Impact of Accessibility on Mobility and Socioeconomic Levels of Slum Dwellers of Kolkata

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1 Introduction

Transport impact significantly on the well-being of individuals and communities as lack of suitable and affordable transportation can marginalize different groups within society by creating barriers to access to various urban facilities [1, 2]. While Indian cities are major contributors to country's (nearly 70% share in the Gross National Product (GNP) of the country), urban poor (nearly 50% of the city's population) can gain access to urban facilities (i.e., source of income, health, and educational institutions) by investing immense physical effort and long travel time [3, 4]. Urban poor encounters a complex trade-off among residential location, travel distance, and travel mode, intending to minimize the social exclusion resulting from low earning potential [5]. Besides, the growth of motorization impacts urban poor well-being directly (e.g., increase of travel time and travel cost to workplaces travel time) and indirectly (e.g., inadequate access to public transport, low priority to infrastructure planning for non-motorized transportation, biases in investment, and regulatory policies) [6, 7]. Thus, general urban mobility policies without inclusion of urban poor targeted mobility strategies aiming to address transport inequity would result in no benefits to the poor [8–14]. Due to lack of narratives regarding urban poor, the master plans or city development plans have very little emphasis to address the mobility issues of urban poor specifically through more rationale location of job centers in proximity to

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their residential areas. In addition, narrow range of researches on how limited accessibility and mobility can result in decreased quality of life and well-being of urban poor especially in developing country like India fails to give insight into application of appropriate inclusive transportation planning interventions. In this context, this research would be helpful for evolving scientific slum specific planning strategies and special schemes focusing on improvement of mobility of urban poor using the concept of accessibility.

2 Methodology

A four-phase methodology has been adopted in this research to assess the impact of accessibility on the socioeconomic condition of urban poor. This paper is based on an empirical study conducted on slum dwellers Kolkata. The study based on surveys of 200 slum dwellers spread over eight slums has analyzed socioeconomic characteristics and mobility pattern of urban poor in case of slums in Kolkata. In the second phase, descriptive statistical analysis has been conducted to give an overview regarding socioeconomic condition of slums. In the third phase, accessibility of those slums have been assessed based on three types of accessibility indexes such as transport accessibility index, public transport accessibility index, and Hansen's access to employment opportunity index.

Transport accessibility index reflects the walking time from the point-of-interest to the transport access point, the reliability of the service modes available, the number of services available within the catchment, and the level of service at the public transport access points, i.e., average waiting time. It has been calculated for all mode separately which includes access time and waiting time for mode [15].

$$\text{Total Access Time} = \text{Walk Time} + \text{Average Waiting Time}. \tag{1}$$

For each selected route, the scheduled waiting time (SWT) is calculated. This is estimated as half the headway (i.e., the interval between services).

$$\text{SWT} = 0.5 * (60/\text{Frequency}). \tag{2}$$

The access time is converted to an equivalent doorstep frequency (EDF).

$$\text{EDF} = 30/\text{Total Access Time (minutes)}. \tag{3}$$

Thus, for a single transport mode, the AIs can be calculated using the following formula:

$$\text{AImode} = \text{EDFmax} + (0.5 * \text{All other EDFs}). \tag{4}$$

Calculating the overall accessibility index is a sum of the individual AIs over all modes:

$$\text{AIpoi} = \Sigma(\text{AImode } 1 + \text{AImode } 2 + \text{AImode } 3 \cdots \text{ AImode } n). \quad (5)$$

The measure does not include the speed or utility of accessible services, crowding, the ability to board services, and ease of interchange.

Public transport accessibility index X_j of zone j is defined as: $X_j = \sqrt{(N_{ij}/A_j)}$, where N_{ij} is off-peak frequency of route I passing through zone j and A_j is an area of zone j. Hansen's access to employment opportunity index provides accessibility to various employment opportunities in an urban area [16]. It is calculated on the basis of a number of formal job opportunities and distance from slum location to the job locations. It is calculated as follows:

$$\epsilon E_j / D_{ij}. \quad (6)$$

where E_j is a number of jobs and D_{ij} is the distance from zone i (slum location) to zone j (job location) and only formal job opportunities are included for index calculation.

After calculating three types of accessibility index value for eight slums, the impact of accessibility on socioeconomic condition has been assessed. This analysis has aimed to given an insight to conclude among three types of accessibility which one is the more impactful for determination of quality of life. Finally, the paper has been concluded with the highlights on the assumptions and limitations of this research.

