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Road Carrying Capacity Assessment of the Heterogeneous Traffic System of Kolkata

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ABSTRACT

As an important component of the urban transportation system, the urban road network plays a crucial role in urban spatial structure, urban traffic operations, and socio-economic activities. The significance of capacity analysis and traffic operations helps in identifying the traffic condition and structure in urban areas in Kolkata city. Traffic congestion is a unique situation when the number of vehicles is much greater than the road-carrying capacity. A growing urban area creates complex problems in daily life with traffic. Technologies have continued to impact society over the years, improving our standard of living and quality of life. Advances in telecommunications, the Internet of Things, cloud and edge computing, scalable storage, and data analytics have made fast computing and data-empowered insights. Road carrying capacity has been measured using speed modeling, PCU (Passenger Car Unit) method, and vehicle area occupancy method. Sinthi More, Chiria More, Shyambazer, Park Circus 7 point, Sealdah, Central Avenue, Strand Road, Maniktala, Rajabazer, Girish Park, Science city more, Panchanna Gram, Tapsia More, Minto Park, P.G.Hospital, Hestings, Golpark, Goriahat more, Kalighat, Taratala auto stand, Behala police station, Behala Chowrasta, Patuli Jheel Park, Goria sitala mandir, Green view, Ruby, Nature park, Garden reach police station, Metiabruz, Chowbaga, Ajay Nagar junction points (31survey point) have been taken for this survey. About Thirteen roads have been taken in Kolkata city to do this project. The average vehicle velocity is 19.2 km/h in Kolkata city.

INTRODUCTION

Rapid urbanization is a common phenomenon within cities across the world. The impact of urbanization can be observed on all the subsystems (physical, social, economy, environment, ecology, infrastructure, and institution of the urban system) (Pankaj et al. 2023). Smart cities are employed in various aspects of society including hospitals, offices, industries, and parking lots. The rise in traffic and the population both contribute significantly to several issues (Ali et al. 2023). The smart city phenomenon has drawn criticism. Global technology corporations have been promoting the concept of "smart cities" for the past 20 years, and their role in urban affairs is steadily expanding (Tathagata 2023).

These trends have had far-reaching impacts on different global dimensions, ranging from political dimensions to technology, and others. Among the most notable impacts are extraction and destruction, with little or replacement, and with increasing pollution, as pursuits to meet human demand continue to increase (Anarfi et al. 2020). This concept also admires the adverse effect on human social and economic life. This leads to the prospect of addressing environmental concerns, especially regarding resilience and adaptability, as noted by recent indicators and frameworks within numerous smart city frameworks (Sharifi & Yamagata 2018).

The carrying capacity concept was pioneered by Thomas Malthus in the year? Carrying capacity for any given area is not fixed, it can be altered by technology but today mostly due to the increase in population pressure, and the environment, degraded carrying capacity shrinks. Transportation system variables including road capacity and level of

services, motorist behaviors, and traffic safety are strongly influenced by motor vehicle time headway (Sukowati 2004, Minh et al. 2005, Suweda 2016). The significance of capacity analysis and traffic operations helps in identifying the traffic condition and structure in urban areas in Kolkata. This study intends to comprehend the performance structure of vehicles regarding traffic operations in urban areas in Kolkata.

This study discusses the capacity of vehicle traffic volume and traffic velocity in the context of conditions in Kolkata (Mohan Reddy et al., 2020). Road traffic congestion is an acknowledged problem worldwide. (Maparu & pandit., 2010) have estimated the delay in minutes on the different corridors of Kolkata to range from 20 minutes to about 60 minutes. This indicates that there is considerable congestion on the roads of Kolkata. Day by day the number of vehicles on the roads of Kolkata is increasing. Between 1996 and 2011, the vehicular population has doubled in Kolkata (Bhaduri. 2013). Road capacity is determined by time headway minimum value and distributions based on the relationship between capacity and traffic flow (Tawari. 2000). The traffic flow characteristics and roadway system in developing and developed countries, commonly referred to as homogeneous traffic, follows lane discipline and is composed of vehicles with not similar predominantly cars and a small proportion of trucks and other vehicles (Pooja et al. 2019). Relentless increase in population is a major problem in India. Because of the increase in population, the various modes of transportation are increased in cities which resulted in jammed traffic conditions on the road (Mir et al. 2020). A substantial increase in traffic volume and speed levels on highways is warranted much safer and secured traffic flow operational system.

Traffic on Kolkata roads is of a heterogeneous nature that incorporates wide variation in vehicles' physical and operational characteristics. Any one type of vehicle is considered to be different in comparison to any other vehicle type. PCU of a vehicle type is used as a volume count adjustment factor to account for the non-uniformity in the traffic flow stream. This problem of non-uniform traffic is resolved by converting the volume count of different types of vehicles into a common unit i.e., PCU (Passenger car unit), and thereby express traffic volume in terms of PCU/hr (Seelam & Mehat. 2017). Urban transport in third-world countries is characterized by huge traffic growth along with a shortage of adequately maintained transport facilities, traffic system inefficiency, and settlement structure thereby causing congestion.

Urban transport technology mix and misuse in these countries are reflected in the coexistence of motorized and non-motorized modes often resulting in congestion and accidents. Weak institutional support caused by a lack of coordination between national and subordinate authorities and the inadequacy of trained manpower further aggravates the problem (Gupta 2007, Aparajita et al. 2015). Vien et al. (2008) state that capacity is the major factor in the design of signalized intersections and saturation flow rate plays an important role in determining the capacity of individual approaches. In the last fifty years, Kolkata has experienced a phenomenal growth of vehicular population. While the total population increased by 1.54 times, the number of vehicles increased by more than 14.92 times within this period. Such amazing vehicular growth with simultaneous urban expansion leads to fostering the qualitative degradation of urban road conditions. Traffic intersection points of Kolkata Municipal Corporation have been selected. The combined effect of transportation and air pollution determines the vulnerability level of the select nodes. To assess this vulnerable condition, the road traffic condition and carrying capacity of Kolkata are the major factors.

METHODS

Data Collection

During the preliminary survey, it was observed that queues at the selected intersection point were and had longer lengths in the morning from 6.00 AM to 8.00 AM, mid-day 10.00 AM To 12.00 PM, and night 6.00 PM to 8.00 PM (Table 1). With the help of a primary survey, traffic volume, road length, road width, vehicle area, car velocity, and rate of traffic connections are calculated (Table 1). From about 17.2.23 to 1.4.23 the survey was conducted and every survey spot took 5 minutes to collect the above data. Up and down data has been taken through the primary survey.

