresses that gap for Rajshahi City Corporation (RCC) area by ranking 30 wards through Alpha, Beta, and Gamma connectivity indices together with roads and nodes in a geospatial analysis. A manual counting method is followed for the data collection process during three peak periods across selected survey days at eight intersections of the location where six surveyors completed the data collection procedure. The field-based traffic volume survey evaluates the level of service using the volume/capacity ratio, Peak Hour Factor, and speed-based method. Being a major influential location based on geospatial analysis, the traffic volume survey conducted in the Court Bazaar intersection reveals the traffic patterns and cumulative mode variations throughout the city corporation that outlines the vehicular patterns where auto-rickshaws accounted for the highest volume on major routes, contributing up to 30% of the total traffic volume, followed closely by motorcycles and bicycles for labourer commuting patterns during morning and evening hours. The geospatial analysis identifies variation in traffic composition and traffic flow patterns, highlighting the critical congestion conditions affecting the operational performance of Court Bazar intersection, as four of the intersection's eight directions reveal level of service F during peak periods. The output provides a clear understanding for transport planners, policy makers, and engineers in developing effective traffic control measures, optimizing signal timings, and enhancing traffic management in the rapidly growing metropolitan cities and similar developing cities in Bangladesh.

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1. Introduction

Integrating new urban development and transportation planning has emerged as a critical technique for building habitable, economically viable neighbourhoods [10]. Rajshahi, the fourth largest metropolitan city in Bangladesh, has faced intense traffic flow due to rapid urbanization and population expansion. Road networks are the backbone of a city, shaping spatial structure and affecting merchandise transport, mobility, and quality of life [1]. According to the current transportation inventory scenario, the city has roughly 186.64 km of paved roads, with approximately 23% in poor condition [2]. However, the increasing growth of private cars due to a lack of an effective public transportation network is causing traffic congestion and inefficient traffic flow [3]. The annual average growth rate for motorized traffic is 8.50%, auto-rickshaws are 12.30%, and motorbikes are 12.60%, demonstrating the probability of an increasing congestion rate at the city corporation. The city's road infrastructure confronts other issues, such as ill-defined road markings, insufficient traffic signals, and widespread unlawful parking, particularly in peripheral locations. Low intersection capacity has also become a source of worry, disrupting traffic flow, jeopardizing driver safety, and worsening congestion [2]. In Rajshahi, effective road network design combines index analysis with physical surveying at key intersections to reveal capacity and peak-hour conditions. Node and density analysis in GIS identifies critical locations with inefficient traffic movement, informing multiple routing options that reduce bottlenecks and strengthen network robustness [8]. Yet transportation assessments in Rajshahi and comparable Bangladeshi cities have generally relied on isolated traffic counts at individual intersections, without situating that data within a network-wide understanding of connectivity. Because congestion at a single junction can be either a localized capacity problem or the visible symptom of a citywide connectivity gap, planners cannot design a lasting intervention from intersection-level counts alone. Pairing a ward-level geospatial connectivity assessment with a targeted field survey at the junction that assessment identifies as a priority directly addresses this gap.

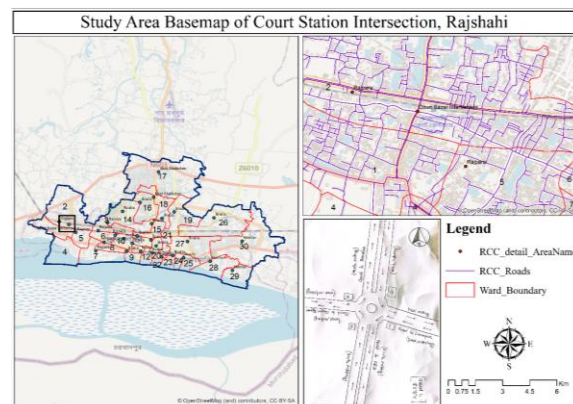
The Alpha, Beta, and Gamma indices employed in this study are derived for characterizing transportation network structure [12]. This framework has subsequently been applied to road networks across Bangladesh and South Asia, including connectivity analyses of all 30 RCC wards using Alpha, Beta, Gamma, and Eta indices computed in ArcGIS Network Analyst that identified Ward 1 among the lowest-ranked wards in network and intersection density, as well as comparable GIS-based connectivity assessments of Aurangabad and other Indian cities [14], [4], [8].

Independently, intersection-level traffic volume surveys employing PCU conversion and Volume/Capacity-based Level of Service (LOS) assessment have been conducted within RCC: a study of three unsignalized intersections reported LOS F at the Laxmipur approach [15], one of the routes that also feeds the Court Bazar intersection considered here. These two bodies of work have not previously been combined at the scale of a single intersection. The present study links them directly, using Ward 1's connectivity ranking to identify Court Bazar as the site for a field-based TVS and LOS assessment.

