9th Urban Mobility India Conference & Expo 2016
Planning Mobility for City's Sustainability

RELATION BETWEEN URBAN FORM AND BRTS TRANSIT USE

Case of Ahmedabad





Image sources: Author

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CEPT UNIVERSITY

9th Urban Mobility India 2016

- Introduction
- Objectives, Research Question
- Transit Ridership and Urban Forms
- Current Debates on Transit Oriented Development
- Study Area Stop areas
- Correlations
- Analysis
- Conclusions

INTRODUCTION

Image source: narendramodi.in

- With increasing personal vehicle use, results in air pollution and GHG emissions. An oft-suggested alternative to reduce the **negative externalities** of the personal vehicle use is the development of an **efficient public transportation system**. (Chakour & Eluru, 2013)

- Many Indian cities dramatically transformed their mobility through the implementation of many **bus transit solutions** in the past few years (India, EMBARQ, 2009).

- BRTS has become populous as a means to provide reliable, non-automobile based mobility and **alleviate** the impacts of rising congestion in the city (India, EMBARQ, 2009).

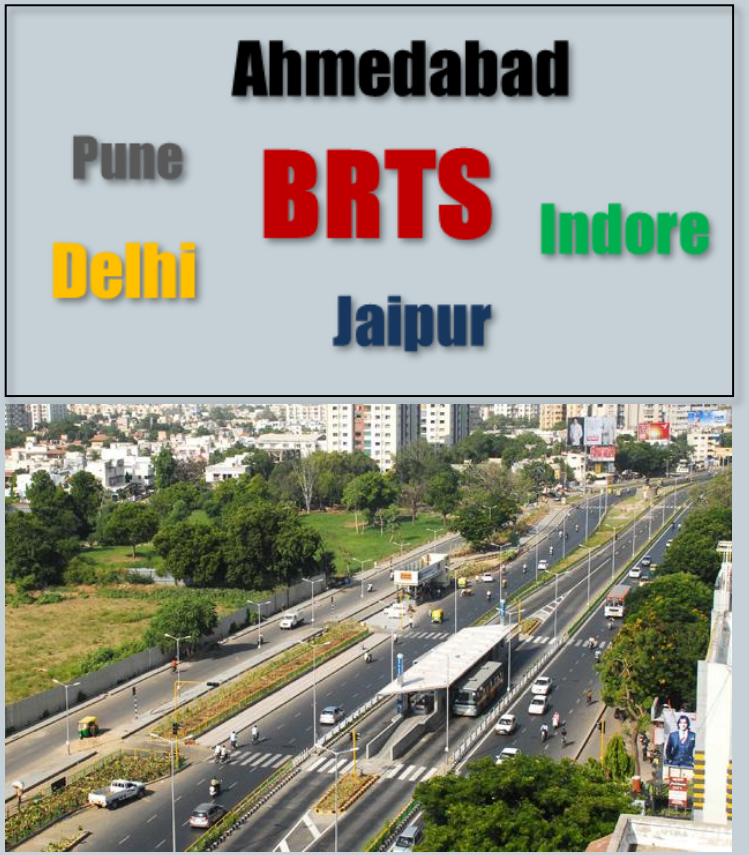


Image source: narendramodi.in

INTRODUCTION

- Understanding the **factors that affect transit ridership** thus becomes important for the **success** of any given transit system. (Banerjee et.al., 2005)

- Previous studies have ascertained that a relationship exists between ridership and the urban forms. Density and land-use mix have a positive impact on ridership. (Ewing & Cervero, 2010; Banerjee, 2005)

- "Urban form is a broad concept, implies the spatial patterns or arrangements of individual urban elements such as buildings, streets and land use." (Munshi, 2013)

Urban forms are conventionally represented by six groups of indicators, referred to as the **6 D's**.

Cervero and Kockelman, 1997			Ewing and Cervero, 2001		
Density	**D**iversity	**D**esign	**D**estination Accessibility	**D**istance to transit	**D**emand Management

(Cervero, 2014; Cervero & Kockelman, 1996; Munshi, 2013)

RESEARCH OBJECTIVES

AIM

To identify the relationship between Urban Form and BRTS transit ridership, at BRTS stop locations in Ahmedabad.

OBJECTIVES

i. To identify the urban form variables of density and diversity that relate to BRTS transit use.
ii. To analyze the relationship of urban form and ridership use of BRT in the selected station areas.
iii. To analyze the relationship between BRTS riders and their residential building typologies.

TRANSIT RIDERSHIP

Ridership is defined as the number of passengers using a particular form of public transport. The 2 methods to measure ridership are:

i. **Average weekday, monthly, or annual boarding**

ii. Transit journey-to-work (commute) mode share, and also the percent of work trips made by public transit

(Brown, 2012; Kolko, 2011 cited in Zhuang, 2014; Banerjee et. al., 2005)

Average weekday boardings were used as a data source due to the correlation between boardings and alightings i.e. **people start on their return trip the same place they ended**- the beginning of the trip.

(Johnson, 2003; Banerjee et. al., 2005 and Estupinan & Rodriguez, 2008)

(Image source: rising citizen.blogspot.com)

Density

Density is always measured as the **variable of interest per unit of area**. The effects of density on travel demand have long been acknowledged. Higher densities are associated with more public transport use, more walking and cycling, and less car use.

Variables: Population density - Persons per hectare
Dwelling Unit density– No. of Single family or multiple family units per hectare

(Source: Estupiñán & Rodríguez 2008; Johnson 2003; Banerjee et. al., 2005)

In Ahmedabad's context

Parameters to measure	Ahmedabad context	Why?
Population density	Considering the growth of the city (morphological make-up)	Net densities will be calculated. Literature shows a positive relationship.
Dwelling Unit	The variable becomes **housing typologies**; as we do not have single family or multi family units rather apartments, slums etc. would be a more interesting look	

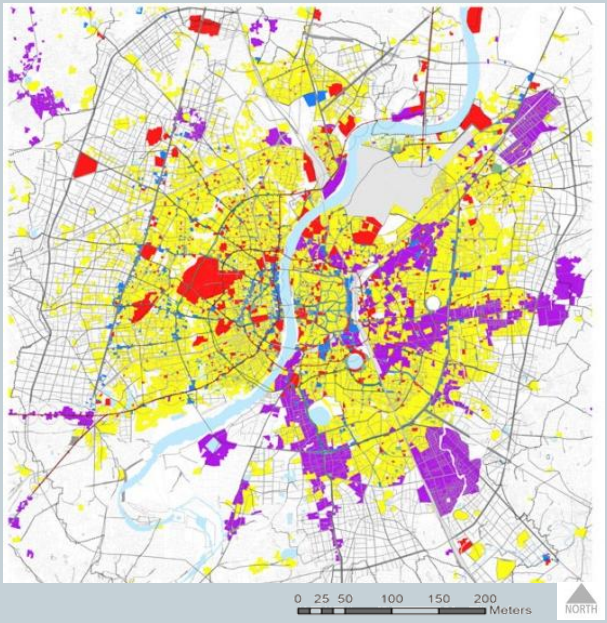


Image Source: Development plan Ahmedabad)

Diversity

Diversity measures pertain to the number of different land uses in a given area and the degree to which they are represented in land area, floor area, or employment.