Table 1. Nature of Intersection Point

Name of station	Road Name	Nature of Junction
Sinthi more	B.T. Road	4
Chiria more		4
Shyambazar		5
Taratala	Diamond Harbour Road	3
Behala police station		3
Behala chowrasta		4
Science city more	Bangaon - Kulpi Road	3
Panchanna gram		3
Ruby		4
Patuli jheel park		4
Ajoy Nagar		4
Central avenue	M.G. Road	4
Stan road		4
Green View	Raja SC Mullick Road	3
Goria Sitala Mandir	Garia Main Road	4
Nature Park	Taratala Road	3
Garden Reach	Garden Reach Road	3
Metiabruz	SA Farooquie Road	4
Chowbaga	Basanti Hwy	3
Manicktala	A. P. C. Road	4
Raja Bazar		4
Sealdah	A. J. C. Bose Road	3
Minto park		3
P.G . Hospital Rd		4
Park Circus 7 point	Park St Road	7
Heasting	Khidderpore Road	5
Goriahat more	Goriahat Road	4
Golpark		5
Girish park	Vivekananda Road	3
Tapsia more	Dr. BN Dey Road	4
Kalighat	Shyama Prasad Mukherjee Road	4

Source: Primary Survey, March 2023

Data Analysis

1. Speed Modelling

Speed is one of the important factors directly influencing mobility and LOS. PCU far a vehicle type depends upon traffic composition, total volume of the road, and physical size of the vehicle. Any change in the traffic volume or composition of the traffic stream influences the speed of individual vehicle types. Hence, the impact of the increase in traffic or replacing a vehicle by another can be witnessed directly from the traffic stream speed. This method is simple and measuring speed from the field is relatively easier. The speed of traffic is usually measured as the average speed of different vehicles. Speed modeling is determined by time again road length.

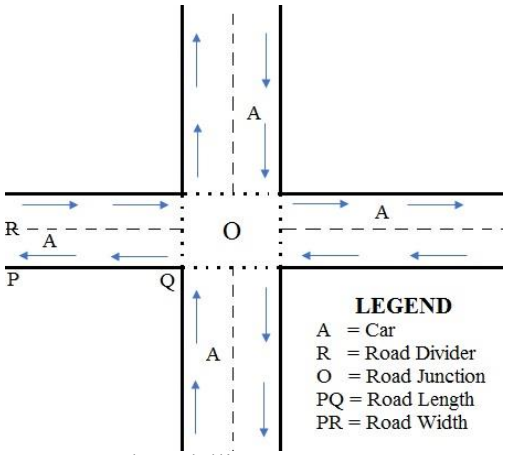

Figure 1. Speed Modelling

2. Vehicle area occupancy method

Carrying capacity estimation using area occupancy as a measure of base for different vehicle classes on multilane urban roads under mixed traffic conditions. For estimating PCUs, area occupancy proposed by Mallikar Juna and Rao (2006) is used instead of density as it does not represent the mixed traffic characteristics appropriately (Table 2).

Table 2. Area Occupancy of Vehicle

Vehicle	Length	Width	Area Occupancy
Bus	10	2.5	25
Minibus	6.8	2	13.6
Truck	9.2	2.37	21.84
4 Wheeler	4.2	1.53	6.4
Auto	3.49	1.52	4.2
Bike	1.8	0.68	1.22

Source: Primary Survey, March 2023

3. PCU Method

Data collection for saturation flow rate was conducted at the study approach several cycle times. Traffic flow was collected by the tally marks. The PCU values were evaluated using the Chandra & Kumer method. To develop a speed volume relationship and to estimate roadway capacity the observed traffic volume is altered in an identical numeral of vehicles by use of passenger car unit capacity estimation was done for 13 roads and the capacity of the road is found by speed-flow relationship in Kolkata city (Table 2 & Eq.1). In a mixed traffic situation traffic volume in terms of vehicles per hour may vary widely depending on traffic mix and different compositions may occur at the same traffic volume. Therefore, it is necessary to estimate the passenger car unit value and variation of PCU with volume and vehicle type.

PCU = (VC/VI)/(AC/AI) ----------(*Eq.1*)

Where,

PCU = *Passenger Car Unit*

VC = *Speed of Car km/h*

VI = *Speed of Any Type of Vehicle km/h*

AC = *Static Area of a Car* m^2

AI = *Static Area of Any Type of Vehicle*

RESULT AND DISCUSSION

Speed Level

Aerde and Yagar (1984), estimated PCU based on the relative rates of speed reduction for each vehicle type traveling in the ongoing direction and for all vehicles combined traveling in the opposing direction in two-lane two-way rural highways under homogeneous conditions. One of the most important determinants behind vehicular emissions is the speed of vehicles. A negative relationship between vehicle speed and pollutants from vehicular emission is present.

Table 3. Vehicle Speed Level in the Morning

STATION NAME	ROAD NAME	V_U_M_Bus	V_D_M_Bus	V_A_M_Bus	V_U_M_Truck	V_D_M_Truck	V_A_M_Truck	V_U_M_MINI-BUS	V_D_M_MINI-BUS	V_A_M_MINI-BUS	V_U_M_FOUR-WHEELER	V_D_M_FOUR-WHEELER	V_A_M_FOUR-WHEELER	V_U_M_AUTO	V_D_M_AUTO	V_A_M_AUTO	V_U_M_BIKE	V_D_M_BIKE	V_A_M_BIKE
Sinthi more		30	25	27.5	30	27	28.5				38	35	36.5				38	40	39
Chiria more		30	26	28	29	26	27.5				37	37	37				38	39	38.5
Shyambazar	B.T. Road	30	24	27	25	24	24.5				38	35	36.5				37	35	36
Taratala		34	32	33	34	32	33				49	45	47	35	29	32	40	42	41
Behala police statio		39	33	36	39	33	36				42	45	43.5	33	30	31.5	53	45	49
Behala chowrasta	Diamond Harbour Road	40	38	39	36	38	37				40	44	42	30	27	28.5	50	49	49.5
Science city more		36	37	36.5	36	37	36.5				50	52	51				52	49	50.5
Panchanna gram		33	36	34.5	33	36	34.5				52	50	51				56	50	53
Ruby		37	39	38	37	35	36				48	50	49				50	45	47.5
Patuli jheel park		40	37	38.5	40	38	39				50	48	49				49	45	47
Ajoy Nagar	Bangaon - Kulpi Road	37	39	38	38	40	39				45	45	45				49	54	51.5
Central avenew		32	29	30.5	32	29	30.5	35	30	32.5	36	40	38	30	26	28	45	42	43.5
Stan road	M.G. Road	30	24	27	26	30	28	25	30	27.5	34	30	32				44	40	42
Green View	Raja SC Mullick Road	28	26	27	28	28	28				40	38	39				40	42	41
Goria Sitala Mandir	Garia Main Road	25	22	23.5	25	24	24.5				34	25	29.5	34	29	31.5	50	42	46
Nature Park	Taratala Road	20	22	21	20	22	21				38	35	36.5				40	35	37.5
Gaden Reach	Gaden Reach Road	22	25	23.5	22	26	24				30	30	30				38	34	36
Metiabruz	SA Farooquie Road	15	10	12.5	15	12	13.5				22	20	21	20	17		25	35	30
Chowbaga	Basanti Hwy	40	31	35.5	40	38	39				49	45	47				51	45	48
Manicktala		33	30	31.5	33	30	31.5				42	38	40				49	45	47
Raja bazar	A. P. C. Road	36	32	34	36	32	34	35	30	32.5	45	42	43.5	35	33	34	50	48	49
Sealdah		26	24	25	24	24	24	30	25	27.5	30	26	28	33	26	29.5	40	35	37.5
Minto park		28	25	26.5	35	25	30				41	36	38.5				48	45	46.5
P.G .Hospital Rd	A. J. C. Bose Road	25	21	23	25	21	23				34	40	37				40	42	41
Park circus 7 point	park St Road	35	29	32	29	29	29	32	30	31	35	30	32.5	35	30	32.5	40	35	37.5
Heasting	Khidderpore Road	33	28	30.5	33	28	30.5				42	30	36				45	41	43
Goriahat more		25	21	23	25	21	23	30	28	29	35	34	34.5	35	29	32	35	30	32.5
Golpark	Goriahat Road	30	30	30	33	30	31.5	30	29	29.5	50	40	45	34	30	32	42	35	38.5
Girish park	Vivakananda Road	38	34	36	38	34	36				47	45	46				55	52	53.5
Tapsia more	Dr. BN Dey Road	38	37	37.5	40	37	38.5				50	45	47.5				50	45	47.5
Kalighat	Shyama Prasad Mukherjee Road	34	26	30	34	26	30	33	30	31.5	42	42	42	32	35	33.5	48	40	44

