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Socio Economic Factors Affecting Travel Behavior: The Case of Workers in Vatva Industrial Area of Ahmedabad

Janak Kaur Khalsa
Assistant Professor, School of Architecture, P. P. Savani University, Surat, India

***Abstract*: Sustainable transportation requires using each mode for what it does best, which typically means greater reliance on non-motorized modes, increased use of public transit, and reduction in use of private modes. Thus, mode choice is one of the most important aspects in transportation planning and policy making. Since, workers commute daily, their travel behaviour becomes crucial for transport policies. Commute trips, have significant contribution to the traffic problems of city, but similarly have a higher contribution in the daily trips of public transit services. It has thus become important to analyse the mode choice decision of commuters & achieve the desired percentage of modal share.**

Thus, the research intends to understand the present travel pattern of workers in Vatva Industrial Area of Ahmedabad, identify the factors influencing it and to what extent. The analysis infers that travel distance and vehicle ownership forms important criteria for mode choice of workers. For shorter distances, those who own vehicle use their private modes whereas, for longer distances transit services are preferred due to travel time and travel costs savings.

***Keywords*: Commute, Modal Share, Mode Choice, Sustainable**

1. Introduction

Human life is full of trade-offs. People often choose how to spend their scarce resources. The decisions thus taken by individuals reflect their options, needs and preferences. Travelling is one such activity where people can meet their transport needs by making use of one or various travel options, such as bicycle, public transport or private mode of transport.

Sustainable transportation requires using each mode for what it does best, which typically means greater reliance on non-motorized modes, increased use of public transit, and reduction in use of private modes (automobiles). Thus, choice of transport mode is one of the most important aspects in transportation planning and policy making.

2. Background & Rationale of the study

Travel behavior is a complex process and a rich area for transportation research. (Carr). It is a normal tendency of people to choose their suitable mode of travel based on their needs and available modes of transport (Dewi). The decisions made by individuals to choose their mode of travel reflect their options, needs and preferences. (Litman, Transport Elasticites: Impacts on travel Behaviour). The transportation needs can be met by making use of one or more travel modes, such as NMT, public transport or private transportation modes.

There are various factors that influence the suitability, feasibility and desirability of such transportation modes. Based on these factors, people choose their preferred option and follow a particular travel pattern. To implement transport policies effectively, it is important to understand these factors well. (Litman, Transport Elasticites: Impacts on travel Behaviour)

According to (Carr), travel behaviour is significantly influenced by personal and situational constraints, and so transport mode choice depends not only on origin, destination, and socio demographic characteristics, but also on individual's interests, motives, and intentions. Thus, there is a range of variables that determine and influence the travel behavior of an individual. There is substantial literature that studies the socio-demographic and lifestyle factors that may influence travel behaviour. The most important ones include age, gender, household composition, income, and vehicle ownership. (Curtis and Perkins)

Commute trips have a disproportionate contribution to metropolitan traffic congestion, and also a disproportionate share of trips on public transit. Transportation planners and decision makers have long focused a significant attention on journey-to-work, or commute, trips (FHWA).

Since, workers commute daily, availability of different mode choices and their travel behavior becomes crucial for transport policies. Commute trips have a disproportionate contribution to metropolitan traffic congestion, and also a disproportionate share of trips on public transit. Transportation planners and decision makers have long focused a significant attention on journey-to-work, or commute, trips.

Commute trips, although have significant contribution to the traffic contribution problems of the city, but similarly have a higher contribution in the daily trips of public transit services which in turn influence in VMT reductions. Table shows the trip distribution for different purposes in Ahmedabad, where work trips show the highest percentage followed by education, recreational and other trips.

Table 1
Trips in Ahmedabad Urban Area

Purpose	Percentage of Trips
Work	*47.16%*
Education	32.82%
Shopping/ Social / Recreation	6.68%
Other	13.34%
Total	100%

Source: (DPR, Appraisal Note, Bus Rapid Transit System, Ahmedabad phase 3)

Table 2 shows the trip distribution of BRTS users in Ahmedabad, where workers have highest and a disproportionate share of almost fifty percent followed by education, health and other trips which share another fifty percentage of trips.

So, worker's travel behaviour plays a key role to achieve the desired mode share and in turn achieve the transit system efficiency.

Table 2
BRT System Trip Purpose

Purpose	Users (%)
Work	49.8%
Education	16.8%
Health	3.0%
Shopping	1.9%
Others	28.5%
Total	100.0%

Source: Primary Survey, CUE (Mahadevia, Joshi and Datey)

Thus, urban travel demand is a complex interaction between commuters (and their characteristics), system features and land use patterns. And these three parameters are interdependent. The changing land use patterns influence the need to travel and system characteristics along with user characteristics and these changing characteristics influence the modal choice of individuals. If there is a gap between the services provided by the transportation system and service attributes valued and expected by the commuters, the system capacity remains underutilized.

It has thus become important to analyze the acceptability of the system influenced by the mode choice decision of commuters and achieve the desired percentage of modal share.

Thus, the research intends to understand the present travel pattern of workers in Vatva Industrial Area of Ahmedabad, identify the factors influencing it and estimate the dependence of this travel behavior on mode share in favour of environmental friendly modes like NMT and Mass Transit to achieve an overall goal of sustainability.

3. Aim & Objectives

A. Aim

The aim of this Research is to understand travel demand of transit services within workers which is achieved by analyzing the travel behaviour of these workers in Ahmedabad.

B. Objectives

- To study the socio economic and travel characteristics of workers in the study area and its impacts on transportation mode choice.
- To determine the factors influencing worker's mode choice & travel behaviour.