This research aims to analyze vehicle composition, service flow rates in PCU units, and directional distribution at Rajshahi's Court Bazar intersection, one of the influential locations with lower interconnectedness among the wards. Analyzing critical nodes based on connectivity and activity density over time can further optimize network planning and resource management, revealing contradictions in network connectivity using the indices [11]. Adding traffic forecasting to assess the LOS at the intersection helps in forming solutions to improve traffic flow and optimize the transportation system at the intersection as well as the overall city corporation. By pairing this citywide connectivity ranking with a targeted intersection-level service assessment, the study offers both a diagnostic tool for prioritizing which of RCC's 30 wards most urgently need network investment and a practical, low-cost field methodology that other medium-sized Bangladeshi cities facing similar rapid motorization can adopt without specialized traffic-modelling software.

2. Study Area

Rajshahi City Corporation covers an area of 96.72 km² and holds substantial educational institutions and industrial and commercial hubs of Bangladesh, where the demand for effective transportation infrastructure has risen over time with rapid population growth, urbanization, and economic activity.



Source: Author's Preparation, 2023

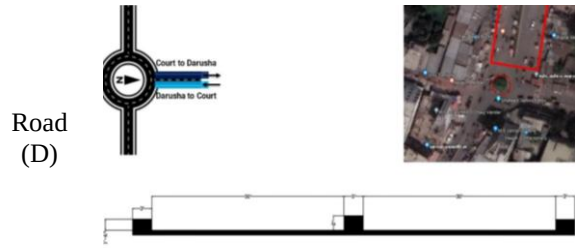
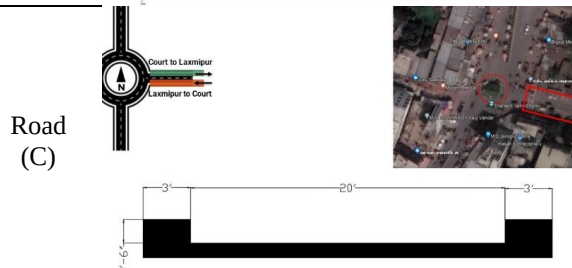
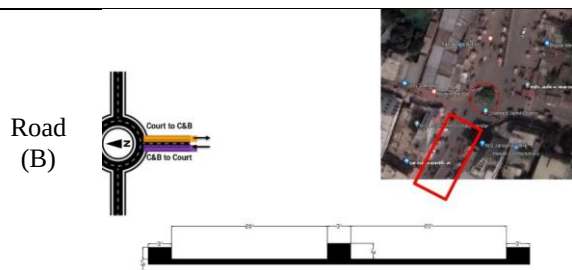
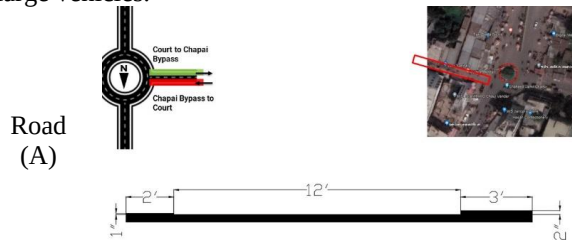
Figure 1. Map of Study Area

The geospatial analysis is conducted across Rajshahi City Corporation for the investigation of the road network condition and connectedness (Figure 1).

Court Bazar intersection was selected for the traffic volume survey because it is located in ward 1, which is the lowest rank among all wards in RCC on the Alpha, Beta, and Gamma connectivity indices, despite having the highest node and road density. The weak structural connectivity and congestion conditions necessitate an evaluation of the level of service (LOS) in this area. Therefore, the junction plays a significant role in facilitating the movement of vehicles, pedestrians, and goods in the area as a junction connecting several key routes like Dhaka-Rajshahi-Chapai Nawabganj.

The Court Bazar intersection is situated in the northern portion of Rajshahi City Corporation (RCC) and has four two-way roads, each with one entering and one exiting lane for traffic movement: Road (A) Chapai Bypass to Court Station, Road (B) C&B to Court Station, Road (C) Laxmipur to Court Station, and Road (D) Darusha to Court Station.

Each road connecting the intersection has unique conditions. As seen in Figure 2, Collector Street Road (A), connecting Court Bazar to Chapai Bypass, is the narrowest road, about 12 feet wide and mostly utilized for property access, with heavy congestion caused by local motorcycles and rickshaws and limited capacity for large vehicles.



Source: Author's Preparation, 2023

Figure 2. Existing Road Network Condition at Court Bazar Intersection

Road (B), the C&B approach, is a smooth one-way minor arterial 40 feet wide with a 20-foot effective width, serving as the entry lane for heavy vehicles towards the station and for labour from Chapai Nawabganj entering the city.

Road (C), the Court Intersection-Laxmi collector street, connects outer residents with Rajshahi's medical facilities and attracts large traffic flow despite being about 20 feet wide without a divider, giving a 10-foot effective width per lane.

The Darusha-Court crossroad (D) is an important regional route linking the court station with the Dhaka-Chapai Nawabganj Highway. The one-way road has an effective width of 30 feet and is mostly utilized by northern labourers entering the city.

3. Methodology

The methodological approach has two segments: a geospatial analysis comparing the wards of RCC by the connectivity indices, and the procedure for conducting the traffic volume survey (TVS) used to evaluate the level of service (LOS) at the Court Bazar intersection.

Framework for delineation of road network spatial variables

The analytical approach identifies the Alpha, Beta, and Gamma indices for describing the connectivity of a transportation network in an area, where e = number of edges and v = number of vertices [12].