3 Case Study Profile

The study area is the Kolkata Metropolitan Corporation Area (KMC) which has an area of 1875 km^2 with a population of 4.58 million people at a density of 7978 persons per km^2 and comprising 141 wards. One third of Kolkata's population lives in approximately 7000 notified and un-notified slums in Kolkata Metropolitan Areas and 1236 notified slums within KMC. A wide range of modal alternatives starting from old transportation systems (e.g., trams, ferries, hand-driven rickshaws, circular rail, especially found in inner city) to advanced transportation systems (e.g., e-rickshaw, public bicycle sharing, OLA/UBER, and taxi) is available in this city along with other common public transportation system and paratransits (e.g., bus, train, metro, shared auto, and rickshaw).

4 Database

For the study, a sample of 200 slum dwellers from eight slums in the city was chosen considering various factors like accessibility to transit services, geographically location, and access to work centers and local shopping areas besides other social infrastructure facilities such as health centers, schools, and community halls (Fig. 1). The city of Kolkata has an estimated 33% of its population inhabited by slum dwellers. The case slums in the city were selected considering factors like accessibility to transit services, geographically location, and access to work centers and local shopping areas besides other social infrastructure facilities such as health centers, schools, and community halls. Households were selected randomly to perform household survey in each selected slum to collect household and individual level socioeconomic characteristics and trip details for a representative day of the week. In addition, bus stop boarding alighting survey was performed at the nearest bus stop of household survey locations which helped in computing public transport accessibility index (readers are requested to refer Nayak and Gupta [17] for further insights).

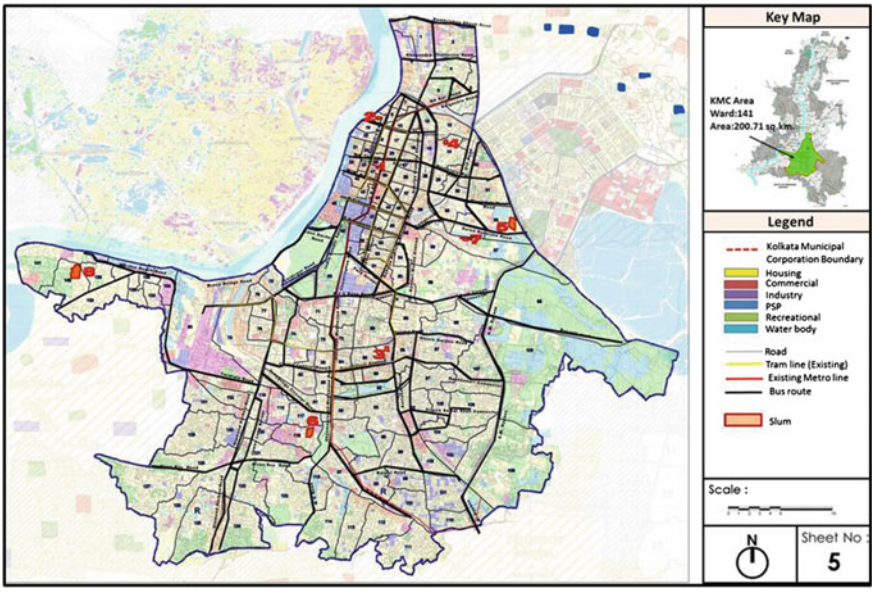

Fig. 1 Location of selected slums for survey

5 Socioeconomic Characteristics and Mobility Pattern of Case Slum Dweller

Eight case slums from KMC area have been selected for this research which are located in three different areas with the different socioeconomic pattern. While three slums are located in the inner area (Zajaria road slum, Garcha road slum, and Gossain para basti) which is old CBD area of Kolkata, two are located in the middle area (Suren Sarkar street and Jojbagan basti) and three are in outer area (Ghol para basti, Tangra, and Ayub nagar basti) which is relatively undeveloped low-density outskirts area, respectively.