4. Methodology

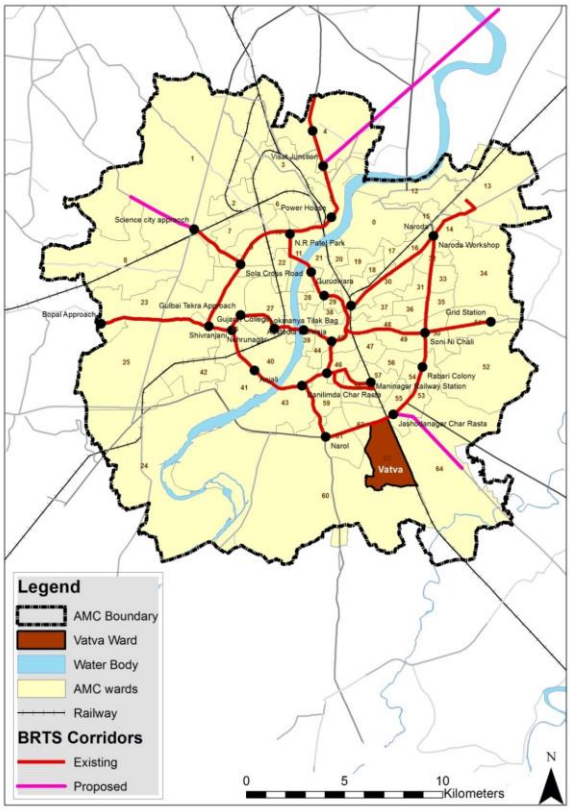
The research is a descriptive quantitative research that uses survey techniques including questionnaires to collect the information from the respondent. A deductive approach is adopted for conducting the research.

Error! Reference source not found. shows the research design, which clearly describes the approach towards achieving each objective of the research. It mentions the data required and methods of analysis for each question of a specific research objective in order to achieve the main objective of the research.

The data was collected from both primary and secondary sources. On the basis of literature and secondary data of Ahmedabad, research location for the study was identified. Here, Vatva area was selected for conduction of primary survey. The sample size was identified and primary survey was then conducted which provided a detailed understanding of travel behaviour of workers in the study area. Map 1, shows the location of the study area in Ahmedabad.

Table 3
Research Matrix

Objectives	Research Questions	Approach	Tools
To study the socio economic and travel characteristics of workers in the study area and its impacts on transportation mode choice	What is the travel pattern of workers in study area?	Study of socio economic & travel characteristics of workers in study area	Primary survey of workers
	How socio economic & travel characteristics affect the transportation mode choice of workers?	Mode choice analysis based on different class of workers	Analysis of data from primary survey
To determine the factors influencing worker's mode choice & travel behaviour	What are the factors that determine the mode choice & travel behaviour of workers and to what extent?	Mode choice analysis based on the socio economic and travel characteristics of the sample population.	Correlation, t- test, Chi square



Map 1: Location of Vatva Industrial Area
Source: AMC

A. *Sampling Strategy*

Vatva Industrial Estate (study area) has a worker population of 55160 employees in year 2011.Solvin's formula was used to determine the sample size which is as follows:

$$n = N/(1 + NR^2)$$

Where,
n = sample size
N = population size
E = Error tolerance

A confidence interval of 95% was taken for determining the sample size, which means the margin of error will be 5%.

$$n = 55160/(1 + 55160*(0.05)^2)$$

$$= 96 \sim 100$$

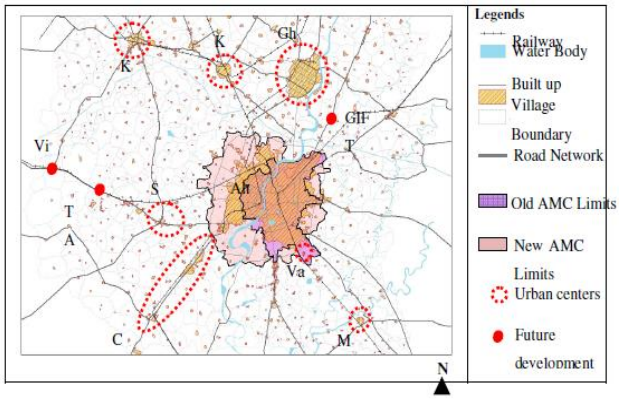
Thus, a sample size of 100 employees was selected for survey. Depending upon the characteristics required for the research, the sample was stratified on the basis of Gender and Occupation, i.e., the sample population was stratified into proportionate number of male & female and proportionate number of population involved in different occupations (laborers, staff & technicians and Manager/Owners). The Vatva Industrial area is divided into four phases and survey was conducted in all the phases. In order to assess the travel behavior of workers and its impacts of on mode choice preference of, the analysis was divided into two stages. The first stage deals with understanding the factors influencing the mode choice of the workers. It describes the profile of the workers (socio economic characteristics) influencing their mode choice preferences. The second stage deals with mode choice analysis, which describes strength of each factor. It compares accessibility of different options available to the workers and trip profile in terms of distance, cost and time taken for a trip (travel characteristic) to assess respective variations in the mode choices.

B. *Survey Area Selection*

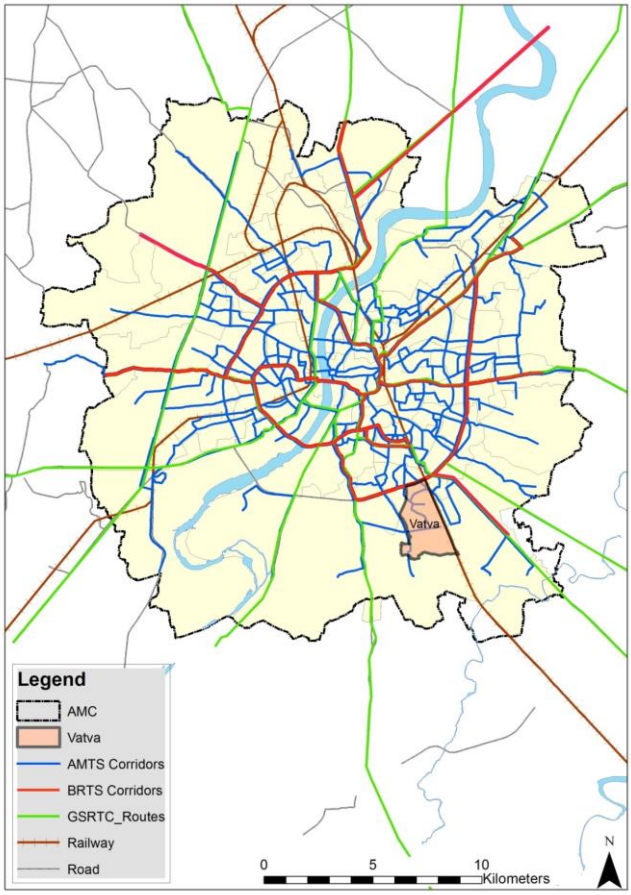
In order to analyze the travel behaviour of workers in Ahmedabad, it was required to identify an activity node where higher number of employees can be located for conduction of primary survey.