- Land Use Diversity/ Entropy = $\sum \frac{P_n \times Ln(P_n)}{Ln(N)}$

Where, N= number of different land-uses in the station area or buffer area; and
P_n = proportion of land in units (acre, hectare) of the n^{th} land-use within the station area or buffer area.
The greater the value of Land Use Diversity greater the mix of land use in the area. The values range from 0 to 1, where 1 denotes maximum possible diversity.

(Banerjee et. al., 2005; Munshi 2014; Kumar & Goliya, 2014)

Parameters to measure	Ahmedabad context	Why?
Land-use balance	Mix land-use prevalent in Ahmedabad	Vertical mix also taken into consideration. Mixed land-use leads to higher ridership

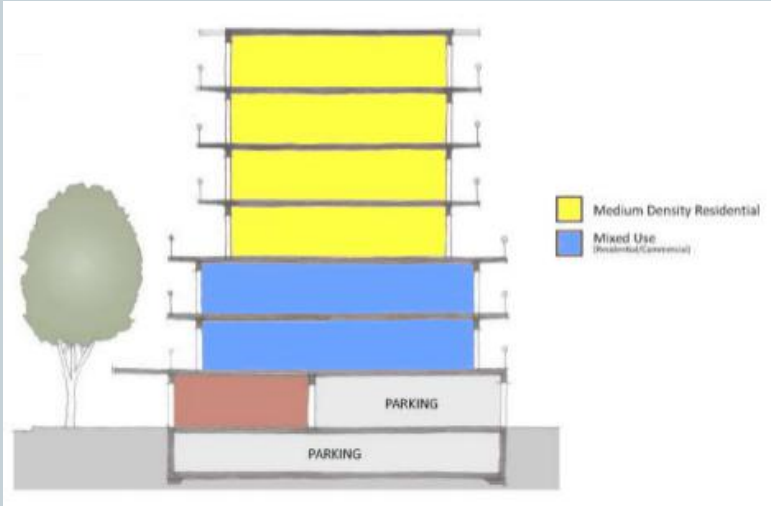


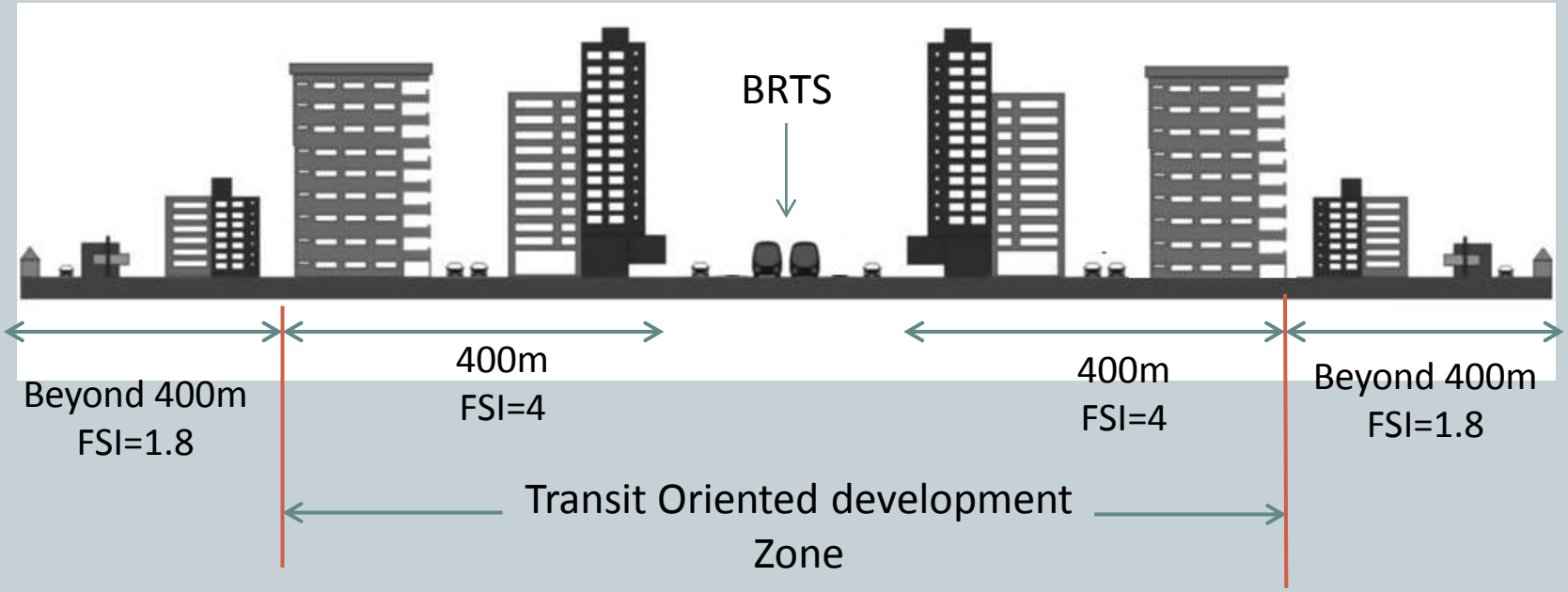
Image source: Author

INDICATOR CATEGORIES

Urban form Characteristics	Indicators	Categories (during surveys) in Ahmedabad's (Indian) context
Density	Housing typology	1) Bungalows, 2) Row Houses, 3) Semidetached, 4) Apartments, 5) Slums, 6) Gamtal and 7) Chawls 8) Other Buildings
Diversity	Land-use balance/ Entropy	1) Residential, 2) Commercial, 3) Mixed, 4) Others

Plotted development

CURRENT DEBATES ON TOD



Transit Oriented development Zone, Ahmedabad

(source development plan, ahmedabad)

- Higher FSI for increasing density, urban form changes drastically.
- High rise, mixed land use promoted so as to maximize access to public transport, and often incorporates features to encourage transit ridership.