From the descriptive statistical analysis (Fig. 2), it is observed that the ratio of male–female is almost same in all the three areas slums, but literacy rate decreases in slums which are located at outer areas in comparison with inner area slums. Further, it has been observed that per capita income and the number of earners in family decreased in slum dwellers residing away from the city center in comparison with inner area slum dwellers, while the expenditure on transport is higher in outer area slums compared to inner area slums owing to inaccessibility factors. In terms of

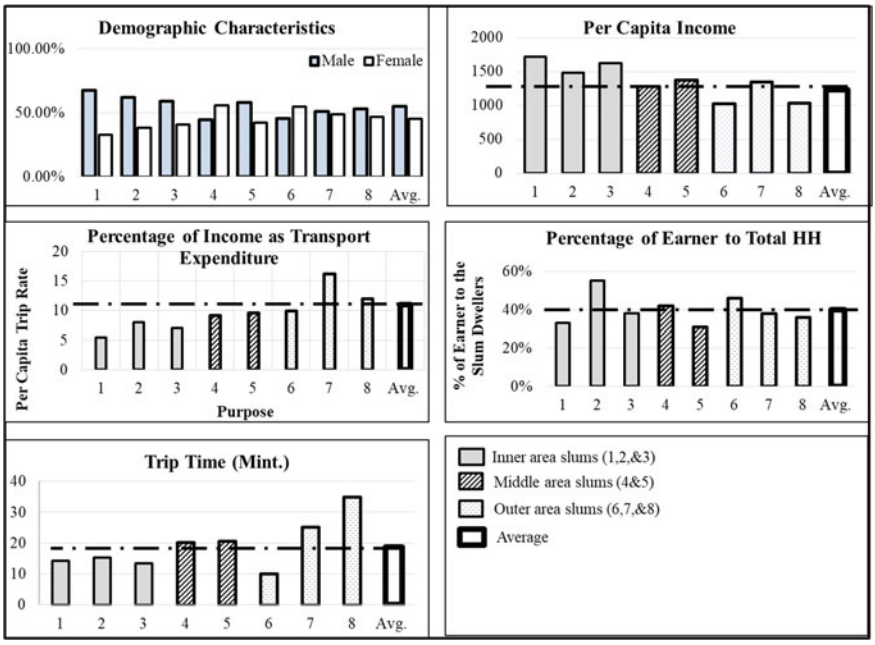

Fig. 2 Socioeconomic and mobility characteristics of slum dwellers

mobility pattern, it has been found that per capita trip rate decreases in slums located away from the city center, while the trip length and travel time increase for outer area slums. For three areas, poor people mainly commute by walk followed by bus. Among three areas in the inner area, the percentage of slum dwellers commute on foot is higher since facilities and job centers are located within walking distance, and in most of part of the inner area, cycle is banned, so walk is an only suitable option for poor. In middle and outer areas where the cycles are allowed, nearly 10 and 6% of slums dwellers use cycle, respectively.

6 Assessment of Accessibility Levels

In order to assess the accessibility levels of different slums and its impact on socioeconomic condition and empowerment of slum dwellers, three types of accessibility indices are chosen such as overall transport accessibility index, public transport accessibility index, and Hansen's access to employment opportunity index, respectively. Based on the cited accessibility indices, the impacts of accessibility indices on socioeconomic and mobility pattern of slum dwellers have been analyzed in this section.

6.1 Transport Accessibility Index

Transport accessibility index reflects walking time from the point-of-interest to the transport access point, the reliability of the service modes available, the number of services available within the catchment, and the level of service at the public transport access points—i.e., average waiting time. It has been calculated for all modes separately which include access time and waiting time for mode. Depending on this index value (Table 1), case slums are categorized into a good, moderate, and poor accessible category, and accordingly slum no 1to 3 are under good accessibility, 4 and 5 moderate, while 6 to 8 have poor accessibility levels, respectively. From the spatial distribution (Fig. 3) of the slums, it can be concluded that as the slums are located away from the core of the city transportation accessibility has been decreased.

6.2 Public Transport Accessibility

As poor people mostly use bus to commuter longer distances, the assessment of public transportation accessibility separately is important. Zajaria Slum (Slum 1) which is located in the inner zone has the highest accessibility, while Ayub Nagar Basti, located at outskirts, has the lowest accessibility (Table 1). It is observed that with the increase in transport accessibility and public transport accessibility, the