Ahmedabad presently has no Central Business District (CBD)[1] or Commercial centers located at a common point. Activities are spread all over owing to the dominant mixed and residential land uses. Since the beginning, University and Industrial areas like GIDC estates, Textile mills etc. have remained major activity centers for employees or workers in Ahmedabad. (Textile and Chemicals have been the major sectors of investment and employment in the district, since 1980. (Industries Commissionerate, Government of Gujarat). This is evident from the employment population, which is concentrated largely in these areas. Another important spatial factor that determines the travel behaviour is the mode choice availability. Thus, it was required to identify an area with widest range of choices available to the workers for their daily commute.

Hence, Vatva industrial area was selected for conduction of primary survey, which is one of the oldest and largest industrial estates in Gujarat and can be accessed by almost all modes of land transport available in the city. Apart from walking and private modes of transportation, the available modes of public transport in Vatva include AMTS, BRTS, GSRTC & regional rail.



Map 2: Urban growth centers around Ahmedabad
Source: Ahmedabad Development Plan, AUDA 2011



Map 3: Availability of Public Transport modes in Vatva
Source: Author; Data Source: AMC, 2013

5. Travel Behaviour of Workers

There are many factors affecting the mode choice decisions of commuters. Those investigated in this study are individual's profile (Age, sex, family structure), trip pattern & Characteristics (travel distance, travel time and travel cost), vehicle ownership, Accessibility to travel mode, convenience etc. Thus, Socio-economic character and the mobility of the people are closely related. In fact, both mobility and socio-economic status influence the type, frequency and intensity of their participation in activities. Individual occupation and income is the indicator of socioeconomic status. Private vehicle ownership and accessibility to public modes of transport are the indicators of mobility. Purpose of the trip defines the activity participation of an individual. Travel behavior is described by travel time and travel mode. Travel behavior is in turn governed by travel distance, private vehicle ownership and mode availability. Thus, all the factors are interlinked and affect the mode choice preferences of an individual. This chapter describes the socio-economic characteristics and the travel behavior of the sample population. The data is then analyzed to understand the travel pattern & mode choice preferences of the workers.

Influence of these parameters on mode choice decisions of workers was studied through primary survey. Table 4 given below shows the socio-economic and demographic characteristics of the sampled population and its comparison with the entire population of Vatva. It shows the relevance and representation of the sample in comparison to the total population. However, there were no data from other studies in case of vehicle ownership and income class to make comparisons in this category with the Vatva population.

Table 4
Socio-economic Characteristics of sample population

Factor	Percentage of Sample Population	Percentage with Vatva population
Gender		
Male	77.0%	70.0%
Female	23.0%	30.0%
Age		
14-30	28.0%	
30-50	66.0%	
50 +	6.0%	
Occupation		
Laborer	65.0%	70.0%
Staff & technicians	31.0%	24.0%
Manager / Owner	4.0%	6.0%
Vehicle Ownership		
4-Wheeler	7.0%	
2-Wheeler	39.0%	
Cycle	17.0%	
Others (Truck)	3.0%	
No Vehicle	34.0%	
come		
< 5000	2.0%	
5000-10000	47.0%	
10000-20000	33.0%	
20000-40000	9.0%	
>40000	4.0%	
Not known	5.0%	

A. Socio-economic profile of workers

Total number of employees in Vatva area as in year 2011 is 27721. Majority of the workers in the sample population are males (77 percent) and accordingly they have higher percentage in the target group. (Refer Figure 1). Most of the individuals belong to the category of 14 - 30 and 30 - 50 years of age group. Most respondents were between this age group was expected since this is the working age group and most of these are expected to use public transport service which indicates good data in the point of view of this research. Compared to the population of Vatva, the sampled population is a relatively good representation in terms of Age and Sex.

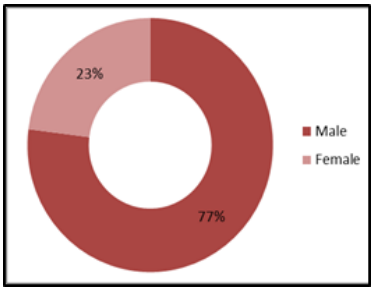


Fig. 1. Gender Composition

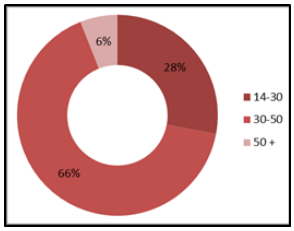


Fig. 2. Age Composition

In general an industry works with 40-50 employees. The Sample population includes workers from three major categories, namely, laborers (65%), Staff and technicians (31%) and Managers/Owners (4%) (Refer Figure 3 & Table 5).