Alpha Index

$$\text{Equation: } \alpha = (e - v + 1) / (2v - 5) \quad (1)$$

The alpha index of a network ranges from 0 (no circuits) to 1 (highest connectedness). It expresses the number of fundamental circuits relative to the maximum number of circuits, so a higher alpha value indicates improved connectedness and a low value indicates poor connectivity.

Beta Index

$$\text{Equation: } \beta = e / v \quad (2)$$

The beta index indicates the average number of edges per node in the network. A value larger than one

implies a complicated network with various paths between nodes.

Gamma Index

$$\text{Equation: } \gamma = e/(3(v-2)) \quad (3)$$

The Gamma index, which ranges from 0 to 1, assesses the ratio of real links to the maximum number of links in a network. A greater gamma value suggests an improved connection [11].

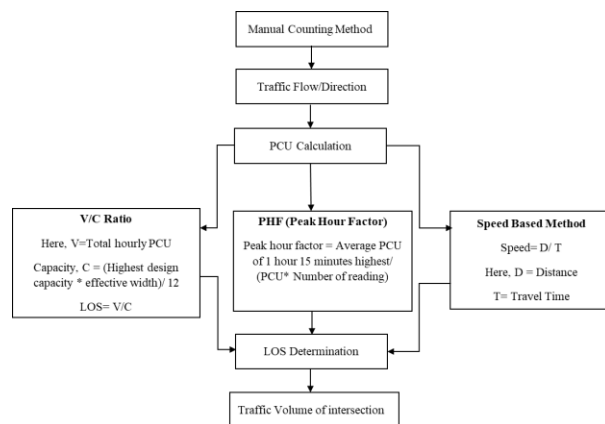
Additionally, the existing road inventory is measured with road network density, an important metric for assessing regional road development magnitude and degree, defined as the total length of roads per unit area in kilometers per square kilometer [1].

$$\text{Equation: } ND = L/A \quad (4)$$

where L = total road network length at the ward and A = area of the ward.

To operationalize this for each of RCC's 30 wards, the road network within each ward boundary was represented as a planar graph of vertices and edges, following the standard graph-theoretic representation of transportation networks [12]. Two categories of vertices were distinguished: actual intersections and dead-ends occurring inside the ward, and border vertices, where a road segment crosses the ward boundary and continues into a neighbouring ward [13]. Only transport vertices were counted toward each ward's vertex total (v), so that a ward's connectivity score reflects genuine intersections within it rather than being inflated by roads that merely pass through. Edges (e) were counted as the road segments connecting these vertices, extracted for each ward using the Network Analyst extension in ArcGIS. This procedure was applied uniformly across all 30 wards to ensure the resulting rankings are directly comparable across the city corporation.

Framework for the traffic volume survey (TVS) at Court Bazar intersection



Source: Author's Preparation, 2023

Figure 3. Methodological framework of the TVS

Traffic volume refers to the total number of vehicles crossing a given point on a route, counted at regular intervals [5]. The methodological framework followed for the TVS is illustrated in Figure 3.

In the methodological approach for TVS, the manual counting method across 8 directions is conducted by six surveyors at the Court Bazar intersection for the counting of traffic flow. May 7, 2023 (Sunday), and May 11, 2023 (Thursday), were selected for the data collection process. Data were collected over two days because one was the first working day and the other was the last working day before the weekend, which differs in the trip's purpose. They represent regular working days characterized by high levels of commercial and commuter activities, thereby capturing typical traffic conditions at the Court Bazar intersection. Both survey days had sunny, cloudy, and rainy conditions. The survey was carried out by a team of six trained surveyors, with one surveyor stationed at each approach/exit direction to avoid double-counting. To validate the manual counts, a 15-minute interval at each station was independently cross-checked by a second surveyor. The counting time is divided into the peak periods detailed in Table 1.

Table 1. Survey Time for Traffic Volume Survey

Morning 8:00 AM to 10:00 AM	8:15 AM – 8:30 AM
	8:45 AM – 9:00 AM
	9:15 AM – 9:30 AM
	9:45 AM – 10:00 AM
Noon 12:00 PM to 2:00 PM	12:15 PM – 12:30 PM
	12:45 PM – 1:00 PM
	1:15 PM – 1:30 PM
	1:45 PM – 2:00 PM
Afternoon 4:00 PM to 6:00 PM	4:15 PM – 4:30 PM
	4:45 PM – 5:00 PM
	5:15 PM – 5:30 PM
	5:45 PM – 6:00 PM
Surveys are conducted every 15 minutes.	

Source: Author's Preparation, 2023

The analysis continues by defining the PCU values for the vehicles on the route. The Passenger Car Unit (PCU) is a relative weightage factor applied to the traffic volume of individual vehicle categories to account for heterogeneity in a mixed traffic situation [9], with the values adopted for each vehicle type in this study presented in Table 2.