Source: Primary Survey, March 2023 and Author's computation

Note: V=Velocity, U=Up Direction, D=Down Direction, A=Average Velocity, M= Morning.

Table 4. Vehicle Speed Level at daytime

STATION NAME	ROAD NAME	V_U_D_ Bus	V_D_D_ Bus	V_A_D_ Bus	V_U_D_ Truck	V_D_D_ Truck	V_A_D_ Truck	V_U_D_ MINI-BUS	V_D_D_ MINI-BUS	V_A_D_ MINI-BUS	V_U_D_ FOUR-WHEELER	V_D_D_ FOUR-WHEELER	V_A_D_ FOUR-WHEELER	V_U_D_ AUTO	V_D_D_ AUTO	V_A_D_ AUTO	V_U_D_ BIKE	V_D_D_ BIKE	V_A_D_ BIKE
Sinthi more		25	17	21	27	18	22.5				26	20	23				32	26	29
Chiria more		22	18	20	25	20	22.5				26	21	23.5				30	26	28
Shyambazar	B.T. Road	14	14	14	20	13	16.5				24	20	22				25	24	24.5
Taratala		27	30	28.5	30	25	27.5				26	30	28	24	16	20	24	26	25
Behala police station		30	29	29.5	25	24	24.5				20	25	22.5	25	19	22	29	20	24.5
Behala chowrasta	Diamond Harbour Road	32	30	31	24	27	25.5				36	34	35	23	17	20	30	36	33
Science city more		24	30	27	30	32	31				34	31	32.5				35	34	34.5
Panchanna gram		25	35	30	26	35	30.5				36	29	32.5				32	36	34
Ruby		31	32	31.5	29	30	29.5				39	36	37.5				35	39	37
Patuli jheel park		32	35	33.5	30	35	32.5				31	36	33.5				35	31	33
Ajoy Nagar	Bangaon - Kulpi Road	25	30	27.5	27	25	26				29	40	34.5				35	29	32
Central avenew		22	16	19	24	22	23	17	15	16	27	25	26	21	20	20.5	24	27	25.5
Stan road	M.G. Road	12	10	11	14	15	14.5	12	10	11	19	19	19				19	19	19
Green View	Raja SC Mullick Road	22	25	23.5	20	25	22.5				28	22	25				20	28	24
Goria Sitala Mandir	Garia Main Road	10	11	10.5	10	10	10				14	12	13	13	10	11.5	15	14	14.5
Nature Park	Taratala Road	23	20	21.5	17	20	18.5				27	19	23				30	27	28.5
Gaden Reach	Gaden Reach Road	14	17	15.5	16	27	21.5				19	22	20.5				26	19	22.5
Metiabruz	SA Farooquie Road	10	10	10	10	10	10				12	12	12	12	10	11	15	12	13.5
Chowbaga	Basanti Hwy	30	27	28.5	35	27	31				26	34	30				32	26	29
Manicktala		20	17	18.5	22	20	21				25	27	26				29	25	27
Raja bazar	A. P. C. Road	20	19	19.5	24	22	23				27	28	27.5	25	23	24	28	27	27.5
Sealdah		10	10	10	10	10	10	10	12	11	15	17	16	17	15	16	17	15	16
Minto park		14	13	13.5	12	14	13				18	21	19.5				22	18	20
P.G .Hospital Rd	A. J. C. Bose Road	10	10	10	10	10	10				10	14	12				17	10	13.5
Park circus 7 point	park St Road	13	15	14	16	10	13	12	10	11	22	19	20.5	20	15	17.5	25	22	23.5
Heasting	Khidderpore Road	20	19	19.5	19	17	18				35	25	30				25	35	30
Goriahat more		12	10	11	19	16	17.5	12	10	11	16	19	17.5	17	10	13.5	18	16	17
Golpark	Goriahat Road	18	18	18	20	18	19	21	16	18.5	30	27	28.5	27	20	23.5	29	30	29.5
Girish park	Vivakananda Road	19	21	20	19	20	19.5				27	25	26				24	27	25.5
Tapsia more	Dr. BN Dey Road	30	25	27.5	25	24	24.5				35	29	32				30	35	32.5
Kalighat	Shyama Prasad Mukherjee Road	21	19	20	19	24	21.5	19	22	20.5	27	25	26	20	13	16.5	22	27	24.5

Source: Primary Survey, March 2023 and Author's computation

Note: V=Velocity, U=Up Direction, D=Down Direction, A=Average Velocity, D=Mid-Day.