Table 5
Employment profile of Workers

Occupation	Male	Female	Total
Laborer	45%	20%	65%
Staff & Technicians (Operators, electrician, Engineer)	28%	3%	31%
Manager/owner	4%	0%	4%

The figures relating to the vehicle ownership by workers is presented in **Error! Reference source not found.** Higher percentage (46 %) of workers owns a vehicle (2- wheeler or 4-wheeler) and 16 % own a cycle. A significant proportion of the sample population (over 54 percent) do not own any motorized vehicles and hence may be considered as potential public transport customer.

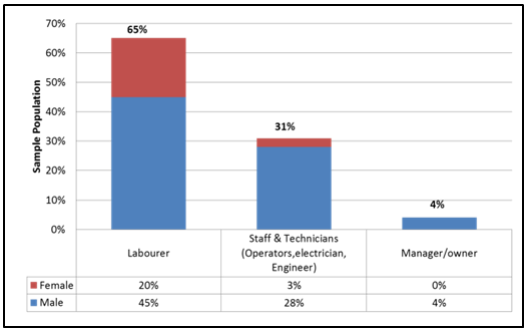


Fig. 3. Employment Profile by Sex

B. Travel Characteristics of workers in commuting daily trips

This section describes mode choice preferences of workers in Vatva. This is achieved by analyzing the modal share of workers based on their gender and employment status which forms a base for the further research.

1) Modal split

The modal split reveals the highest share of 2-wheelers overall. Public transport contributes only 28 percent of the total share (Refer Figure 4). Thus, majority of the people are using private modes and only minority group are using public transport and auto rickshaw. This shows that people are more interested towards private mode uses, especially motorcycle and less attracted to use of bus for their daily trips. A significant share of Non-Motorized mode of transport (walking and cycling) is seen by the workers residing close to their work place or within 8 kms of their work place.

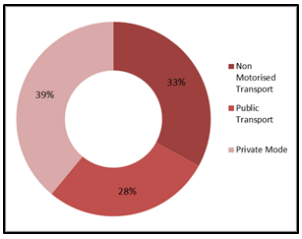


Fig. 4. Transport mode

Table 6
Modal Split by Gender

Travel Mode	Male	Female	Total
Walking	10%	7%	17%
Cycling	16%	0%	16%
Shared Auto	6%	10%	16%
AMTS	2%	0%	2%
BRTS	3%	3%	6%
Train/GSRTC	5%	4%	9%
2-Wheeler	32%	0%	32%
4-Wheeler	4%	0%	4%
Other Private Vehicle	3%	0%	3%
Total	77%	23%	100%

When studying the modal split, it is observed that out of the total trips; two wheelers have the highest share (32%), followed by walking and cycling. This shows that two wheelers are the most preferred mode of transport.

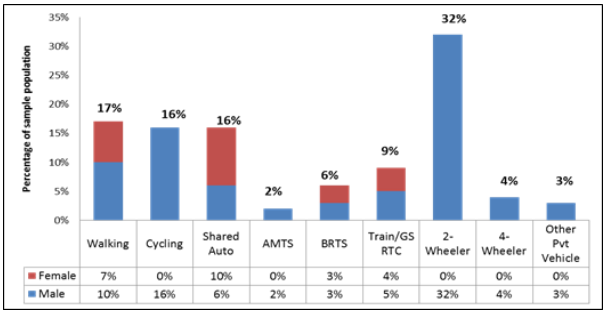


Fig. 5. Modal split by Gender

Male are more contributing to the total trips (77%) but most of them are from private modes (55%) followed by NMT and public modes (Refer Table 6). As female workers in the sample do not own a vehicle, they use public transport and auto rickshaw as their mode of travel. This is evident from the gender composition of the modal split for commuting daily trips by workers at vatva, where share of public transport and auto rickshaw is comparatively higher for females than males.

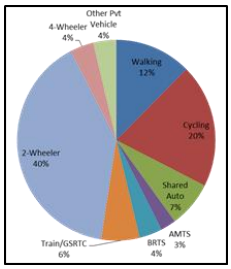


Fig. 6. Travel mode by males

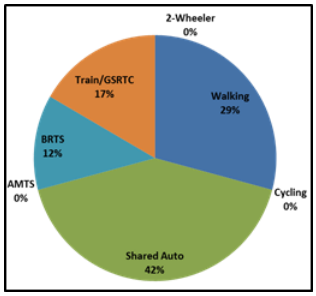


Fig. 7. Travel Mode by Females

C. Modal Split of worker by occupation

The mode choice preferences of the employee differ according to their employment status. To understand this, the employees were categorized in three major classes, namely, laborers, Staff & technicians and Owners/ managers. Laborers include workers involved in manual labour and physical work. Staff & technicians include people are involved in machine, laboratory and store operations for different tasks in the industries. And owners/managers form the higher class of the employees that own the industries or manage the operations performed by other two categories of workers.

Table 7 and Figure 8 show the mode share of respondent workers based on their employment status.

Table 7
Mode choice of workers based on occupation

S. No.	Mode	Laborers	Staff & technicians	Owners	Total
1	NMT	32%	1%	0%	33%
2	Private	10%	25%	4%	39%
3	Shuttle	14%	1%	0%	15%
4	Bus	3%	3%	0%	6%
5	Train	6%	1%	0%	7%
	Total	65%	31%	4%	100%

Source: Primary survey

Laborers are more contributing to the total trips (65%) but most of them are from NMT (32%) followed by public modes (23%) and only 10 % of them come by private modes of transport (Refer Table 7). The next higher share in total number of trips is by staff & technicians. Most of them use their owned private vehicles as a daily mode of commute and have fewer shares in the public transport. Owners/Managers being high profile workers, contribute least to the share in public transport.