CURRENT DEBATES ON TOD

Transit oriented zone with higher FSI

Land Values go up

Cost of infrastructure go up

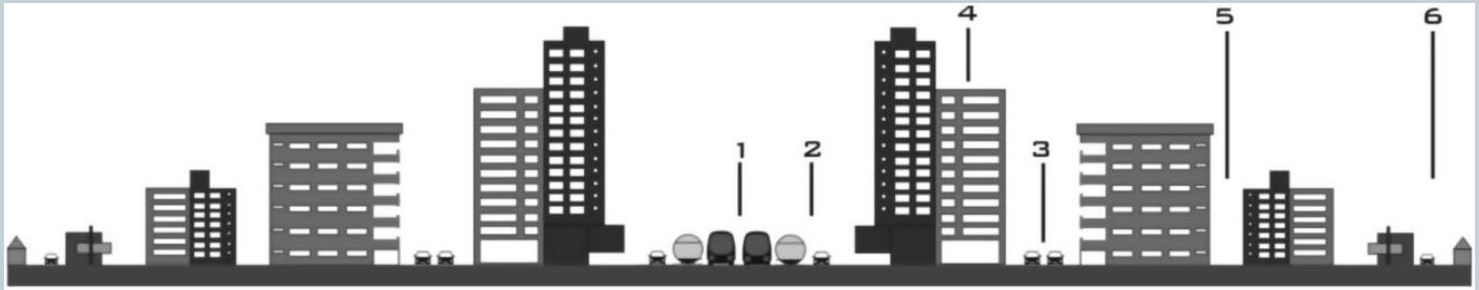
Pressure on the developers to recover these expenses

Higher floor space area units built

Affordable to Higher income groups that do no use public transit occupy

Lower and middle income groups pushed out of this transit zone, thus reducing the transit ridership

CASE of CURITIBA, BRAZIL



1. Bus corridor; 2. Local traffic lanes; 3. Fast traficc lanes; 4. Verticalization and high densities;
5. Medium density; 6. Low density and local traffic

(Case study Curitiba Brazil, Dualtre & Ultramari, 2012)

JANMARG Bus Rapid Transit System IN AHMEDABAD

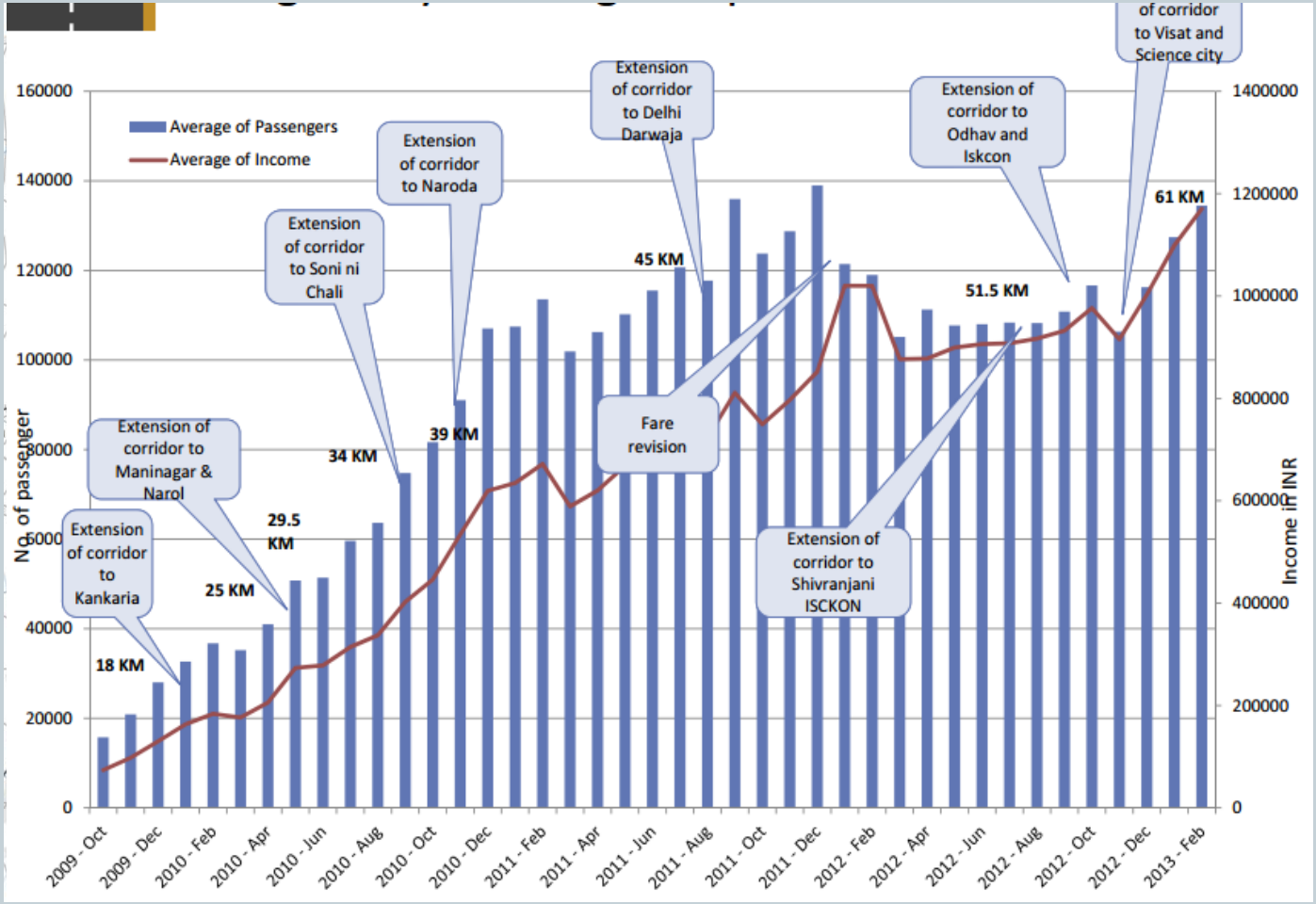
- An average of **1,35,000** passengers ride daily in the BRTS

- Network length of **86 kilometers**

- Number of working stations are **120**

- Distance between 2 stations **800m**

- Bus fleet **160 buses**



NORTH

Average daily passenger trips and revenue collection

(Source: Thennarasan, M & CEPT)