Table 2. PCU (Passenger Car Unit) Value of transportation modes

Vehicle Type	PCU	Vehicle Type	PCU
Heavy truck	5	Car	1
Medium truck	4.5	Auto rickshaw	2
Small truck	3	Motor cycle	0.75
Large bus	3.5	CNG	2
Minibus	3	Van	2
Microbus	1	Cycle rickshaw	2
Bicycle	0.5		

Source: [9]

The LOS is identified by three methods. The volume-to-capacity (V/C) ratio compares the traffic

volume in a facility to its capacity, representing the extent to which the facility is utilized [6]. According to the Highway Capacity Manual (HCM) [18], the highest design capacity is 2000 for freeways, 1200 for major arterials, 90 for minor arterials, and 60 for collector roads.

The peak hour factor (PHF) converts hourly traffic volume into flow rate during the busiest 15 minutes of rush hour, and the Speed-Based Method is calculated by distance divided by the travel time, with the LOS thresholds for all three methods summarized in Table 3.

Table 3. LOS (Level of Service) Value of Road Network

LOS	V/C	PHF	Speed (Km/h)
A	≤ 0.6	≤ 0.7	≥ 40
B	0.6- 0.7	0.7- 0.8	30- 40
C	0.7- 0.8	0.78- 0.85	25- 30
D	0.8- 0.9	0.85- 0.9	15- 25
E	0.9- 1.0	0.9- 0.95	5- 15
F	≥ 1.0	≥ 1.0	≤ 5

Source: [18]

4. Data analysis and discussion

Spatial analysis of the road network at Rajshahi City Corporation (RCC)

The geospatial analysis combines the Alpha, Beta, and Gamma indices with node density and road density analysis to rank the wards of RCC by connectivity and by the availability of existing transportation infrastructure, indices frequently combined with density and accessibility indicators to fully evaluate transportation networks [4], [8].

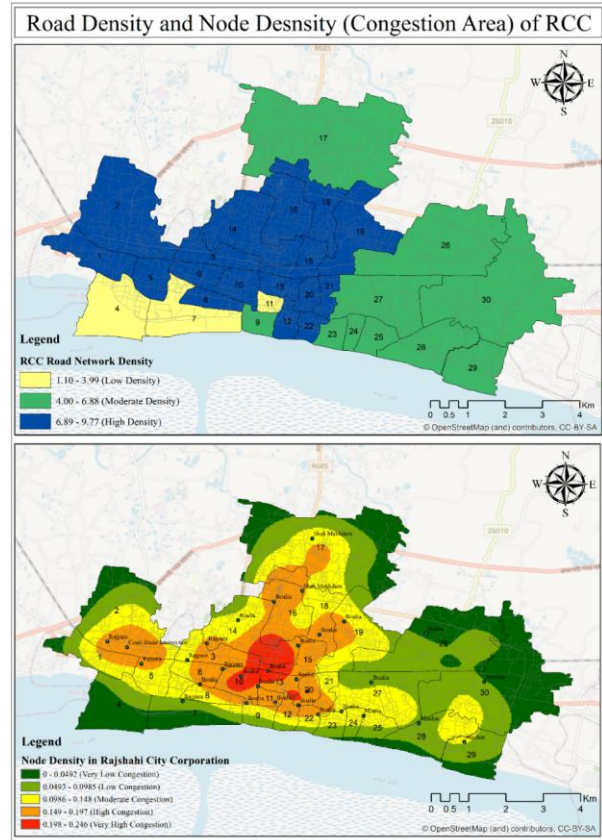
Road density and node density analysis for RCC

Road network proportions are one of the key factors for the qualitative development of the standard, commercial, and industrial sectors, and the requirements of roads differ by location and use. The road and node density scenarios for the wards of Rajshahi City Corporation are shown in Figure 4.

About 17 wards fall under the high-density road networks, while low-density and moderately dense road networks are found on the Padma River side. The high-density areas are major areas of commercial space, educational institutions, and small industries, and highways such as N6 add further road density. Ward no. 1 contains the entry intersection named Court-Station Bazaar from Chapai Nawabganj, and the highway towards Dhaka makes it fall under a high-density area, so the frequent movement at the intersection needs to be maintained.

Another influential factor is node density, which affects accessibility, mobility, and economic activity within a certain location and is frequently associated with improved connectivity and development [4]. As

seen in Figure 4, areas near RUET and RU have higher node density, and areas with train stations, industry, and commercial functions are considered high-congestion with relevant density at the cornered areas of the city corporation.