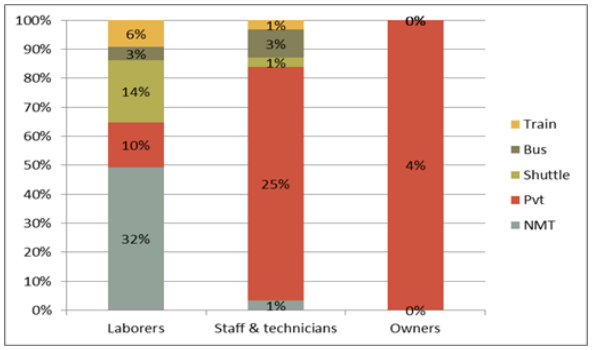


Fig. 8. Mode share of workers based on occupation

D. Mode choice Analysis- Factors affecting Mode choice

Mode choice preference by an individual plays a pivotal role while planning and assessment of public transport services. It can also influence the ridership and in turn the efficiency of the transit system.

Selection of a particular mode of transport for daily commute is an individual decision of worker which is influenced by the socio economic background of the individual (gender, occupation, income, Vehicle ownership etc.), by the characteristics of the trip (trip length, travel time, travel cost) and also by the service of the transportation modes (availability, accessibility, frequency, pricing etc.). It is thus important to identify those attributes of travel that influence individual choice of mode and to what extent.

Keeping the transport services constant, the study is further analyzed at different aggregation levels as per the occupation of workers in the study area. People at different level of occupations have different mode choice preferences based on their socio-economic and travel characteristics and these preferences decide how and where the actual modal shift is taking place. The hypothesis here is that workers who own a vehicle and travel shorter distances have less tendency to shift to public modes of transport and vice versa.

1) Trip length and Mode Choice

Trip length can be defined as the distance, a commuter is travelling in his/her daily trip. Here, it is derived as distance from origin to destination for 'Home Work trips' of the commuters or workers. Workers in the Vatva Industrial area come from different locations in and nearby Ahmedabad with trip lengths varying between 0 to 50 kilometers. The average trip length for all work trips comes out to be 9.98 km, i.e. 10 km. The origin locations of the sample population with average travel distance are shown in Map 4.

Table 8
Trip length of different modes used by sample

Mode Split	% of sample population	Min (km)	Max (km)	Avg (km)
Walking	17%	1	8	2.80
Cycling	16%	2	13	6.88
Shuttle	13%	2	10	5.00
Bus	7%	10	50	29.33
Train/GSRTC	8%	14	50	32.25
2-Wheeler	32%	3	25	10.00
4-Wheeler and others	7%	2	11	6.50

Source: Primary survey

When considering the average trip lengths of different modes of transport, bus and train trips are reported to have the highest trip length of 29.33 km and 32.25 km respectively. Non-motorized Transport is used for smaller trip lengths (between 2.8km to 6.88km). Whereas private vehicles (2-wheelers, 4-wheelers and cycle) are used for average trip lengths of 6.50 to 10 kms. Figure 9 is the graphical representation of the same. Thus, if we consider Bus transport, it is used for longer distances (here, distances more than 10 km) by the sample population.

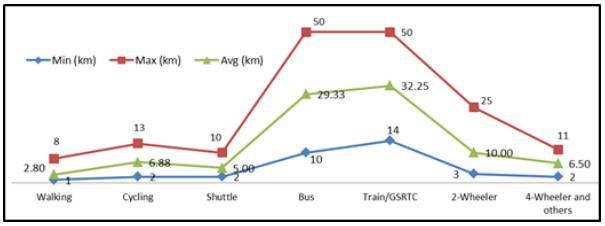
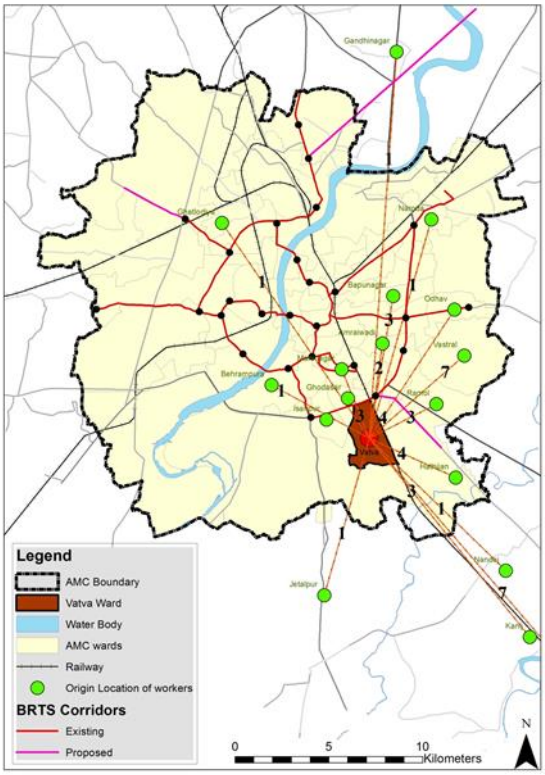


Fig. 9. Average trip length per mode

Optimal distance for different modes ranges from 3 km for two wheeler to more than 14 km for Bus and rail modes of transport. For shared auto, average trip length is 5 km, and for car it is 6.5 km. But Percentage of trips having length more than 14 km seems to be very low, approximately 23 % in the sample population.



Map 4: Map showing origin locations of Workers in sample population
Source: Primary Survey
Note: The Numbers written on the map show the percentage of workers taking trips from the respective origin locations.

2) Vehicle Ownership and Mode Choice

Comparing the mode of travel with their vehicle ownership, it is observed that workers who do not own a vehicle have higher percentage of patronage for public transport. Out of total laborers 52% do not own a vehicle and about 45.7 percent (excluding walking) of them can be considered as captive travelers of bus with no vehicles owning. But highest percentage of these captive riders, i.e., 31.6% of them use shared auto as the mode of transport.

Workers who own a vehicle have fewer tendencies to use public modes of transport. As seen in the figure, only 8.1 % of them use public modes of transport and rest of all use their private vehicles for commuting. Moreover, due to improved economic wellbeing of the people and easy availability of loans for procuring personalized vehicles, Vehicle ownership is increasing at higher rate. Both these situations are presenting a challenge for maintaining the captive riders of the transit system. Those who own a vehicle, travel least by public transport. As seen 80% of them travel by their private means of transport and none of them use Mass transit as their mode of commuting.