STOP AREA DELINEATION

Influence zone Radius

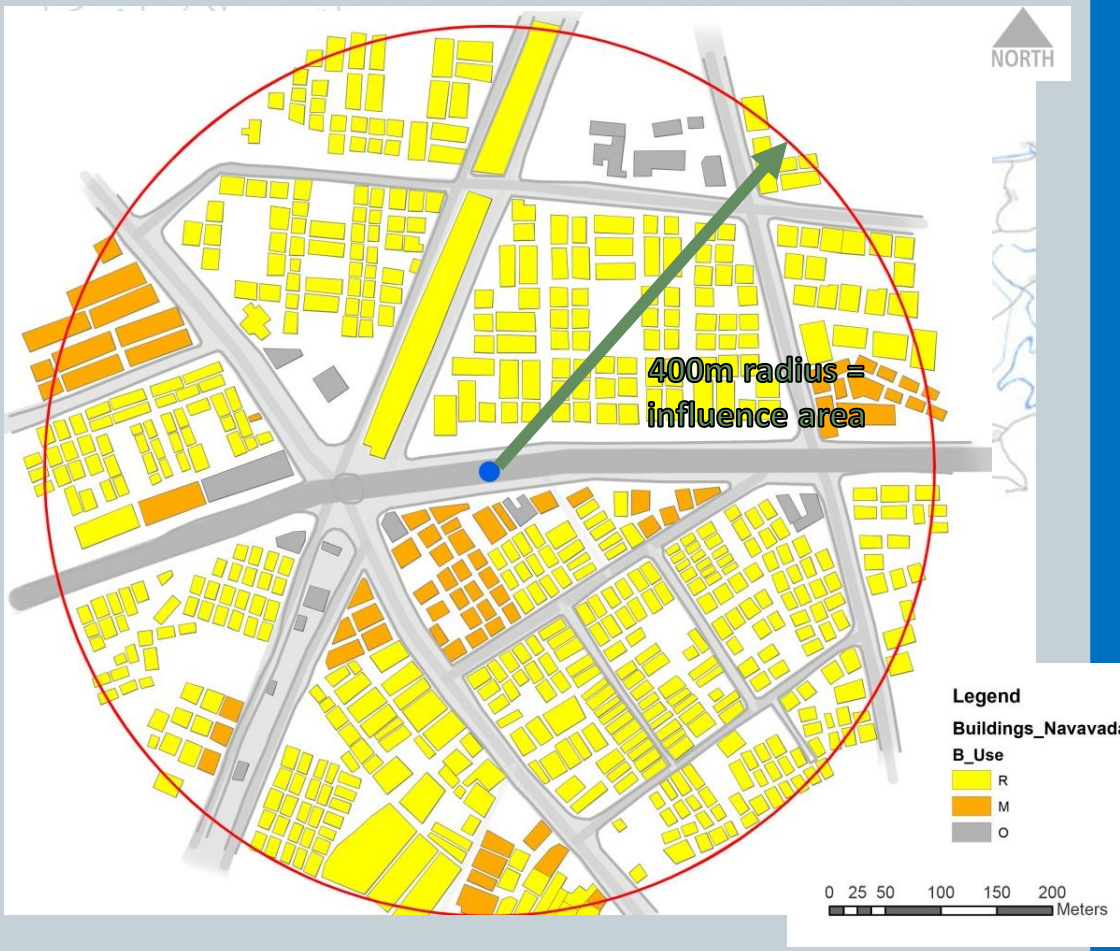
- Proximity or Distance to transit station is an important factor.
- Transit ridership diminishes rapidly as distances from transit stations increases.
- One- quarter mile i.e. 400m is the limit that most people will walk for most trips.

(Banerjee, 2005 ; Cervero 2014; Janmarg BRTS, 2006; Utermann, 1984)

Stop area Selection criteria's

i. Higher ridership station areas.

ii. Areas that are not transfer station.



Selected Stop areas (Image Source: Janmarg BRTS, 2006; CUE office, A'bad)

SECONDARY DATA SUMMARY

	Akhbarnagar	Dharnidhar Derasar	Isanpur
Station area (in sq. km)	0.5	0.5	0.5
Ridership (Average Daily boarders)	**3604**	**1528**	**1492**
Density (in persons/sq. km)	36448	25649	41779
Density (in persons/ hectare)	**366**	**257**	**418**
Building Use (Entropy)	**0.004**	**0.003**	**0.002**
Plotted development density (units/Ha)	116	191	220
Apartment density (units/Ha)	37	44	68
Slum and chawl density (units/Ha)	617	0	226
FSI (currently consumed Average)	**0.8**	**0.8**	**0.9**

(Source: Area Planning Studio data, 2014 & 2016; GIS maps)

CORRELATIONS

Between urban form and BRTS transit use variables

			B_Type	B_Use	Pop Density
Pearson Correlation	Ridership (average daily boardings)	Pearson Correlation	.357**	.103**	.028
		Sig. (2-tailed)	.000	.000	.125
		N	2911	2911	2911

- Relationship significant at $p<0.05$
- Relationship between ridership ad population density is insignificant ($p=0.125>0.05$)
- Small associations exists between building use (entropy) and transit ridership.
- Moderately strong relationship exists between building typologies and BRTS transit ridership.

As Building Typologies is the most associated of the Urban Form variables with ridership, further a survey of boarders at the three delineated stops were carried.