Table 5. Vehicle Speed Level at Night

STATION NAME	ROAD NAME	V_U_N_ Bus	V_D_N_ Bus	V_A_N_ Bus	V_U_N_ Truck	V_D_N_ Truck	V_A_N_ Truck	V_U_N_ MINI-BUS	V_D_N_ MINI-BUS	V_A_N_ MINI-BUS	V_U_N_ FOUR-WHEELER	V_D_N_ FOUR-WHEELER	V_A_N_ FOUR-WHEELER	V_U_N_ AUTO	V_D_N_ AUTO	V_A_N_ AUTO	V_U_N_ BIKE	V_D_N_ BIKE	V_A_N_ BIKE
Sinthi more		17	25	21	18	26	22				17	26	21.5				26	32	29
Chiria more		18	22	20	20	25	22.5				21	26	23.5				26	30	28
Shyambazar	B.T. Road	14	20	17	15	20	17.5				18	26	22				24	25	24.5
Taratala		30	27	28.5	25	30	27.5				30	26	28	16	24	20	25	28	26.5
Behala police stati		29	31	30	24	25	24.5				25	20	22.5	19	25	22	20	29	24.5
Behala chowrasta	Diamond Harbour Road	30	32	31	27	24	25.5				34	36	35				27	30	28.5
Science city more		30	27	28.5	32	28	30				35	28	31.5				34	28	31
Panchanna gram		30	26	28	35	26	30.5				35	30	32.5				36	32	34
Ruby		29	31	30	27	32	29.5				36	39	37.5				35	30	32.5
Patuli jheel park		35	32	33.5	35	30	32.5				36	31	33.5				35	27	31
Ajoy Nagar	Bangaon - Kulpi Road	30	25	27.5	30	29	29.5				37	29	33				36	27	31.5
Central avenew		16	22	19	20	24	22	17	15	16	25	27	26	20	21	20.5	24	27	25.5
Stan road	M.G. Road	10	12	11	15	14	14.5	12	10	11	19	19	19				17	21	19
Green View	Raja SC Mullick Road	22	25	23.5	25	20	22.5				22	28	25				20	27	23.5
Goria Sitala Mandi	Garia Main Road	11	10	10.5	10	10	10				12	14	13	10	12	11	14	15	14.5
Nature Park	Taratala Road	20	23	21.5	20	17	18.5				20	27	23.5				25	30	27.5
Gaden Reach	Gaden Reach Road	18	13	15.5	27	16	21.5				22	25	23.5				20	26	23
Metiabruz	SA Farooquie Road	10	10	10	10	10	10				12	10	11	10	12	11	12	15	13.5
Chowbaga	Basanti Hwy	30	27	28.5	32	27	29.5				34	26	30				35	30	32.5
Manicktala		19	22	20.5	20	22	21				19	25	22				22	29	25.5
Raja bazar	A. P. C. Road	17	20	18.5	20	24	22				22	27	24.5	23	25	24	23	30	26.5
Sealdah		10	10	10	10	10	10	10	12	11	17	15	16	15	17	16	22	28	25
Minto park		13	12	12.5	14	12	13				21	18	19.5				18	22	20
P.G .Hospital Rd	A. J. C. Bose Road	10	10	10	10	10	10				14	10	12				10	17	13.5
Park circus 7 point	park St Road	13	15	14	10	16	13	12	10	11	19	22	20.5	15	20	17.5	22	27	24.5
Heasting	Khidderpore Road	19	20	19.5	17	19	18				25	35	30				23	27	25
Goriahat more		10	12	11	16	19	17.5	12	10	11	19	16	17.5	10	17	13.5	16	18	17
Golpark	Goriahat Road	16	20	18	18	20	19	21	16	18.5	27	30	28.5	20	27	23.5	25	30	27.5
Girish park	Vivakananda Road	18	20	19	20	17	18.5				25	27	26				23	30	26.5
Tapsia more	Dr. BN Dey Road	30	24	27	24	25	24.5				32	28	30				35	30	32.5
Kalighat	Shyama Prasad	19	21	20	24	19	21.5	19	22	20.5	25	27	26	13	20	16.5	22	27	24.5

Source: Primary Survey, March 2023 and Author's computation

Note: V=Velocity, U=Up Direction, D=Down Direction, A=Average Velocity, N= Night

The Average speed of the bus is approximately 27 km/h in the morning in Kolkata (Table 3). Central & West Kolkata bus speeds are slower, and North, South, and East Kolkata bus speeds are high in the morning in Kolkata (Table 3). The speed of up and down is roughly the same in the morning. The Bus speeds approximately 17 km/h on the day of Kolkata city. Towards day up direction and night down direction vehicle speeds are the same (Table 4 & 5). Towards day down direction and night up direction, vehicle speeds are the same illustrating that the speed of the vehicle is different at different intersection points. The said research work assesses the average speed of four-wheelers, Bike, Auto Truck, and Mini Bus at different intersection points. As has been pointed out earlier most of the traffic intersection point is experiencing low vehicular speed mainly due to huge traffic congestion. A traffic congestion trap has been made to show a cyclic relationship between traffic congestion and environmental quality in the city of Kolkata. Most of the busy traffic intersection points from North and South Kolkata, especially Chiriamore, Shyambazar Five Points, Science City, Sealdah, P.G. Hospital, M.G. Road, Rajabazer. Different intersection points have experienced different speeds as a result vehicular emissions also changed. On the other side, it can also be seen that increased personalized cars, improper parking systems, and mixed vehicles are the cause of traffic congestion at many intersection points such as Gariahat More, P.G. Hospital, and New Market. Low-speed two-wheelers, four-wheelers, buses, autos, and trucks have been found to be more energy-efficient than their conventional counterparts. The average speed is approximately 35 km/h in the morning in Kolkata. The average speed is approximately 20 km/h at day & night in Kolkata.

B.T Road

There is a huge difference exist in between traffic congestion during peak and normal hours. On BT Road the traffic speed is highest in the morning time. Parking places aren't available so that deepens the problem of traffic. The number of trucks on this road is high as it is the only road into north Kolkata.

Diamond Harbour Rd

Table no. 3, 4, and 5 expresses that the vehicular speed is more or less similar in the day. Similarly, several stretches of Diamond Harbour Road have Developed large craters. Some of the worst stretches that the state PWd needs to repair immediately include Behala Chowrasta, Sahkerbazar, Thakurpukur, and Tatatala intersection. Width is less on this road. The vehicle ratio of Bikes: 4 wheeler: Track : Bus: Auto is very high.

Bangaon Kulpi Road

It is difficult to drive through the bypass at night width so many lights are defunct. Eastern Metropolitan Bypass is the main communication road entering Newton, Sector-v. eastern metropolitan Bypass's width is very high and the signalling system is very good.

M.G. Road

MG Road is one of the busiest roads in north Kolkata. In the morning time, traffic congestion is not available so the vehicles take the highest speed at this time. Town planners feel that MG road needs to be 100 ft but encroachments have narrowed the width down to 15 ft near Keorapukur Bazaar and Jibonmohini Ghosh Market. Two Buses or trucks are enough to block the road. Trucks and cycle vans ferry vegetables to various south Calcutta bazaars from the market.

APC Bose & AJC Bose Road

Due to the lack of traffic congestion in the morning time, the speed of vehicles is the highest in the morning time in APC Bose & AJC Bose Road (Table 3, 4 & 5). The main problems at these intersections are vehicles moving beyond the stop line and blocking the zebra crossings and the traffic signal for pedestrians. There are many markets on the road. These two roads surround central Kolkata. There are many offices and courts around these roads. A lot of traffic is accompanied during the afternoon (Table 5).

Traffic Congestion

Kolkata has a high and dense population. A huge number of migrating people are also responsible for to increase in the population of Kolkata as well as India. Kolkata is a metropolitan city. Another reason is the cross-border migration in Bangladesh. Since the partition of India and through the Bangladesh war, migration has continued and continues because of the porous border between India and Bangladesh. But there was not enough work for such a large number of people and hence to survive these people took a hawking. Hawkers occupy a large section of road space in Kolkata. Not

only the footpaths they encroach upon the roadways also. The maximum number of vehicles is observed in the mid-day to night hours but the rate of traffic is very low in the morning time. Kolkata is most busiest metropolitan in India, so about 75% -80% of its population is engaged in non-agriculture or office activities. That's why the night shift office and late night work are very common phenomena. These updated time schedules are also reflected in the traffic system. The rate of connections is high from mid-day to night (Table 6).