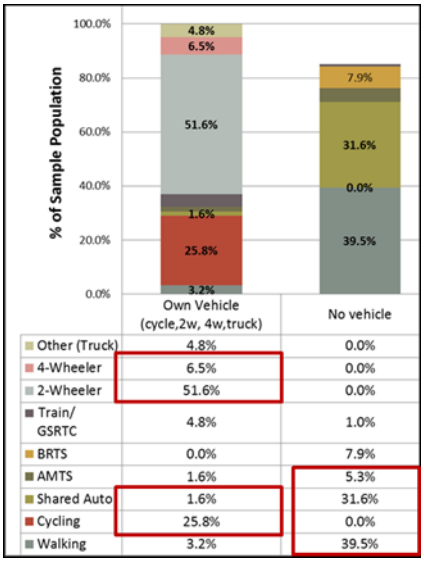


Fig. 10. Vehicle Ownership & Mode choice

Vehicle ownership & Mode choice of Laborers:

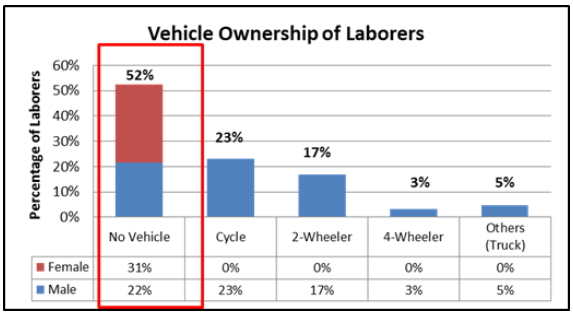


Fig. 11. Vehicle Ownership of laborers

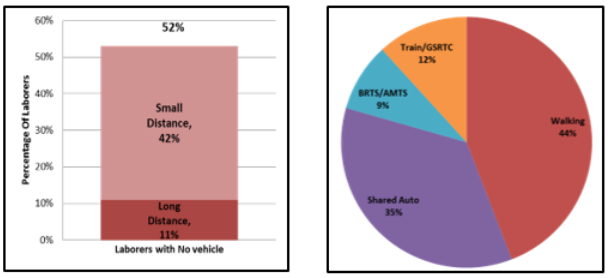


Fig. 12. Mode choice of laborers with no vehicle

Higher percentage of laborers who do not own vehicle, generally reside close to their work place and use walking and shared Auto as their mode of travel.

Although the travel by shared auto costs slightly higher than other public transport, but it is used by most of the laborers, since it provides better accessibility to their work place and saves time with the cost being almost similar.

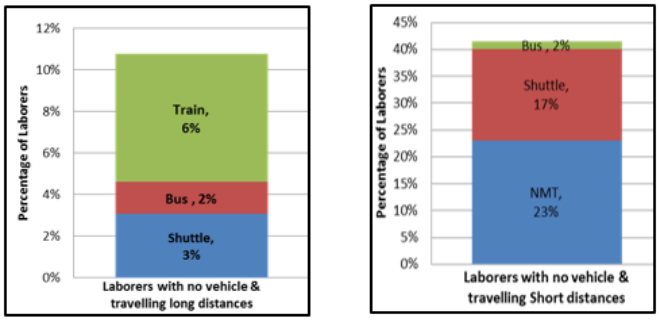


Fig. 12. Mode choice for longer and shorter distances

Laborers who do not own a vehicle, for longer distances prefer Train (6%), followed by Shared Auto. (Most of them are females). Bus is used by least of them as a mode of transport, although they save time of travel but waiting time is higher. For shorter Distances, Non-Motorized Transport is more preferred, whereas some use Shared auto for saving time of commute.

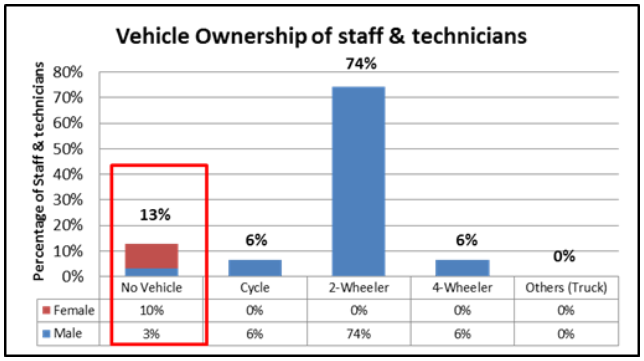


Fig. 13. Vehicle Ownership of staff & technicians

Maximum of staff & technicians own a 2-wheeler (74%) and use the same for commuting. Just 13% of them do not own a vehicle and use Bus or shared Auto as their mode of travel for long distance commute.

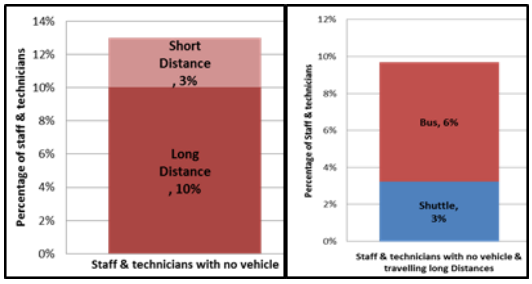


Fig. 14. % of trips by Staff & Technicians by distance

3) *Income & Mode Choice*

Income is another important factor that affects the mode choice decisions of workers. The amount a worker is willing to pay for his/her daily work trip is governed by the income of the individual.

By comparing income and mode choice of the workers, it is observed that with the increase in income, people are willing to pay more for a commute but their share in public transportation decreases with increase in income. Moreover, with the increase in income, there is a shift toe=wards private modes of transport. (Refer Figure 15).