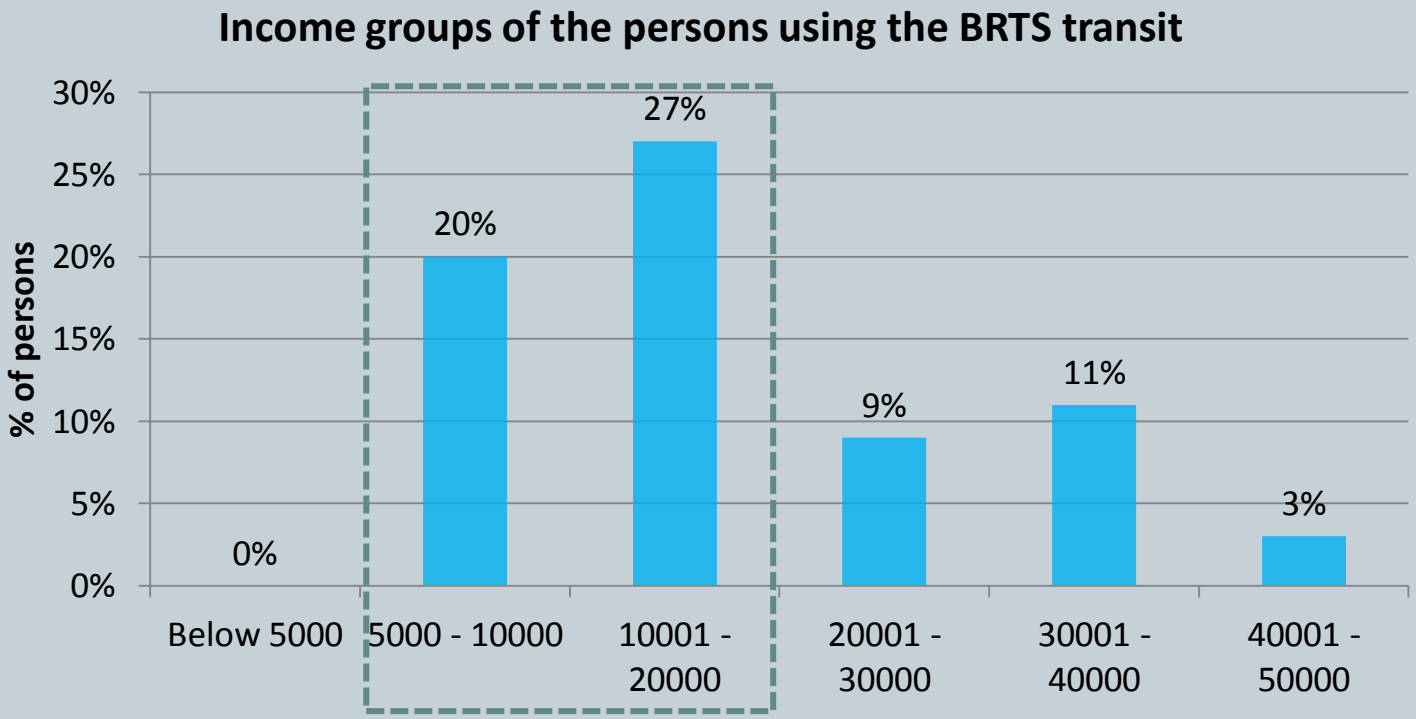
A total survey of 120 BRTS boarders to establish the Transit Ridership profile in three categories:

- Socio-economic profile
- Travel Characteristics profile
- Housing typology profile

SOCIO-ECONOMIC PROFILE- AHMEDABAD

Income	Count	Percentages
Below 5000	0	0%
5000 – 10000	24	20%
10001 – 20000	32	27%
20001 – 30000	11	9%
30001 – 40000	13	11%
40001 – 50000	3	3%

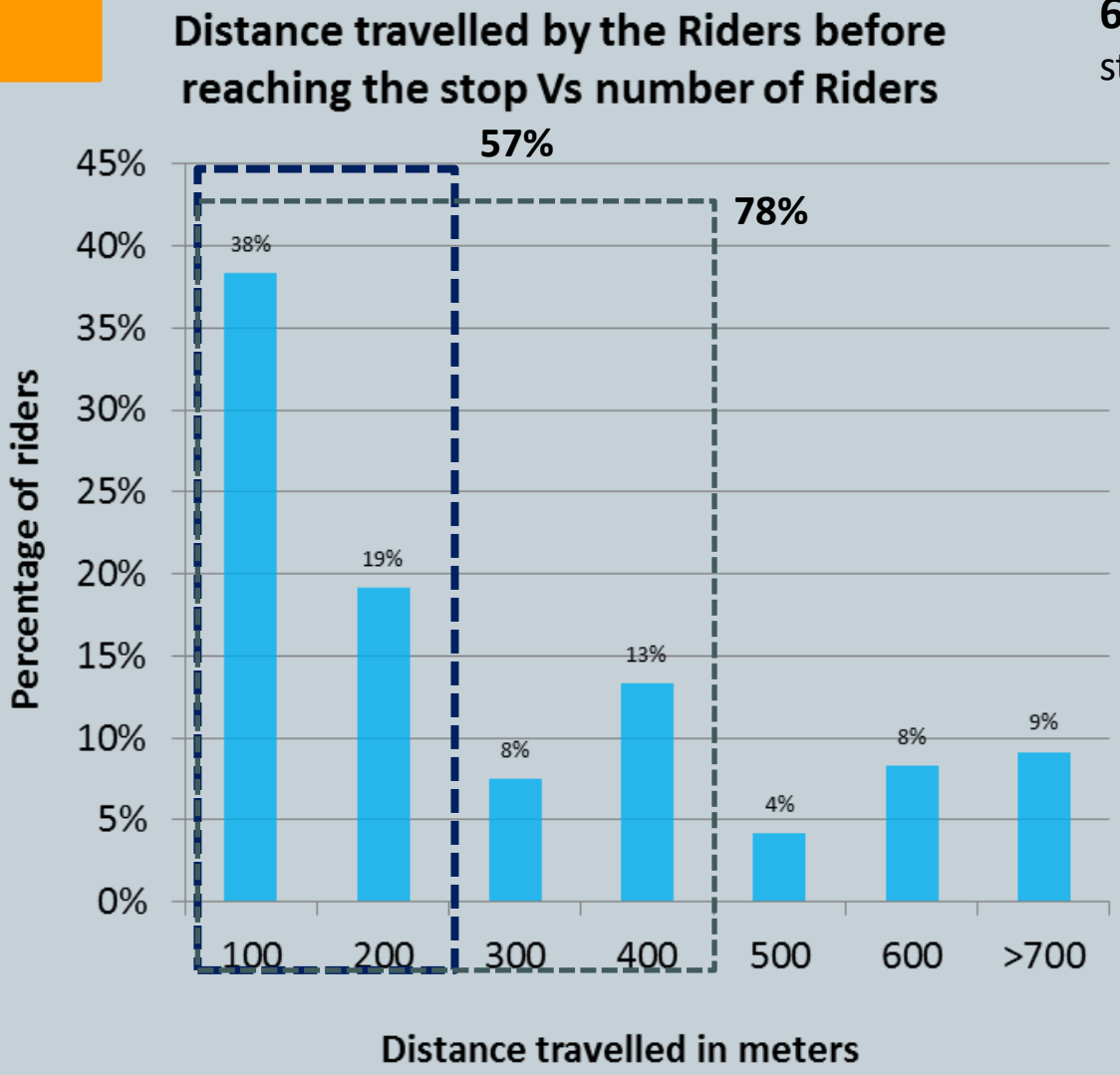
47% of the persons belong to the Lower income group