Table 6. Traffic Congestion Length

Station Name	Road Name	Morning		Mid-Day		Night	
		Congestion Length (m) UP	Congestion Length (m) Down	Congestion Length (m) Up	Congestion Length (m) Down	Congestion Length (m) Up	Congestion Length (m) Down
Sinthi more	B.T. Road	11.5	20	35	92	80	30
Chiria more		15	19	50	110	93	35
Shyambazar		14	21	42	62	84	27
Taratala	Diamond Harbour Road	10	12	30	55	43	30
Behala police station		9	15	42	56	75	25
Behala chowrasta		12	15	70	62	68	38
Science city more	Bangaon - Kulpi Road	30	16	60	40	37	110
Panchanna gram		27	19	92	42	40	123
Ruby		29	17	90	62	52	44
Patuli jheel park		20	27	80	70	90	40
Ajoy Nagar		20	10	77	37	27	121
Central avenue	M.G. Road	20	21	71	34	72	45
Stan road		21	15	110	40	78	59
Green View	Raja SC Mullick Road	15	19	43	39	60	98
Goria Sitala Mandir	Garia Main Road	11	6	55	44	62	29
Nature Park	Taratala Road	20	10	20	18	30	52

Garden Reach	Garden Reach Road	10	13	41	40	20	38
Metiabruz	SA Farooquie Road	16	10	22	25	20	25
Chowbaga	Basanti Hwy	10	12	30	42	47	30
Manicktala	A. P. C. Road	9	16	55	30	43	60
Raja Bazar		10	14	40	48	50	49
Sealdah	A. J. C. Bose Road	10	12	92	38	85	40
Minto park		10	16	55	30	35	55
P.G . Hospital Rd		32	42	70	140	120	72
Park Circus 7 point	Park St Road	12	23	30	40	38	35
Heasting	Khidderpore Road	13	10	60	42	31	37
Goriahat more	Goriahat Road	10	6	20	33	20	29
Golpark		16	20	40	60	41	30
Girish park	Vivakananda Road	15	11	35	32	35	37
Tapsia more	Dr. BN Dey Road	17	10	40	28	20	65
Kalighat	Shyama Prasad Mukherjee Road	16	20	50	70	79	37

Source: Primary Survey, March 2023 and Author's computation

From the primary survey, it is clear that the M.G Road is the most congested road in the mid-day time. Mainly the congestion length is maximum in the up line while A.G.C Road holds the maximum down length congestion in the mid the day (Table 6). A.G.C Road also faces traffic congestion in up lines direction, at night, while Bangaon-Kulpi Road records the highest congestion

length in the night hours (Table 6). A.G.C Road also holds the highest traffic congestion length in up and down lines in the morning time also. This data clearly declares that the AG.C Road is no doubt a more congested area than its surroundings (Table 7). Encroachment of roads results in congestion (Chakrabarty & Gupta 2014). The traffic congestion scenario has been highlighted to show the relationship between traffic congestion and vehicle speed. Huge traffic congestion at different intersection points causes slow vehicle speed in Kolkata city. If the vehicle speed reduces different types of vehicular emissions also increase. Mostly busy traffic intersection points are-Sealdah, Shyambazer, Sciencecity More, Golpark, P.G.Hospital, Hestings, Stan Road, Behala, Rajabazer. maximum points congestion length is very high at day and night time such as Sealdah, Strand Road, Panchanna Gram, Ruby, Patuli Jheel Park, Ajoy Nagar, Chiria More, Sinthi More, P.G.Hospital Rd, Shyambazar, Kalighat. Mixed vehicular modes along with slow-moving vehicles like cycle-rickshaws, hand-pulled rickshaws, and more personalized and private cars, which has been observed in some of the traffic nodal points mostly in Science City More, Shyambazer, Ajoy Nagar (Table 6 & 7). Low road space, lack of planning of city roads, and improper time intervals can create high traffic congestion length (Table 7).

Table 7. Types of Traffic Congestion in Kolkata

Types	Features	Location
I. Simple Station on heterogeneous or homogeneous traffic	Where vehicles dive close together in the same direction or both directions (viz., up and down)	This type of traffic is observed at Sealdah, Shyambazar, Garia, Garden Reach, and Khidderpore Rd.
II. Multiple Stations on heterogenous	Where vehicles from different roads, interact at the junction point.	These types of stations have been pointed out at Park Circus Seven Points, Golepark, Behala, Central Avenue, etc. where different types of vehicles from different roads interact on a particular node.
Bottlenecks	Where lots of vehicles are trying to pass through narrow lanes.	The bottlenecks have been traced at P.G. Hospital, Sealdah, Stan Road, Garia. Green View, Central Avenue, Metiabruz, Hesttings, Mintupark, Behala, Taratala, and Chowrasta road spaces are characterized as very narrow due to the illegal encroachment by hawkers and the increasing number of vehicles day by day.
Trigger neck traffic congestion	During pick hours, if vehicles do not follow the jam itinerary and try to interfere in the narrow vehicle queue.	This type of congestion scenario has been viewed all over Kolkata, especially at Garia, Gariahat, Jadavpur, Green View, P.G.Hospital, Shyambazar, Sinthi More, Chiria More, Behala, Taratala, Mintupark.
Congestion due to unplanned traffic control	Inevitably delays occur during off-peak hour traffic due to unscientific traffic control management during peak hour.	Traffic congestion due to unscientific network control has been reported at P.G.Hospital, Goriahat, Park Circus Seven Point, Sciencecity More, Panchanna Gram, Ajay Nagor, Ruby, Tapsia More, Kalighat, Sealdah, Garden Reach, Stan Road, Behala, Chowrasta, Mintu park, Patuli Jheel park & Hestings.

Network morphological traffic congestion	Traffic congestion of the particular station reflects the average traffic congestion status for all nodes.	Congestion due to unplanned network nodes has been traced at Rajabazer, Maniktal, Goria, Goriahat, Behala, Behala Chowrasta, Taratala, Green View, Mintu Park, Central Avenue, Gaden Reach and Metiaburuz.

Source: Traffic Congestion scenario of the third world by William Vickrey (2004), Roy Chowdhury (2015) and Primary Survey, March 2023

Road Carrying Capacity

The homogenization coefficient method is the earliest method of PCU estimation and is based on the method of PCU value of a vehicle calculated by the ratio of the theoretical maximum capacity of the subject vehicle type to only passenger car. Basically, this method compares the traffic stream which contains all vehicles as passenger cars and all vehicles other than passenger cars (Seelam Srikanth 2017).

Roadway factor: Roadway factor increased lane width. According to the highway capacity manual, a lane width of 3.6 meters is considered ideal. So if the lane width is varying the lesser than 3.6 meters, obviously the capacity will be less. Width of solder: Narrow solders affect the road capacity. It reduces the effective width of the traffic lane as the vehicles travel toward the center of the pavement. Presence of intersection: Intersection restricts the vehicles from free flow and those obviously affect the capacity. Lateral clearance: Roadside wall, light post, parking cars, and signpost located closer the 1.8 meters from the edge of the traffic lane, reduce the capacity. If the lateral clearance is less than 1.8 meters, those obstacles influence the road capacity. Surface condition: Surface condition also will affect the road capacity. If the road surface condition is very poor obviously the speed will be reduced because vehicles cannot travel at high speed. Alignment: Alignment also influences the capacity, particularly the side distance, if adequate side distance is not available then it will affect the shifty as well as the capacity of the road.