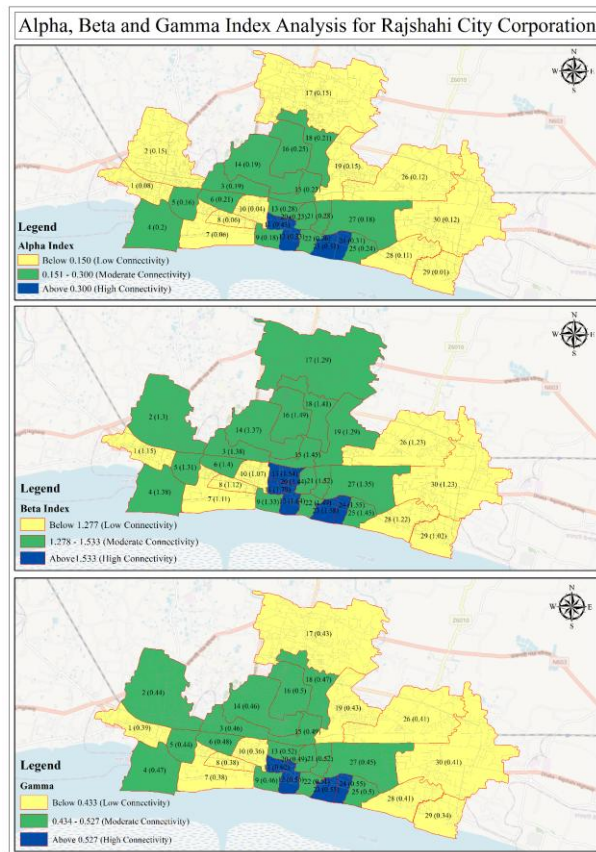
Source: Author's Preparation, 2023

Figure 4. Road and node density of Rajshahi City Corporation

Comparative analysis of Alpha, Beta, and Gamma Index for RCC

The index analysis permits a critical comparative analysis of the wards of Rajshahi City Corporation, with the Alpha indices categorized into three equal class intervals for ranking the wards by transportation network facility.

This pattern indicates that road density in RCC has increased mainly in response to commercial development rather than through planned transportation network expansion. Consequently, wards located near major traffic-generating areas experience high traffic volumes without adequate improvements in roads. This imbalance is particularly evident at the Court Bazar intersection in Ward 1, which is examined in detail.



Source: Author's Preparation, 2023

Figure 5. Alpha, Beta, and Gamma Index maps of Rajshahi City Corporation

Ward 1's relatively low node density despite its high traffic volume helps explain why congestion concentrates so heavily at the Court Bazar intersection rather than being dispersed across parallel routes, since higher node density is typically associated with more alternate routing options and therefore greater resilience to localized congestion.

The alpha index describes the connectivity and complexity of a road network system. As seen in Figure 5, Ward 29 has the lowest alpha value and Ward 11 the highest. Wards 1, 2, 7, 8, 10, 17, 19, 26, 28, 29, and 30 have low connectivity to transportation routes, influenced by their cornered geographic locations. On the contrary, Wards 11, 12, 13, 23, and 24 have higher connectivity, as proximity to major educational institutions like RUET, RU, and RMC, along with the main markets of the commercial hub Saheb-Bazar and Newmarket, has an immense impact on the extensive development of the road network.

Considering the influence of the Beta and Gamma indices demonstrating the accessibility and connectedness among the roads, Wards 1, 7, 8, 26, 28, 29, and 30 have poorer conditions than Wards 11, 13, 23, and 24. Though Ward 1 has higher road density and node density, it has much lower index values. For an in-depth

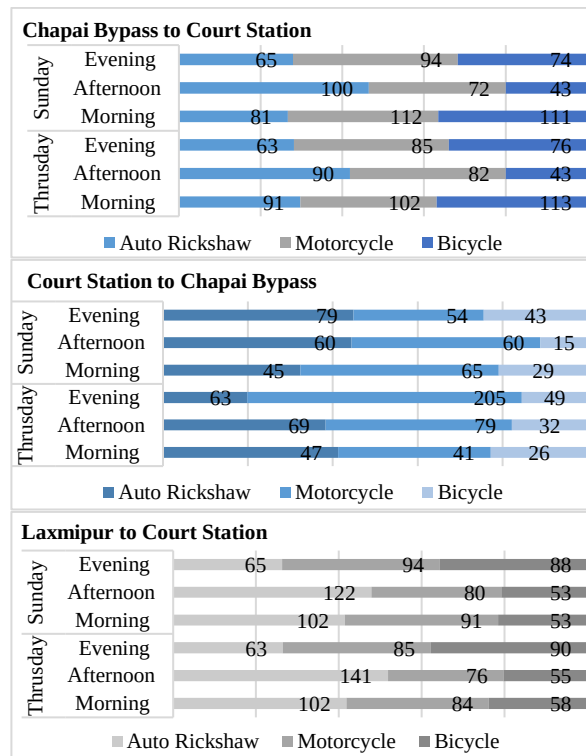
analysis of this scenario, the TVS is executed at the major intersection of Ward 1, the Court Bazar intersection, to identify the road infrastructure that needs development and to understand the vehicular pattern and peak-hour conditions.