Table 1 Accessibility levels of case slum dwellers

Range of Index	Map colour	Description	Slums	Off-peak frequency of routes passing through	Area (sq.km.) (A)	PT Accessibility Index	Slum No	Employment Index
Transport accessibility index				**Public transport accessibility index**				**Hansen's access to employment opportunity index**
0.01 –2.5		Very poor	6,7 and 8	19	0.28	8.23	1	1,38,292
2.51– 5.00		Very poor		3	0.5	2.45	2	1,08,979
5.01– 10.00		Poor		5	0.28	4.23	3	89,228
10.01– 15.00		Mode rate	4 and 5	19	8.04	1.54	4	83,972
15.01– 20.00		Good	1, 2, 3	10	0.5	4.47	5	56,051
20.01– 25.00		Very good		1	3.14	0.56	6	52,239
25.01– 40.00		Excell ent		2	3.14	0.79	7	31,504
40.01+		Excell ent		2	18.1	0.33	8	12,106

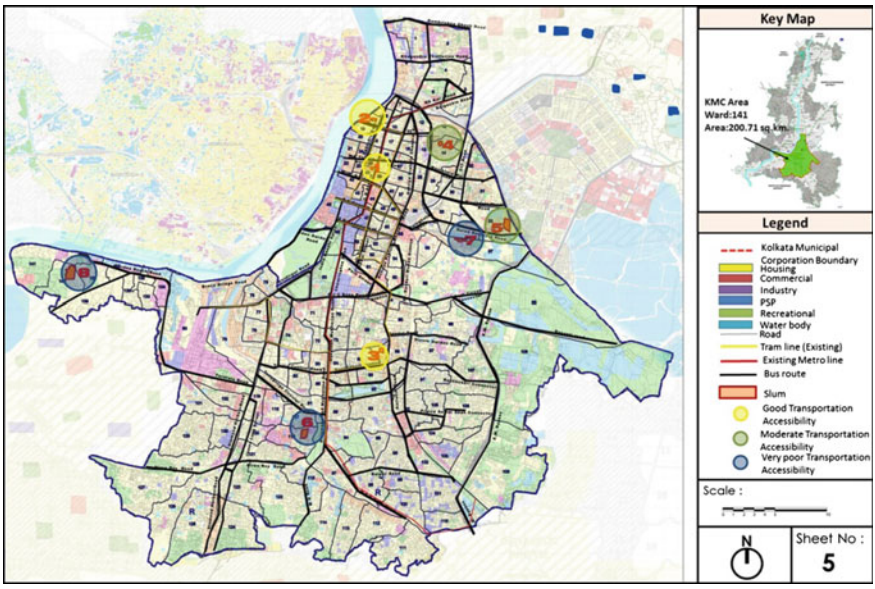

Fig. 3 Spatial distribution of transportation accessibility

average travel time and waiting time decrease, while per capita trip rate increases (Fig. 4). Also, people from good accessible areas can travel a longer distance and access to an area with more job opportunities which results in an increase of workers in the formal sector, higher per capita monthly income with reduced transportation expenditure, thus resulting in increased savings.

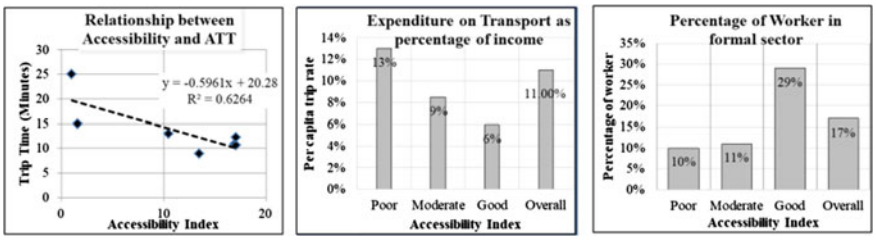

Fig. 4 Impact of transportation accessibility and public transport accessibility on socioeconomic and mobility of slum dwellers

6.3 Hansen's Access to Employment Opportunity Index

Hansen's access to employment opportunity index provides the accessibility to various employment opportunities. It is calculated on the basis of a number of formal job opportunities and distance from slum location to the job location. The access to employment opportunity calculation procedure for slum 1 is given in Table 2.

It is observed that the average monthly per capita income increases with the increase of access to employment opportunity using Hansen's accessibility index formula. As a result, with improved income and reduced trip expenditure, the household savings increases which help to improve the quality of life of slum dweller reflected by an increase of child literacy rates, a decrease of child labor rate, and increase of a number of people involved in formal secure jobs. In all the regression equations, the high R-square value (> 0.6) and robust sign and small constant value have established good statistical fit (Fig. 5).