Table 8. PCU Values in the Morning

Station Name	Road Name	Morning PCU Value																	
		Bus			Mini Bus			Truck			Four Wheeler			Auto			Bike		
		Up	Down	Average	Up	Down	Average	Up	Down	Average	Up	Down	Average	Up	Down	Average	Up	Down	Average
Sinthi more	B.T. Road	0.848	0.707	0.777				0.691	0.622	0.657	1.133	1.017	1.075				1.068	1.124	1.096
Chiria more		0.848	0.735	0.791				0.668	0.599	0.634	1.075	1.075	1.075				1.068	1.096	1.082
Shyambazar		0.848	0.678	0.763				0.576	0.553	0.565	1.133	1.017	1.075				1.039	0.984	1.0115
Taratala	Diamond Harbour Road	0.961	0.904	0.933				0.784	0.737	0.761	1.133	1.307	1.22	1.067	0.884	0.9755	1.124	1.18	1.152
Behala police station		1.103	0.933	1.017				0.899	0.761	0.829	1.22	1.307	1.2635	1.006	0.914	0.96	1.489	1.265	1.377
Behala chowrasta		1.131	1.074	1.103				0.829	0.876	0.852	1.162	1.278	1.22	0.914	0.823	0.8685	1.405	1.377	1.391
Science city more	Bangaon - Kulpi Road	1.018	1.046	1.032				0.829	0.853	0.841	1.453	1.511	1.482				1.461	1.377	1.419
Panchanna gram		0.933	1.018	1.003				0.761	0.829	0.795	1.511	1.453	1.482				1.573	1.405	1.489
Ruby		1.046	1.102	1.071				0.853	0.807	0.829	1.395	1.453	1.424				1.405	1.265	1.335
Patuli jheel park		1.131	1.046	1.088				0.922	0.876	0.898	1.453	1.395	1.424				1.377	1.265	1.321
Ajoy Nagar		1.046	1.102	1.074				0.876	0.992	0.898	1.307	1.307	1.307				1.377	1.517	1.447
Central avenew	M.G. Road	0.905	0.819	0.862	0.942	0.807	0.875	0.737	0.668	0.703	1.046	1.162	1.104	0.914	0.792	0.853	1.265	1.18	1.2225
Stan road		0.848	0.678	0.763	0.673	0.807	0.74	0.599	0.691	0.645	0.987	0.872	0.9295				1.236	1.124	1.18
Green View	Raja SC Mullick Road	0.792	0.735	0.763				0.645	0.645	0.645	1.162	1.104	1.133				1.124	1.18	1.152
Goria Sitala Mandir	Garia Main Road	0.706	0.622	0.664				0.576	0.553	0.565	0.987	0.726	0.8565	1.036	0.884	0.96	1.405	1.18	1.2925
Nature Park	Taratala Road	0.565	0.622	0.593				0.461	0.507	0.484	1.133	1.016	1.0745				1.124	0.984	1.054
Gaden Reach	Gaden Reach Road	0.622	0.707	0.664				0.507	0.599	0.553	0.872	0.872	0.872				1.068	0.955	1.0115
Metiabruz	SA Farooquie Road	0.424	0.282	0.353				0.346	0.277	0.311	0.639	0.581	0.61	0.609	0.518	0.5635	0.703	0.843	0.773
Chowbaga	Basanti Hwy	1.131	0.876	1.004				0.922	0.876	0.898	1.133	1.307	1.22				1.433	1.265	1.349
Manicktala	A. P. C. Road	0.933	0.848	0.89				0.761	0.691	0.726	1.22	1.133	1.1765				1.377	1.265	1.321
Raja bazar		1.018	0.905	0.961	0.942	0.807	0.875	0.829	0.738	0.784	1.307	1.22	1.2635	1.067	1.006	1.0365	1.405	1.349	1.377
Sealdah	A. J. C. Bose Road	0.735	0.678	0.706	0.807	0.673	0.74	0.553	0.553	0.553	0.872	0.755	0.8135	1.006	0.792	0.899	1.124	0.984	1.054
Minto park		0.791	0.706	0.749				0.807	0.576	0.691	1.191	1.046	1.1185				1.349	1.265	1.307
P.G .Hospital Rd		0.707	0.593	0.65				0.576	0.484	0.53	0.988	1.162	1.075				1.124	1.18	1.152
Park circus 7 point	park St Road	0.989	0.819	0.905	0.861	0.807	0.834	0.668	0.668	0.668	1.016	0.872	0.944	1.067	0.914	0.9905	1.124	0.984	1.054
Heasting	Khidderpore Road	0.933	0.792	0.862				0.761	0.645	0.703	1.22	0.872	1.046				1.265	1.152	1.2085
Goriahat more	Goriahat Road	0.707	0.593	0.65	0.807	0.753	0.78	0.567	0.484	0.53	1.016	0.987	1.0015	1.067	0.884	0.9755	0.984	0.843	0.9135
Golpark		0.848	0.848	0.848	0.807	0.78	0.794	0.761	0.691	0.726	1.453	1.162	1.3075	1.036	0.914	0.975	1.18	0.984	1.082
Girish park	Vivakananda Road	1.074	0.961	1.018				0.875	0.783	0.829	1.365	1.307	1.336				1.546	1.461	1.5035
Tapsia more	Dr. BN Dey Road	1.074	1.046	1.06				0.922	0.853	0.887	1.453	1.307	1.38				1.405	1.265	1.335
Kalighat	Shyama Prasad Mukherjee Road	0.961	0.735	0.848	0.888	0.807	0.848	0.784	0.699	0.691	1.22	1.22	1.22	0.975	1.067	1.021	1.349	1.124	1.2365