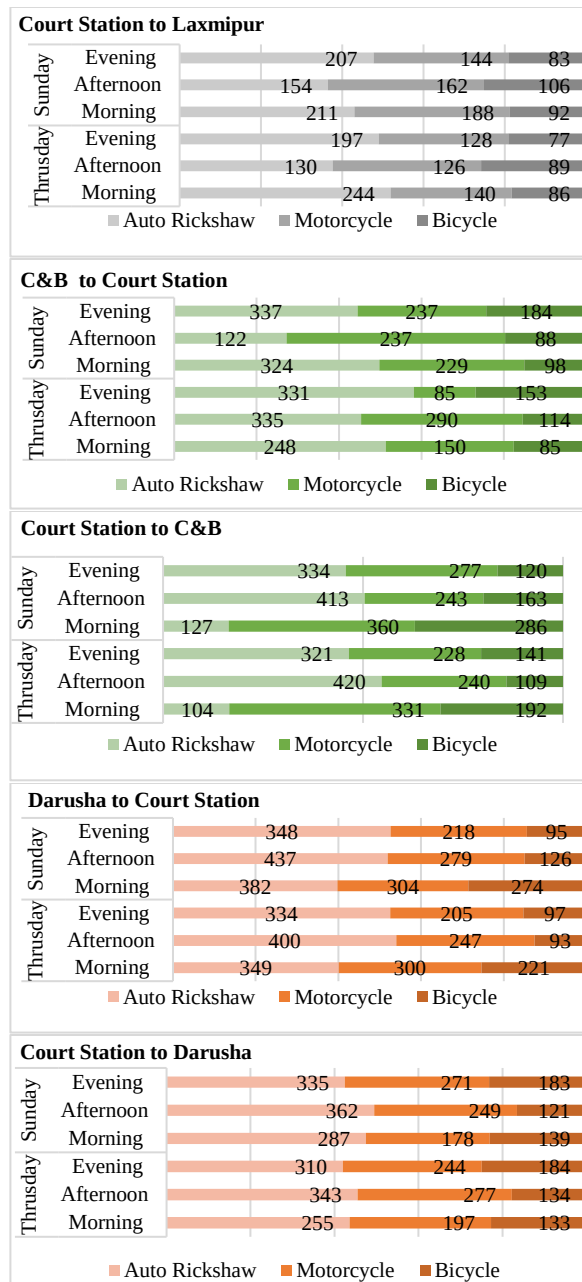
Traffic volume survey analysis at Court Bazar intersection

A traffic count survey or TVS is one of the crucial methods for finding the attributes of vehicle patterns and road network conditions. Additionally, the survey provides essential data for traffic engineering, road design, and transportation planning [5], [18]. These surveys help determine the number of vehicles passing through a section of road over a specific period, which is fundamental for assessing road capacity and performance [5].

Leading Number of Vehicles at Court Bazar Intersection

Figure 6 visualizes the leading numbers of auto-rickshaws, motorcycles, and bicycles on Thursday and Sunday across the morning, afternoon, and evening periods for all eight surveyed directions.





Source: Traffic Volume Survey, 2023

Figure 6. Leading number of vehicles at Court Bazar Intersection

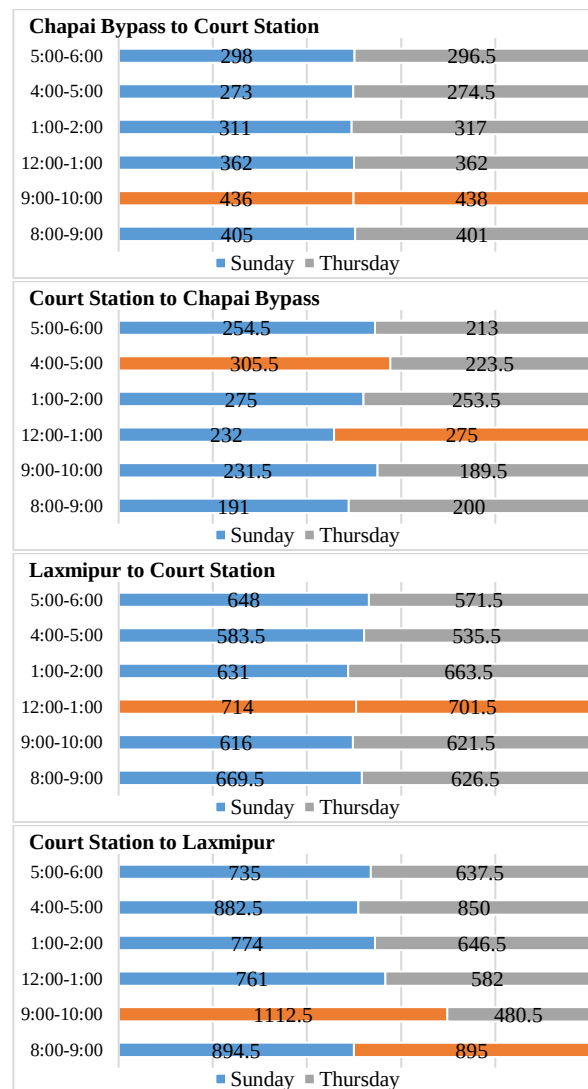
Auto-rickshaws dominate in almost all time slots, motorcycles rank second consistently, and bicycles are present in substantially smaller numbers. The highest single count recorded was 437 auto-rickshaws on the Darusha to Court Station route on Sunday afternoon, while Chapai Bypass to Court Station was the only direction where bicycles led (113, Thursday morning), consistent with laborer commuting patterns from Chapai Nawabganj. The busiest routes are therefore Darusha to Court Station and C&B to Court Station.