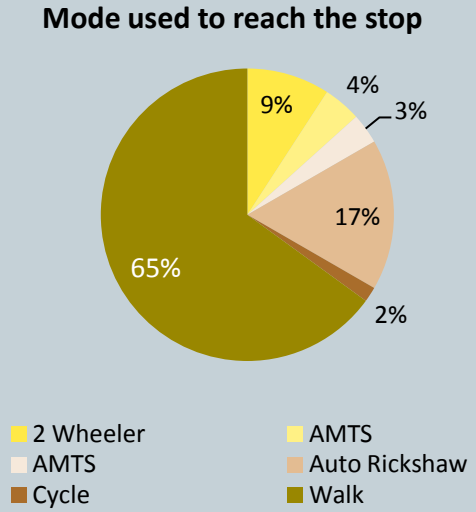


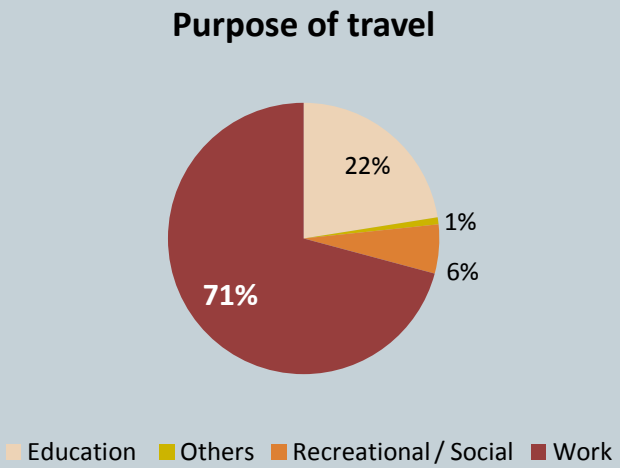
TRAVEL PROFILE

78% of the BRTS transit riders live within the influence zone of 400m.

65% of the riders walk to the transit stop

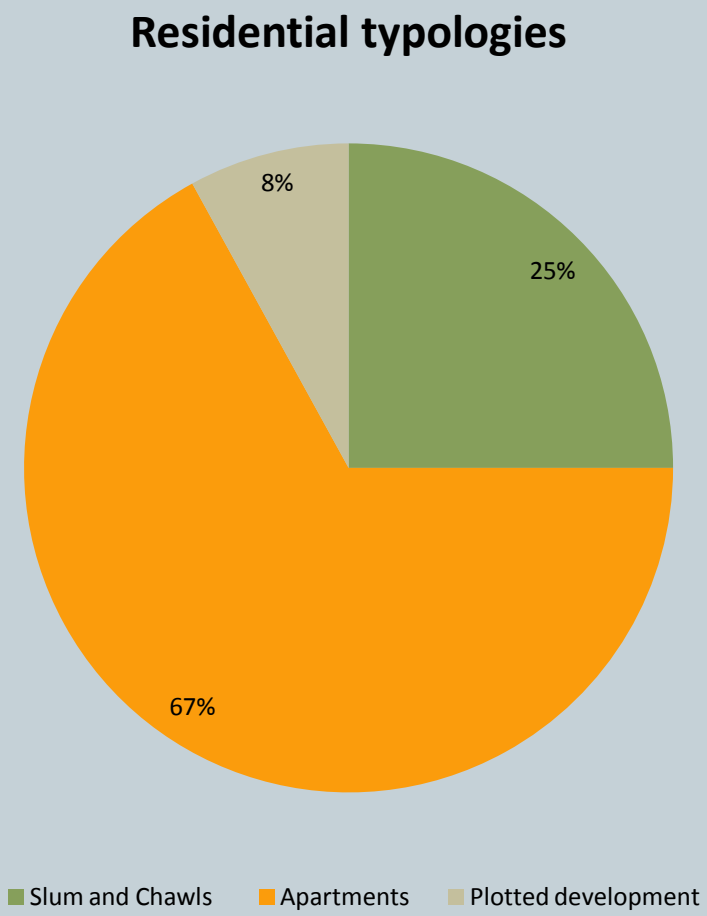


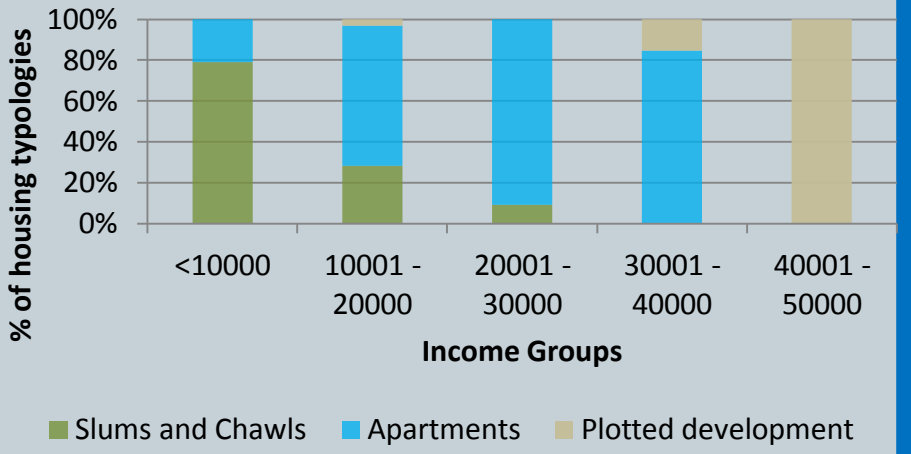


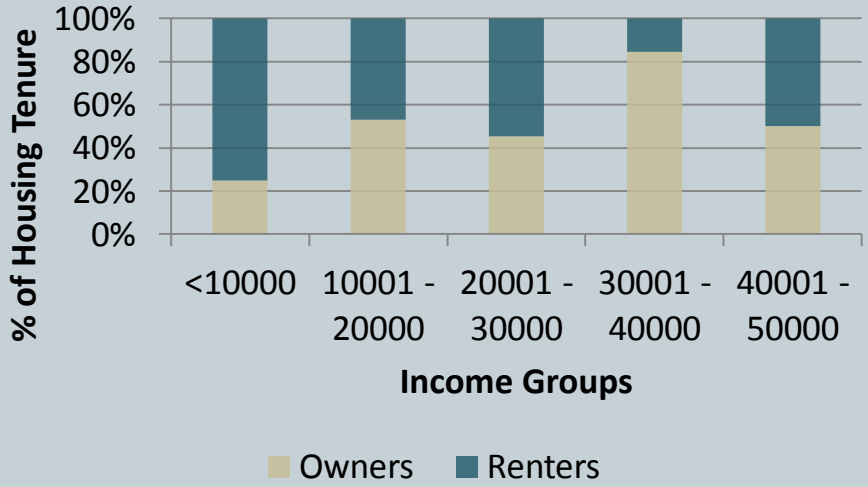


As Strong associations were observed previously, residential typology profile of the BRTS riders is analyzed.