Source: Primary Survey, March 2023 and Author's computation

Table 9. PCU Values in Mid-Day

Station Name	Road Name	Day PCU Value																	
		Bus			Mini Bus			Truck			Four Wheeler			Auto			Bike		
		Up	Down	Average	Up	Down	Average	Up	Down	Average	Up	Down	Average	Up	Down	Average	Up	Down	Average
Sinthi more	B.T. Road	1.237	0.841	1.039				1.089	0.726	0.9075	1.322	0.807	1.0645				1.574	1.278	1.426
Chiria more		1.088	0.891	0.9895				1.008	0.806	0.907	1.048	0.847	0.9475				1.475	1.278	1.3765
Shyambazar		0.692	0.692	0.692				0.806	0.524	0.665	0.968	0.807	0.8875				1.229	1.18	1.2045
Taratala	Diamond Harbour Road	1.336	1.484	1.41				1.21	1.008	1.109	1.332	1.21	1.271	1.28	0.853	1.0665	1.18	1.278	1.229
Behala police station		1.484	1.435	1.4595				1.008	0.968	0.988	0.806	1.008	0.907	1.333	1.013	1.173	1.426	0.985	1.2055
Behala chowrasta		1.583	1.484	1.5335				0.968	1.089	1.0285	1.452	1.371	1.4115	1.226	0.907	1.0665	1.475	1.77	1.6225
Science city more	Bangaon - Kulpi Road	1.187	1.484	1.3355				1.21	1.29	1.25	1.371	1.25	1.3105				1.721	1.672	1.6965
Panchanna gram		1.237	1.732	1.4845				1.048	1.411	1.2295	1.452	1.169	1.3105				1.574	1.77	1.672
Ruby		1.583	1.373	1.478				1.21	1.411	1.3105	1.25	1.452	1.351				1.721	1.524	1.6225
Patuli jheel park		1.534	1.583	1.5585				1.169	1.21	1.1895	1.573	1.452	1.5125			0	1.721	1.918	1.8195
Ajoy Nagar		1.237	1.484	1.3605				1.089	1.008	1.0485	1.169	1.613	1.391				1.721	1.426	1.5735
Central avenew	M.G. Road	1.088	0.792	0.94	0.801	0.706	0.7535	0.968	0.887	0.9275	1.089	1.008	1.0485	1.12	1.067	1.0935	1.18	1.328	1.254
Stan road		0.594	0.495	0.5445	0.565	0.471	0.518	0.565	0.605	0.585	0.766	0.766	0.766				0.934	0.934	0.934
Green View	Raja SC Mullick Road	1.088	1.237	1.1625				0.806	1.008	0.907	1.129	0.887	1.008				0.984	1.377	1.1805
Goria Sitala Mandir	Garia Main Road	0.495	0.544	0.5195				0.403	0.403	0.403	0.564	0.484	0.524	0.693	0.533	0.613	0.737	0.688	0.7125
Nature Park	Taratala Road	1.138	0.989	1.0635				0.685	0.806	0.7455	1.089	0.766	0.9275				1.475	1.328	1.4015
Gaden Reach	Gaden Reach Road	0.692	0.841	0.7665				0.645	1.089	0.867	0.766	0.887	0.8265				1.278	0.934	1.106
Metiabruz	SA Farooquie Road	0.495	0.495	0.495				0.403	0.403	0.403	0.484	0.484	0.484				0.737	0.59	0.6635
Chowbaga	Basanti Hwy	1.484	1.336	1.41				1.411	1.089	1.25	1.048	1.371	1.2095				1.574	1.279	1.4265
Manicktala	A. P. C. Road	0.989	0.841	0.915				0.887	0.806	0.8465	1.008	1.089	1.0485				1.426	1.229	1.3275
Raja bazar		0.989	0.94	0.9645				0.968	0.887	0.9275	1.089	1.129	1.109	1.33	1.227	1.2785	1.377	1.328	1.3525
Sealdah	A. J. C. Bose Road	0.495	0.495	0.495	0.471	0.565	0.518	0.403	0.403	0.403	0.605	0.686	0.6455	0.907	0.8	0.8535	0.836	0.738	0.787
Minto park		0.692	0.643	0.6675				0.484	0.565	0.5245	0.726	0.847	0.7865				1.082	0.885	0.9835
P.G .Hospital Rd		0.495	0.498	0.4965				0.403	0.403	0.403	0.403	0.565	0.484				0.836	0.492	0.664
Park circus 7 point	park St Road	0.643	0.742	0.6925	0.565	0.471	0.518	0.645	0.403	0.524	0.887	0.766	0.8265	1.067	0.8	0.9335	1.229	1.082	1.1555
Heasting	Khidderpore Road	0.989	0.94	0.9645				0.766	0.686	0.726	1.442	1.008	1.225				1.229	1.721	1.475
Goriahat more	Goriahat Road	0.594	0.495	0.5445	0.565	0.471	0.518	0.766	0.645	0.7055	0.645	0.766	0.7055	0.906	0.533	0.7195	0.885	0.787	0.836
Golpark		0.891	0.891	0.891	0.989	0.753	0.871	0.806	0.726	0.766	1.21	1.089	1.1495	1.44	1.067	1.2535	1.426	1.475	1.4505
Girish park	Vivakananda Road	0.94	0.989	0.9645				0.766	0.806	0.786	1.089	1.008	1.0485				1.18	1.328	1.254
Tapsia more	Dr. BN Dey Road	1.484	1.237	1.3605				1.008	0.968	0.988	1.442	1.169	1.3055				1.475	1.721	1.598
Kalighat	Shyama Prasad Mukherjee Road	1.039	0.94	0.9895	0.894	1.036	0.965	0.766	0.968	0.867	1.089	1.008	1.0485	1.067	0.693	0.88	1.082	1.328	1.205