It is further observed that (Table 3) when both transport accessibility index and employment opportunity indexes both are high, then the income of slum dwellers is highest (slum number 1–3). The average monthly savings of slum dwellers residing

Table 2 Hansen's accessibility index calculation for Slum 1

Job location	No. of jobs	Distance (Km)	Hansen's employment index
45 (B.B.D. Bag)	26,562	2.2	12,074.07
46 (Esplanade)	22,500	2	11,250
47 (chadni)	35,000	1	35,000
150 (Saltlake)	24,300	17.4	1396.55
Within Ward	55,000	0.7	78,571.42

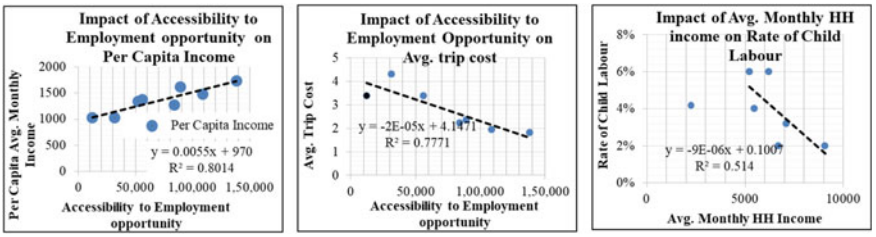

Fig. 5 Impact of Hansen's accessibility to employment's opportunity index on socioeconomic and mobility of slum dwellers

Table 3 Impact of transport accessibility and access to the job opportunity on slum dwellers

Slum no.	No. of inhabitants	Transport accessibility index	Accessibility to employment opportunity index	ATL (Km.)	ATT (Mint.)	Per capita income	Avg. monthly savings /head
1	505	17.06	138292	6.03	29.53	1731	401
2	330	17.04	108979	4.70	42.52	1479	183
3	3137	16.96	89228	2.85	25.06	1621	226
4	1264	10.2	83972	5.42	49.32	1343	82.5
5	1340	13.5	56051	7.18	42.78	1375	89
6	2100	1.6	52239	4.83	32.23	1274	66.4
7	7298	1.1	31504	8.09	48.55	1027	10.27
8	3054	1	12106	14.68	84.66	1030	12.3

in slum number 5 which has good transport accessibility but moderate accessibility to employment opportunity is higher than slum dwellers residing in slum number 4 which has moderate transport accessibility but good accessibility to employment opportunity. The per capita average monthly savings is more sensitive with transport accessibility than accessibility to employment opportunity highlighting the importance of transport accessibility.

7 Conclusion

This paper has attempted to analyze the accessibility of slum dwellers of Kolkata and its impact on their socioeconomic condition and mobility pattern. The paper using the indices of transport accessibility, public transport accessibility, and Hansen's access to employment opportunities index, respectively, brings out the impact of varying accessibility levels on the economic well-being of case slum dwellers. It is observed from the findings that an improvement of accessibility to transport, particularly especially public transport, followed by accessibility to the employment opportunity is indispensable for holistic improvement of case slum dwellers. It is concluded that transport accessibility is more sensitive with regard to economic upliftment of slum dwellers as a consequent to enhanced mobility levels in comparison with accessibility to employment opportunity. This reveals that policy planners must lay more emphasis on the enhancement of transportation accessibility as part of pro-poor mobility policies and strategies. The impact of different policies on transportation accessibility as well as quality of life of urban poor may be analyzed in future which will assist policy makers for selection of the right mix of policies. This research has been limited to the slum dwellers only. The other section of urban poor such as homeless, people lived in squatter settlements could be included. In future, this study can be extended for the other socioeconomic strata also and interface among them can be established. In addition, this study can be conducted in other cities in India for preparation of national level policy to create an inclusive travel environment.

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Appendix: Survey Questionnaire

SCHOOL OF PLANNING AND ARCHITECTURE, NEW DELHI
MASTER OF URBAN PLANNING
RESEARCH STUDY ON PLANNING FOR INCLUSIVE MOBILITY OF URBAN POOR

Household Survey

Name of the surveyor: …… Date/day: ……

Name of respondent: …… Address ……

A. Socio-economic profile (Household Level)

1. **No. of persons (HH Size):** a. 1……b.2……c.3…….d.4……..e. 5…….f. 6…….g. More than 6

2. **Duration of stay in this area**
   (a) Since Birth (b) If not since birth, then the reason for migration
   (b.1) Employment (b.2) Education (b.3) Search of employment (b.4) Others, specify

3. **When did you move to this area?** From where did you migrate (District name ……)
   (a) 0 - 2 Years (b) 2 - 5 Years (c) 5 -10 Years (d) More than 10 Years4

4. **Tenure of Housing** a. Owned b. Rent ……(Rent /Month)

5. **Monthly Household Income** …… (Rs./Month)

6. **Number of student in the household** a. 1 b.2 c.3 d.4 e. >4

7. **Number of earner in the household** a. 1 b.2 c.3 d.4 e. >4

8. **Vehicle Owned and No.** : a. Cycle ……. b.2 Wheeler…… c. cycle rickshaw……. d. Auto rickshaw……..
   e. Others (Specify)……..