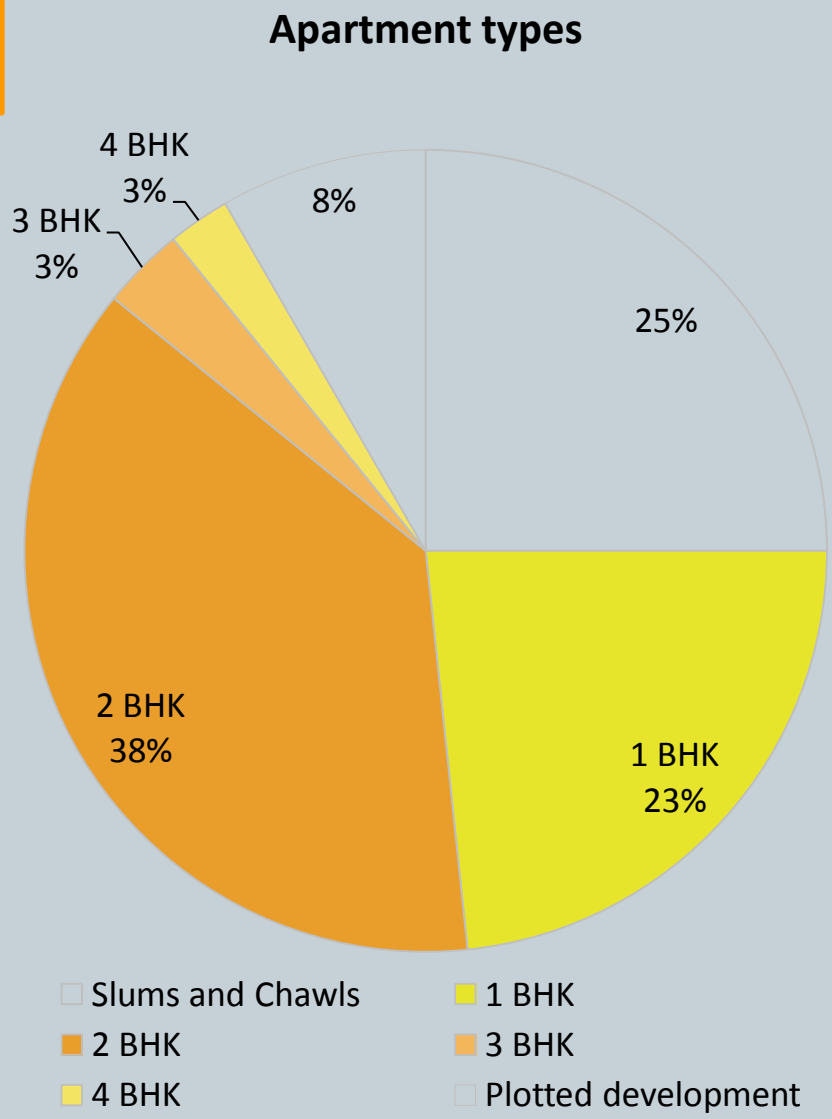
RESIDENTIAL TYPOLOGY PROFILE

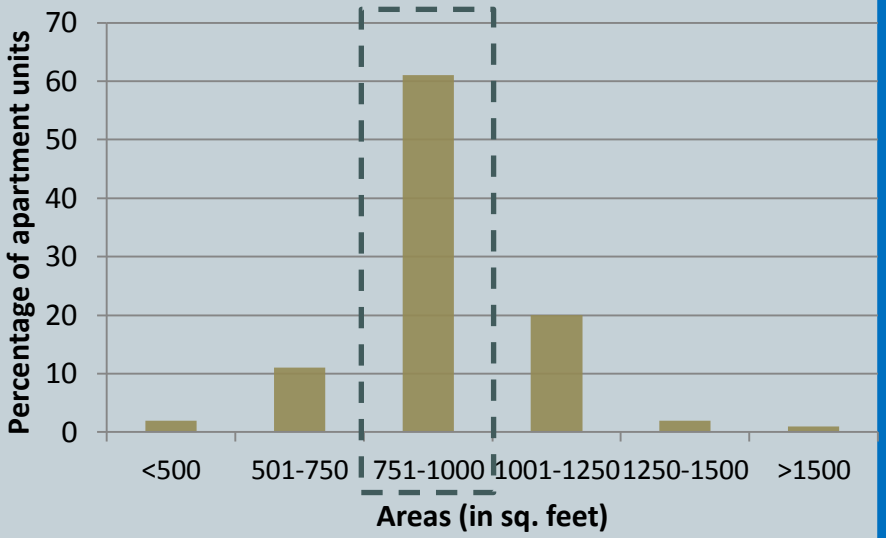






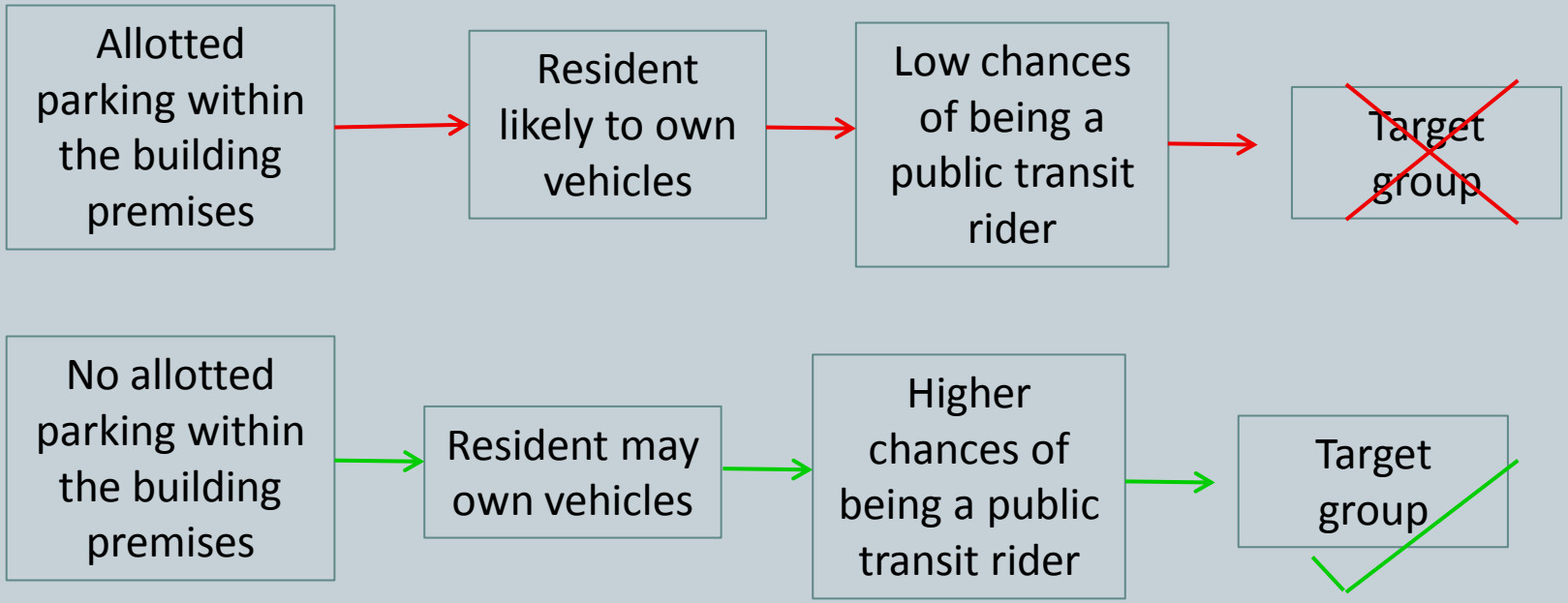
RESIDENTIAL TYPOLOGY PROFILE





Understanding the Parking provisions in the residential typologies

Hypothesis: Parking management researches prove that 'If a provision of allotted parking is present in the buildings, then a resident is likely to be a vehicle owner and have low chances of using the public transit.'



(Source: Mohan, 2013)

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Depending upon the descriptive analysis of the three locations and overall Ahmedabad the following correlations between variables are conducted to understand which of the variables have strong associations:

- Housing typologies and socioeconomic variables
- Travel characteristics

CORRELATIONS

Housing typologies and socioeconomic variables

Correlations		Pearson's Correlation value	Significance (p)	Inference
Variable 1	Variable 2			
Housing typologies	Area of the residence	0.493	0.000 (p<0.05)	Strong associations
Housing typologies	Number of rooms (residence)	0.417	0.000 (p<0.05)	Moderate associations
Housing typologies	Tenure	-0.398	0.000 (p<0.01)	Moderate associations, inversely related
Housing Typologies	Income	0.183	0.045 (p<0.05)	Small associations
Housing typologies	Vehicular ownership	0.260	0.004 (p<0.01)	Small associations
Vehicular Ownership	Parking provision	-0.343	0.000 (p<0.05)	Moderate associations, inversely related
Ridership (average daily value)	Income	0.279	0.002 (p<0.05)	Small associations

TYPICAL BRTS RIDER'S HOUSING TYPOLOGY

Housing typologies
Area of the residence
Number of rooms
Tenure
Income
Vehicular ownership

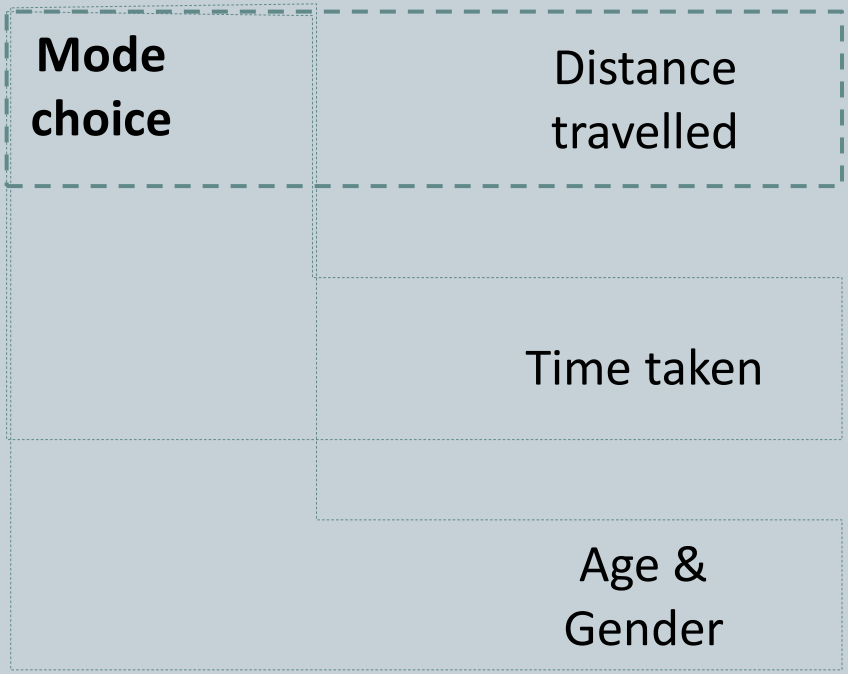
- Averagely 750-1000 sq. feet
- 1 BHK- three rooms and 2 BHK – four rooms
- Tenure an important consideration
- Income groups of Rs. 5,000-20,000
- 1 owned two-wheeler with no allotted parking provision inside the building compound

CORRELATIONS