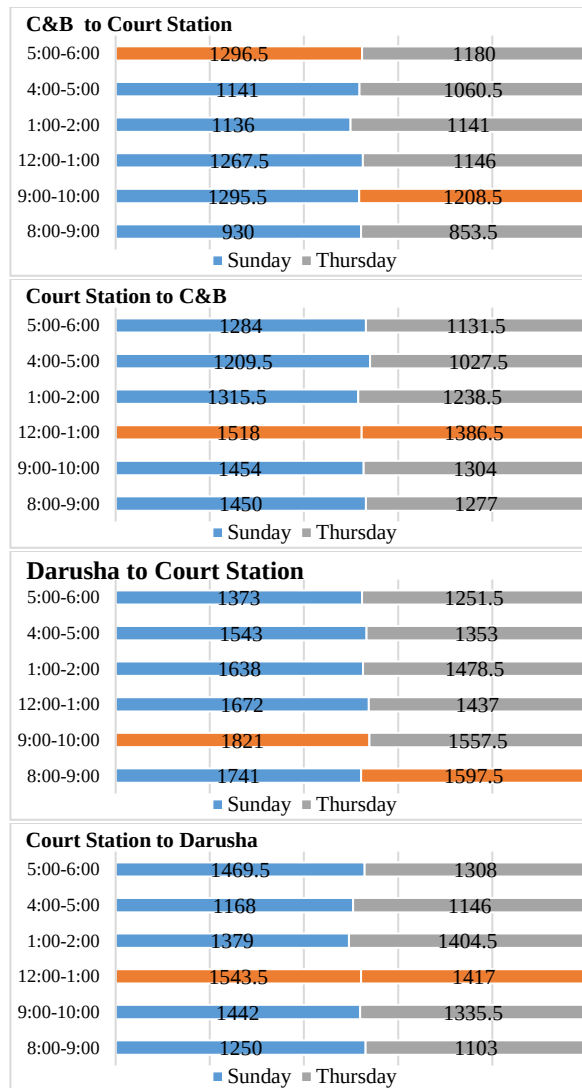
These patterns are closely associated with the surrounding land use of each corridor. The Chapai

Bypass-Court Station route records higher bicycle volumes in the morning from labourers and market vendors travelling from Chapai Nawabganj, whereas the C&B and Darusha corridors are dominated by auto-rickshaws and motorcycles because of their role as major commuter and regional routes.

Vehicle Condition (PCU/hour) at Court Bazar Intersection

There is a general rise in traffic flow on Sunday compared to Thursday across nearly every lane, with the increase most pronounced on the Darusha and C&B corridors and comparatively minor on the Chapai Bypass corridor; full lane-by-lane PCU/hr values for both days are shown in Figure 7.





Source: Traffic Volume Survey, 2023

Figure 7. PCU (Passenger Car Unit)/hour at Court Bazar Intersection

The consistently higher Sunday PCU/hr values across most lanes likely reflect regular commuting traffic combined with market- and shopping-related trips associated with Sunday's role as a working day in Bangladesh, and the pronounced increases along the Darusha and C&B corridors highlight their importance as major regional entry routes.

A paired t-test on the eight lane-level PCU/hr values (Sunday minus Thursday) presents a significant difference between the two days. The mean increase was 80.4 PCU/hr (SD = 63.9), giving $t(7) = 3.55$, $p = 0.009$, which is significant at the 0.05 level.

Level of service analysis at Court Bazar Intersection

The Level of Service (LOS) for the eight directions is summarized in Table 4, which compares the volume-to-

capacity ratio, the peak hour factor, and the speed-based result for the two survey days, Thursday and Sunday.

Table 4. LOS value of different roads at Court Bazar Intersection

Roads	LOS				
	Methods	Thursday		Sunday	
Chapai Bypass to Court Station	V/C	1.157	F	1.156	F
	Peak Hour Factor	0.118	A	0.1189	A
Laxmipur to Court Station	V/C	1.24	F	1.2873	F
	Peak Hour Factor	0.1499	A	0.1428	A
C&B to Court Station	V/C	0.7321	C	0.7856	C
	Peak Hour Factor	0.13	A	0.1267	A
Darusha to Court Station	V/C	0.6425	B	0.725	C
	Peak Hour Factor	0.1332	A	0.1312	A
Court Station to Chapai Bypass	V/C	0.754	B	0.8275	C
	Peak Hour Factor	0.1211	A	0.7615	B
Court Station to Laxmipur	V/C	1.524	F	1.7193	F
	Peak Hour Factor	0.1223	A	0.1235	A
Court Station to C&B	V/C	0.8183	D	0.9145	E
	Peak Hour Factor	0.1389	A	0.1365	A
Court Station to Darusha	V/C	0.5714	A	0.6122	B
	Peak Hour Factor	0.1424	A	0.1501	A

Note: the speed-based method returned 24.6 km/hr (LOS D) uniformly for all eight directions on both survey days.

Source: Author's Preparation, 2023

As summarized in Table 4, Chapai Bypass to Court Station, Laxmipur to Court Station, and Court Station to Laxmipur operate at LOS F on both survey days based on the V/C ratio, while C&B to Court Station, Darusha to Court Station, and Court Station to Chapai Bypass show moderate service (LOS B-D) that generally worsens slightly from Thursday to Sunday. Court Station to Darusha records the best performance, at LOS A on Thursday and B on Sunday. The uniform speed-based result of 24.6 km/h (LOS D) indicates moderate congestion across the whole intersection regardless of the direction-specific V/C result.