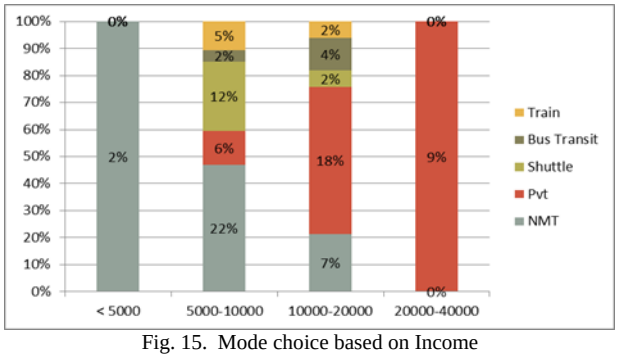


Fig. 15. Mode choice based on Income

As most of the laborers belong to lower income group with a monthly salary less ranging between INR 5000-10000 and do not own a vehicle, they are dependent on public modes of transport for their commute.

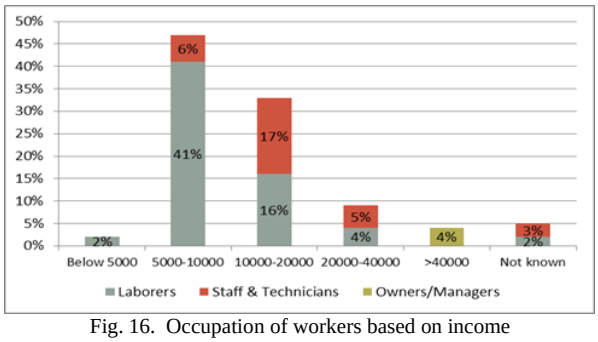


Fig. 16. Occupation of workers based on income

4) *Travel cost and mode choice*

Travel cost presents another important aspect for selection of particular mode. Any individual choses a convenient mode of travel based on his/her economic affordability and willingness to pay for a trip and for a particular distance of trip making. Figure 17 shows variation in travel cost with increasing travel distances for different modes. The distances vary as per the stages. Each stage is equals two kilometers.

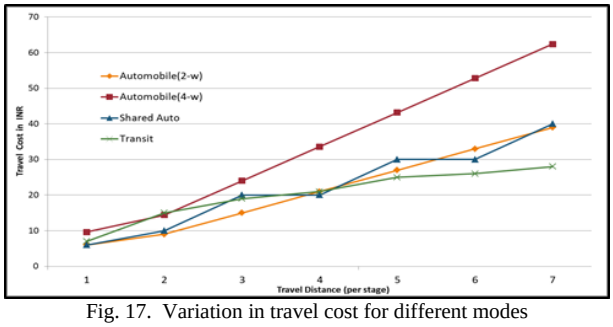


Fig. 17. Variation in travel cost for different modes

For shorter distances, travel cost for transit system is higher in comparison to Automobiles and shared auto, whereas the same comes down for longer distances. Up till 8-10 km, the costs for two wheelers, shared auto remains low or almost similar to the cost of transit but beyond that distance the transit becomes cheaper than all other modes of transport. Hence, if travel cost is considered, transit becomes a mode choice for longer distances.

But as mentioned earlier, the average trip length of the respondent workers is approximately 10 km. at this trip length, the costs for transit, shared auto and two wheelers remains almost similar. Workers therefore, decide their mode based on their income levels and affordability. It is used majorly as an inferior good to the private vehicle and shared Auto. And travel time becomes another key determinant for deciding mode choice of workers.

5) Travel time and mode choice

Figure 18 shows variation in travel time with increasing travel distances for and for different modes. Overall, automobiles (two wheelers & four wheelers) take less time in travelling (if traffic congestion is ignored). Transit services running in separate lanes with an average speed of 24 km per hour are second to automobiles in case of travel time followed by shared Auto, cycling and walking.

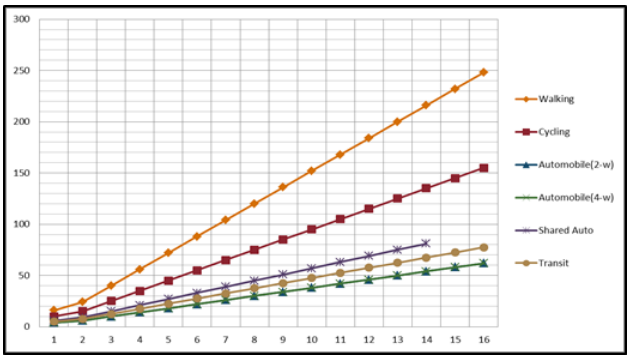


Fig. 18. Travel time for different travel modes

Walking and cycling, being Non-motorized modes of transport, have more travel time in comparison to motorized modes. Travel time for private modes of motorized transport is almost similar to that of transit buses.

Although travel time for transit services is less in comparison to shared auto and almost similar to automobiles but the same becomes much higher if we incorporate waiting time and interchange times to it.

6) Trip frequency and Mode Choice

The mode choice is also affected by the frequency or no. of trips carried out by an individual. For higher frequency of trips per day, private modes are used due to ease of access, travel time and travel cost savings.

Table 9
Average no. of trips by sample population for different modes

Travel mode	Average No. of trips per day of respondents	% of Respondents
Walking	2	17%
Cycling	4	16%
Shuttle	3	13%
Bus	2	7%
Train/GSRTC	2	8%
2-Wheeler	5	32%

Table 9 and Figure 19 show that the mode choice is largely influenced by the frequency of trips by an individual. How frequently a mode can be used or accessed decides its convenience level. Private modes can more frequently be accessed and large number of trips for different purposes can be carried out conveniently. In contrast, transit modes are quite difficult to access and thus are used only twice a day by most of the respondents. Cycling trips have higher frequency, again due to ease of access and zero travel costs.