Travel characteristics

Correlations		Pearson's Correlation value	Significance (p)	Inference
Variable 1	Variable 2			
Distance travelled	Travel time	0.721	0.000 (p<0.01)	Strong associations
Mode Choice	Distance travelled	0.445	0.029 (p<0.05)	Moderate associations
Mode Choice	Travel time	0.199	0.000 (p<0.01)	Small associations
Mode Choice	Age of the user	0.198	0.031 (p<0.05)	Small associations
Mode Choice	Gender of the user	0.252	0.005 (p<0.01)	Small associations

TYPICAL BRTS RIDERS TRAVEL CHARACTERISTIC



- Walking is preferred when distance lower than 400m
- Walking is preferred when time taken to reach the stop is less than 5 minutes.
- Age and gender also affect mode choice, age group (16-60) and males as well as females prefer walking to the stop.

CONCLUSIONS

- At the station area level, urban form variables of density as well as diversity have an impact on the BRTS transit ridership- positive and strong relations.

- Building typologies are strongly correlated to transit ridership.

- Residents from certain building typologies are the target group, if transit ridership is to be increased then this target group is to be allowed to live near the transit stops.
  - Target group: Residents living in mid-rise, apartment type buildings.

- If this kind of development that allows the typical BRTS rider to accommodate it is promoted then there is more probability of increasing BRTS ridership in Ahmedabad.

RECOMMENDATIONS

1. The following land-use can be promoted in the BRTS influence zone.
    - Can be location specific aspect
    - Promotion of mid-rise apartment buildings
    - Average unit size of 750 sq. feet to 950 sq. feet
    - Low parking requirements.

2. Parking requirements
    - case specific as on- street parking in congested parts of the city should be reduced.
    - Regulations with parking maximums
    - Chargeable parking FSI

3. Plots reserved for rental housing

4. Walk-able stop areas, as walking is the most popular mode choice

THANK YOU