The persistent LOS F observed on the Chapai Bypass and Laxmipur corridors across both survey days is primarily attributable to their narrow, undivided carriageways, which limit traffic capacity under mixed traffic conditions. In contrast, the comparatively better LOS of the Darusha corridor and its return direction reflects its wider, one-way carriageway, enabling it to accommodate higher traffic volumes before reaching critical congestion levels.

These findings sit within a wider pattern already reported for Bangladeshi and other South and Southeast Asian cities. Within Rajshahi itself, an earlier survey of three unsignalized intersections likewise found LOS F conditions on the Laxmipur approach, suggesting that the congestion recorded at Court Bazar is part of a

broader city-wide pattern of intersection failure [15]. Comparable heterogeneous-traffic settings elsewhere show the same volume/capacity-based classification struggling once auto-rickshaw- and motorcycle-dominated flows exceed roughly 70-80% of total volume, as documented for Kanpur, India [16], and a similar motorcycle-dominance effect on PCU-based capacity estimates has been reported for Bogor, Indonesia [17]. This cross-city consistency indicates that the narrow, undivided carriageway problem identified here is regional rather than purely local, and that solutions tested in comparable cities may transfer to Rajshahi with limited adaptation.

5. Recommendation

The findings from the spatial analysis and TVS present intrinsic factors for the development of the overall transportation network. The strategic actions for the dependent variables, presented in Table 5, could help in the development of overall transport flow and intersection service improvement.

Table 5. Strategic actions for the traffic improvement at Court Bazar Intersection

Dependent variable	Supporting facilities	Strategic action	Responsible Agency
Improvement of Narrow Road	Smooth traffic flow in the intersection.	Reconsider the land use plan of the intersection.	RCC, RHD
Captured Road Space (Retail Shop on the Road)	Efficiency, road safety, and proper use of land.	Law enforcement according to 'Road Safety Law'.	RCC
Volume of Auto Rickshaws	Traffic quality and mode fitness control.	Integrate route rationalization for auto-rickshaws under Traffic Division monitoring.	Traffic Division (RMTP)
Designated Routes for Eco-Friendly Mode	Separate motorized and non-motorized roads.	Designate protected non-motorized lanes.	RHD, DoE, NGOs, ESDO
Traffic Signs and Digital Vertical Traffic Light	Speed limitation, stop and give-way direction, vehicle restriction.	Install standardized signage and signal control.	RMTP, RHD
Level of Service	Focus on speed, travel time, and density parameters.	Measures of Effectiveness (MOEs), Congestion Index, and Coefficient of Variation of Speed [7].	RCC Traffic Engineering Cell

Source: Author's Preparation, 2023

From the perspective of road network improvement, widening to a four-lane configuration is required at the intersection, with the width needed on each approach derived from the highest observed PCU values at peak hours for the entering and exiting directions.

6. Conclusion

The research delved into an in-depth analysis of the Rajshahi Court Station intersection and determined the various outputs of the traffic management, demonstrating the geospatial connectivity indices to justify the study area, and the three crucial methods, Volume/Capacity Ratio, Peak Hour Factor, and Speed-Based methods, assess the quality and traffic dynamics of the study area. The Alpha, Beta, and Gamma indices show connectivity in RCC is unevenly distributed among wards adjacent to major educational and commercial centres. In practical terms, an LOS F rating signifies that the intersection is functioning beyond its intended design capacity where vehicles form queues exceeding the distance that can be discharged within a single signal or gap cycle, travel speeds decline to approximately 5 km/h or less, and delays accumulate rather than diminish throughout the peak period conditions that are likely to be exacerbated as Rajshahi's motorized vehicle and auto-rickshaw fleets continue to expand at an annual rate of 8.5 – 12.6%. So, the leading transport modes- autos and auto-rickshaws highlight to consider in the modification of the traffic management system. These findings suggest that congestion at Court Bazar reflects broader connectivity deficiencies in Ward 1, indicating that intersection-level improvements alone are unlikely to alleviate traffic congestion without complementary network-level interventions. The comprehensive development approach needs to be initiated with methodical interventions for optimization and improvement of LOS to ensure smooth traffic flow and pattern in this node.

Future research could extend the TVS across multiple weeks and seasons to evaluate the consistency of the observed Thursday and Sunday traffic patterns, incorporate signal timing and pavement condition variables into the connectivity assessment to develop a composite performance index, and apply the integrated connectivity of TVS framework to other high-density, low-connectivity wards within Rajshahi City Corporation to determine whether the Court Bazar traffic characteristics are representative of the broader urban network. These strategic aims serve as the foundation of Rajshahi transportation development, which provides insights for decision-makers in forming a flawless transport network and vehicular movement at the intersection, ultimately helping the economic growth of the city corporation.

7. Limitations of the Study

This study's TVS was conducted over two single-day counts, which cannot capture seasonal variation combining monsoon season effects, festival travel, or the academic term cycles of nearby RUET and RU. The manual counting method also remains susceptible to observer fatigue and potential undercounting during peak traffic periods. Furthermore, the Alpha, Beta, and Gamma connectivity indices are exclusively structural measures derived from network topology and do not incorporate factors such as pavement condition or traffic enforcement, which can independently influence the LOS.

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