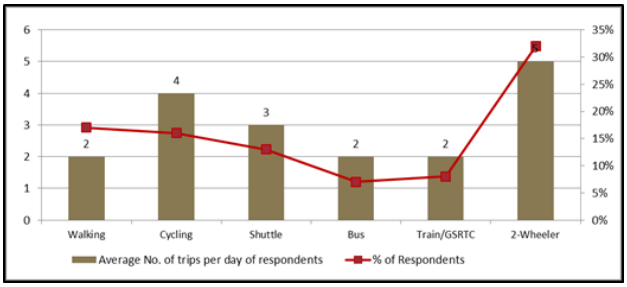


Fig. 19. Frequency of trips and mode choice of workers

7) Impact of trip characteristics on mode choice

By comparing the average trip length, trip cost and travel time, it can be inferred that Since transit increases the overall travel time of the journey, it is less preferred by the workers, as although the travel costs might be slightly less but the added time costs are much higher.

Table 10 shows the characteristics of trips by the respondent workers in terms of trip length, travel time and travel costs. Transit trips, although have less average travel cost but due to long time of journey (including waiting time) drives its mode share towards shared Auto and train as mode choice preference of workers. This is evident in Figure 20 which shows that due

Table 10
Trip Characteristics of different modes

Mode	Average Trip Length (km)	Average Travel Time (per day)	Average Travel cost (per km.)	% of respondents
Walking	2.2	16.5	0.0	17%
Cycling	5.3	24.6	0.0	16%
Shuttle	4	12	1.5	13%
Transit	21.6	51.3	0.1	7%
Train/GSRTC	37.6	35	0.1	8%
2-Wheeler	10	19	1.2	32%
4-Wheeler	6.5	22.6	1.0	7%

Source: Primary survey

to longer travel time of transit is losing its share to private modes and other modes of transport.

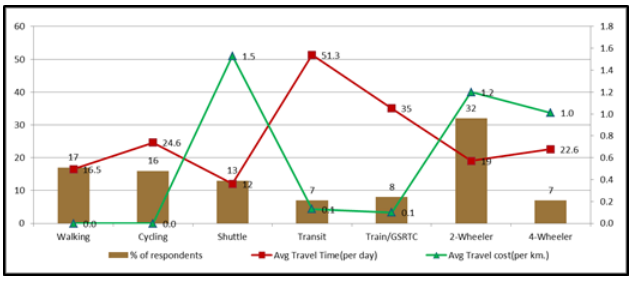


Fig. 20. Mode choice based on trip characteristics

E. Strength of factors influencing mode choice decisions

Previous analysis shows how different socio economic of an individual and trip characteristic of the journey affect the mode choice preferences of a worker. This section defines the strength of each factor affecting the mode choice decisions which will be helpful in framing inferences for each factor.

Pearson's correlation and Chi square test is used to identify the significance of association between these factors. The Chi Square test is used to identify whether any relationship in the sample data is strong enough to justify our making inferences about the larger population from which the sample has been drawn and correlation provides us the strength of the relation.
The results show that Occupation status, Vehicle ownership, income and trip length have maximum influence on the mode choice decisions of the workers as these factors have p value significant at less than 0.005 which shows higher strength. The figures also show that the variables are statistically significant at a confidence interval of 95%.

The t test results and the correlation factors with negative sign depict negative relation between the variables whereas, those with positive signs show direct positive relation.
Thus, income, trip length, trip cost and trip frequency have correct negative relation and all others have positive. The results and coefficients can be used for preparing a model to address these influencing characteristics in the planning of transportation services.

6. Conclusion

This paper analyse the influence of identified factors on mode choice decisions of individual. From the overall modal share it can be inferred that most of the workers private modes (39%) as their modal preference for daily commute. A major share of reside close to their work place and have NMT (33%) as their preferred mode. Although 28% of people use public mode of transport, but most of them prefer Shared auto (16%) in comparison to bus (BRTS or AMTS) which is 8 % of total population.

For workers, travel time and travel costs are the important factors that decide their mode. For shorter distances, those who own vehicle, use their private modes for commuting because it leads to travel time and travel costs savings. Those who do not own a vehicle, depend on public transport services. But out of all shared auto is most preferred as it provides better accessibility to work place in less time and at almost similar cost to transit systems. Whereas, for longer distances transit services are preferred due to travel time and travel costs savings by transit.

Thus travel distance and vehicle ownership forms other important criteria for mode choice of workers. Optimal distance for different modes ranges from 3 km for two-wheeler to more than 14 km for Bus and rail modes of transport. For shared auto, average trip length is 5 km, and for car it is 6.5 km. But Percentage of trips having length more than 14 km seems to be very low, approximately 23 % in the sample population.

Thus, workers who do not own a vehicle are captive riders of mass transit, but highest percentage of these captive riders, i.e., 31.6% of them use shared auto as the mode of transport. Thus shared auto presents a tough competition to transit in terms of travel time and costs savings.

Most laborers reside close to their workplace ant use NMT which saves their travel costs. Most staff & technicians own a vehicle and use the same for commuting and it saves their travel time or cost or both.

Thus, analyzing the overall travel behaviour of workers, it is seen that individual characteristics and also the characteristics of trip or journey influences the mode choice decisions of workers.

To the workers, Private vehicles appear to be more convenient option due to ease of access and comparatively less travel cost. Based on these characteristics, one decides to adopt a particular mode of travel or to shift towards a particular mode of travel.

Also, depending on the change in pattern of the city and transport, these characteristics also change. For example, rise in income levels and vehicle ownership will make people switch to private motorized vehicles. Whereas, expansion of the city and large distance commute at lower travel costs, will make individuals switch towards public modes of transport.

And efficiency of such public transportation projects is achieved if higher mode share is achieved in favour of these modes of transport, i.e., a substantial percentage of population switches to public modes of transport.

So, it is important to analyze the impact of these factors on mode share which will derive the challenges for transit systems from the demand side and will be helpful in addressing these issues and challenges to improve the efficiency of these projects.

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