9. **Monthly Household Expenditure** ……..(Rs./Month)

Sl No.	Heads	Monthly Expenditure (Rs.)
1	**Food**	
2	**Cloth**	
3	**Home**	
4	**Transport**	
5	**Health**	
6	**Others**	

10. **How much do you save?** ……(Rs./Month)
    If any savings, how do you invest your savings?
    i. bank (with an interest rate) ii. buy immovable properties iii. Invest in business
    iv.Other (please specify) ……

B. Socio- Economic Data (Personal Level)

Sl. No	Relation with Head of the family	M/F	Age	Education	Occupation	Income (Rs. /Month)
1.						
2.						
3.						
4.						
5.						
6.						
7.						

C. Trip Information:

1. O-D Survey

Person No.	Trip No.	Origin	Destination	Purpose	Mode 1	Length (Km)	Waiting time	Time of travel	Cost (Rs.)	Interchange Point	Mode 2	Length (Km)	Waiting time	Time of Travel	Cost (Rs.)
1															
2															
3															
4															
5															
6															

2. Opinion on Service on different mode used:

Sl. No.	Facility	Good	Satisfactory	Poor	Remarks
1.	**Public Transport**				
2.	Accessibility				
3.	Availability				
4.	Affordability				
5.	Safety				
6.	Comfort				
7.	Condition of Road				Kutcha:……. Pucca:…… Water loggiong:……
8.	Condition of Footpath				
9.	Connection to the city				
10.	Quality of Infrastructure				i. Shelter at bus stop a. Y…..b. N….. ii.Cycle Track a. Y……. b. N…….
11.	Availability of alternate modes				Specify:

D. Attitudinal Information:

i. **Issues: a.** …… **b.** …… **c.**…… **d.**……

ii. **Suggestions:**

……

……

E. Slum Catchment Area Study: (Community Level):

i. **Slum Size: ..... sq. m.**

ii. **Inhabitants: .....**

iii. **Year of Establishment: .....**

iv. **Road Network: a. Density.....(Km/Sq.km.) b.Pucca..... . Kutcha .....**

v. **Facilities within slum pockets:**

Sl. No.	Facility	Distance (Km.)
1.	Daily market	
2.	Shopping area	
3.	Primary School	
4.	Secondary School	
5.	Private doctor	
6.	Govt. Hospital	
7.	Private Hospital	
8.	Bank	
9.	Recreational/ Social visit	

vi. **Availability of Modes:**

Modes	Availability (Y/N)	Distance from stop (Km.)
Buses		
Cycle Rickshaw		
Auto Rickshaw		
Metro		
Rail		
Circular rail		
Tram		
Ferry		

Code:

Source of Income	Code
Industrial Labour	1
Contraction Labour	2
Rickshaw puller	3
Auto driver	4
Street vendors	5
Shop owner	6
Business man with no employee	7
Business man with employee	8
Self employed professional (Specify)	9
Maid/Servant	10
House wife	11
Student	12

Mode of Travel	Code
Walk	W
Bicycle	C
2 Wheler	2W
Auto rickshaw	A
Bus	B
Train	T
Metro	M
Ferry	F
Tram	Tr
Taxi	Ta
Own Car/Jeep/Van	J
Others car/Jeep/Van	J1
Others (Specify)	O

Purpose	Code
Work	W
Education	E
Shopping	S
Recreational	R
Health	H
Social	S
Others	specify
Origin/ Destination	**Code**
Home	**H**
Workplace	**W**
Institution	**I**
Market	**M**
Hospital	**H**
Others	**specify**

Bus-stop Survey at..... Date:.....

Sl. No.	Bus No.	Origin	Destination	Time of Arrival	Time of Departure	No. of board	No. Of Alighting	Avg. Occupancy/ Bus
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
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