Source: Primary Survey, March 2023 and Author's computation

Table 10. PCU Values at Night

Station Name	Road Name	Night PCU Value																	
		Bus			Mini Bus			Truck			Four Wheeler			Auto			Bike		
		Up	Down	Average	Up	Down	Average	Up	Down	Average	Up	Down	Average	Up	Down	Average	Up	Down	Average
Sinthi more	B.T. Road	0.801	1.178	0.9895				0.691	0.997	0.844	0.823	1.259	1.041				1.217	1.499	1.358
Chiria more		0.848	1.036	0.942				0.768	0.96	0.864	1.017	1.259	1.138				1.217	1.405	1.311
Shyambazar		0.659	0.942	0.8005				0.576	0.768	0.672	0.872	1.259	1.0655				1.124	1.171	1.1475
Taratala	Diamond Harbour Road	1.414	1.272	1.343				0.96	1.152	1.056	1.453	1.259	1.356	0.812	1.219	1.0155	1.171	1.311	1.241
Behala police station		1.366	1.46	1.413				0.922	0.96	0.941	1.211	0.968	1.0895	0.965	1.269	1.117	0.937	1.358	1.1475
Behala chowrasta		1.414	1.508	1.461				1.037	0.922	0.9795	1.646	1.743	1.6945				1.265	1.405	1.335
Science city more	Bangaon - Kulpi Road	1.414	1.272	1.343				1.229	1.075	1.152	1.695	1.355	1.525				1.592	1.311	1.4515
Panchanna gram		1.414	1.225	1.3195				1.344	0.999	1.1715	1.695	1.452	1.5735				1.686	1.499	1.5925
Ruby		1.649	1.507	1.578				1.344	1.152	1.248	1.743	1.501	1.622				1.639	1.311	1.475
Patuli jheel park		1.366	1.46	1.413				1.037	1.229	1.133	1.743	1.888	1.8155				1.639	1.405	1.522
Ajoy Nagar		1.414	1.178	1.296				1.152	1.114	1.133	1.792	1.404	1.598				1.686	1.311	1.4985
Central avenew	M.G. Road	0.754	1.036	0.895	0.801	0.707	0.754	0.768	0.992	0.88	1.211	1.307	1.259	1.015	1.066	1.0405	1.124	1.265	1.1945
Stan road		0.471	0.565	0.518	0.565	0.448	0.5065	0.576	0.538	0.557	0.92	0.92	0.92				0.796	0.984	0.89
Green View	Raja SC Mullick Road	1.037	1.178	1.1075				0.96	0.691	0.8255	1.065	1.355	1.21				0.936	1.311	1.1235
Goria Sitala Mandir	Garia Main Road	0.518	0.471	0.4945				0.384	0.384	0.384	0.581	0.677	0.629	0.507	0.609	0.558	0.656	0.702	0.697
Nature Park	Taratala Road	0.942	1.083	1.0125				0.768	0.653	0.7105	0.968	1.307	1.1375				1.171	1.405	1.288
Gaden Reach	Gaden Reach Road	0.848	0.613	0.7305				1.073	0.615	0.844	1.065	1.211	1.138				0.659	1.218	0.9385
Metiabruz	SA Farooquie Road	0.471	0.471	0.471				0.384	0.384	0.384	0.581	0.484	0.5325	0.507	0.609	0.558	0.562	0.702	0.632
Chowbaga	Basanti Hwy	1.414	1.272	1.343				1.229	1.037	1.133	1.646	1.259	1.4525				1.639	1.405	1.522
Manicktala	A. P. C. Road	0.895	1.036	0.9655				0.768	0.845	0.8065	0.92	1.211	1.0655				1.03	1.358	1.194
Raja bazar		0.81	0.942	0.876				0.768	0.922	0.845	1.065	1.307	1.186	1.168	1.269	1.2185	1.077	1.405	1.241
Sealdah	A. J. C. Bose Road	0.471	0.471	0.471	0.448	0.538	0.493	0.384	0.384	0.384	0.823	0.726	0.7745	0.762	0.863	0.8125	1.03	1.311	1.1705
Minto park		0.613	0.565	0.589				0.538	0.461	0.4995	1.016	0.872	0.944				0.843	1.03	0.9365
P.G .Hospital Rd		0.471	0.471	0.471				0.384	0.384	0.384	0.677	0.484	0.5805				0.468	0.796	0.632
Park circus 7 point	park St Road	0.613	0.706	0.6595	0.538	0.448	0.493	0.384	0.615	0.4995	0.92	1.065	0.9925	0.762	1.016	0.889	1.03	1.265	1.1475
Heasting	Khidderpore Road	0.895	0.942	0.9185				0.653	0.691	0.672	1.211	1.694	1.4525				1.077	1.265	1.171
Goriahat more	Goriahat Road	0.471	0.565	0.518	0.538	0.448	0.493	0.615	0.691	0.653	0.92	0.775	0.8475	0.507	0.863	0.685	0.749	0.843	0.796
Golpark		0.754	0.942	0.848	0.989	0.754	0.8715	0.691	0.768	0.7295	1.307	1.452	1.3795	1.016	1.371	1.1935	1.171	1.405	1.288
Girish park	Vivakananda Road	0.848	0.942	0.895				0.768	0.653	0.7105	1.211	1.307	1.259				1.077	1.405	1.241
Tapsia more	Dr. BN Dey Road	1.414	1.131	1.2725				0.922	0.96	0.941	1.549	1.355	1.452				1.639	1.405	1.522
Kalighat	Shyama Prasad Mukherjee Road	0.895	0.989	0.942	0.895	1.036	0.9655	0.922	0.691	0.8065	1.211	1.307	1.259	0.66	1.016	0.838	1.03	1.265	1.1475

Source: Primary Survey, March 2023 and Author's computation

Field data collected at the study section in Kolkata is used for the estimation of PCU from the most popular methods given in the literature (Tables 8, 9 & 10). PCU values of different vehicles are estimated as the product of speed factor, and area factor (Table 2, 3, 4 & 5). From this computation, it follows that the PCU value is lowest in the morning in Metiabruz because there are many factories in west Kolkata (Table 8). A high congestion zone is seen in the morning, with a large number of heavy vehicles moving in the city of Kolkata (Tables 8 & 9). PCU value is almost the same during the day and night for heavy vehicles, but the PCU value increases a little at midnight (Tables 9 & 10). PCU value is closely related to congestion length. Traffic congestion at various intersection points slows PCU value. The above computation illustrates a relation between traffic congestion and PCU value at different time intervals. From the said computation (Table 8, 9 & 10), it has been marked that there was a negative and positive relationship between the two variables. This implies that the main reason behind the decrease in the speed of the vehicle is the traffic congestion. Most of the busy traffic intersection points in Kolkata are badly affected by huge traffic congestion during peak hours. As a result, the speed of the vehicles is decreasing and the level of emission is increasing (Tables 3 & 8). PCU value is closely related to vehicle velocity (Table 4 & 9). PCU value is a very important indicator for road vulnerability measurement. For example, the relationship between vehicle velocity and PCU value is significant in the morning, day, and night (Tables 8, 9 & 10).

CONCLUSION

Kolkata's smart city plan exemplifies a technology-enabled road map for a big city-sized, toward people-centric planning with a strong focus on social sustainability. At the end of this project, it can be concluded that every developing country has a challenge to reduce traffic congestion. There has been rapid urbanization in the city which has led to an increase in demand for mobility. Public transport has not been able to satisfy the transportation needs of the population leading to a rise in vehicle ownership. The huge numbers of private vehicles, heterogeneous traffic, and limited road space have led to the problem of congestion. In the contemporary situation where people are thinking about a Green City with a sustainable transport system, Kolkata is still lagging. In this crucial period of environmental crunch, PCU value, and vehicle growth at different traffic intersection points. If the process of urbanization keeps well the congestion should be less. If different measures are taken then the traffic speed would improve in the future and consequence, the emission level in the city of Kolkata would have been lowered. The main outcome of the study is to obtain a set of values that can be used for the calculation of traffic capacity.

This paper demonstrates the dynamic value of PCU on Kolkata highways with a heterogeneous nature of traffic. With the help of car velocity & PCU value, we can predict the impact of any vehicle on the traffic stream. Speed Modelling is calculated (Chandra & Kumer Method). PCU values are calculated by the Chandra & Kumer method. The study shows that car velocity & PCU values vary with traffic composition and total traffic count. In India, the static values of PCU are considered which is not reliable for the traffic data analysis. As we can see the PCU values estimated are not the same as those given by the Road Carrying Capacity Manual. In modern times various are running on the roads to India which requires more category of vehicles in Road Carrying Capacity. PCU values change from one location to another location. The traffic mix derived from this study shows that there are as many motorcycles in the traffic stream as there are cars/taxis. Most motorcyclists stop ahead of the intersection stop line because no proper demarcation has been made for than at all intersection points. Passenger car units (PCU) have been derived for the mixed traffic conditions in the Kolkata metropolis. This should be confirmed and adopted for design. The passenger car unit values (PCU) obtained wear not the same at the various intersections, therefore it can be concluded that unified PCU values for different vehicles do not hold well for non-lane based traffic conditions. Even in low-traffic areas, the larger PCU values of slow-moving vehicles mean that we need to provide a separate way for slow-moving vehicles. Road width should be increased, traffic signals should be improved, illegal parking should be removed, and Kolkata roads should be made one-way.

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