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Travel Behavior Modeling: Exploring Household Characteristics as Predictors

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Urbanization

68 %

Global population will live in urban areas in 2050 (United Nation)

(Amegnaglo (ONU). 2018. *World Urbanization Prospects. Demogr. Res)*

3 %

Annual increase in the urban population in India (in last two decades)

(Report of Population Projection 2011 – 2036)

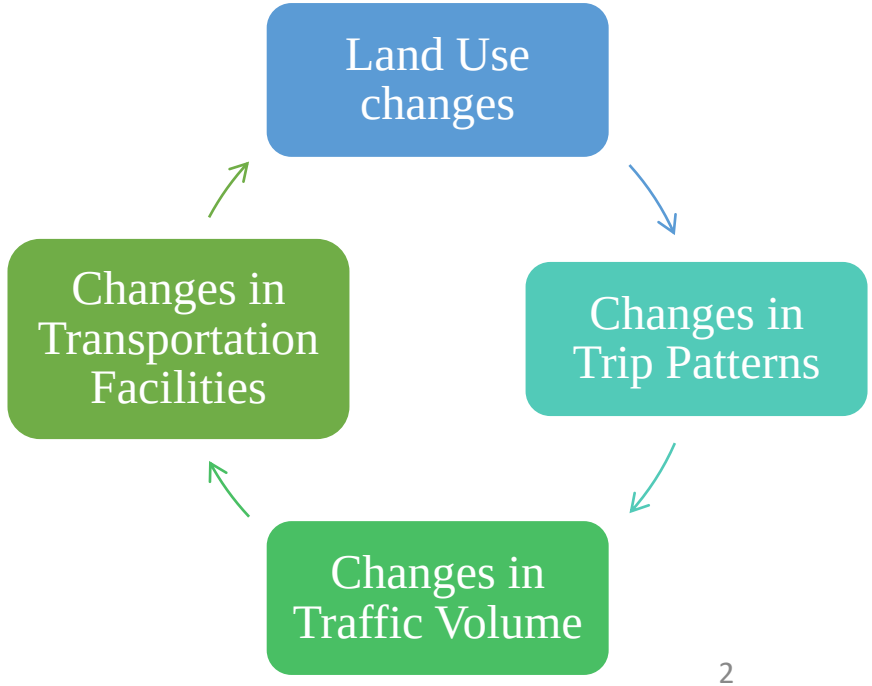
38 %

Indian population will live in urban areas in 2036

(Report of Population Projection 2011 – 2036)

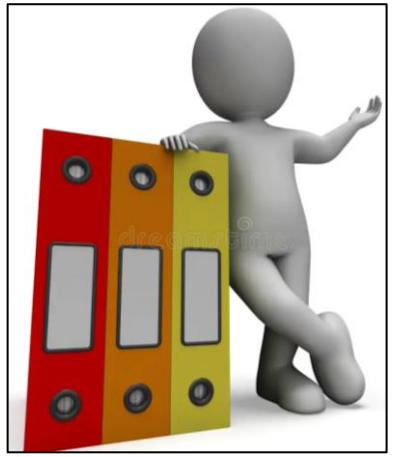
Transportation system is an essential component of urban planning.

"If urban transport is not managed well, it has the potential to choke cities and bring economic activity to a grinding halt." **(Agarwal et al., 2014)**



Need of Study

- Obtaining household information and trip characteristics in India poses a difficult undertaking
- Availability of data only from city transportation master plans and reports of other development plans
- Travel patterns are highly dynamic and are influenced by various socioeconomic and city development patterns; hence the data from the secondary sources loses credibility with every passing year
- To determine the per capita trip rate (PCTR), a specific set of instructions or a manual is needed



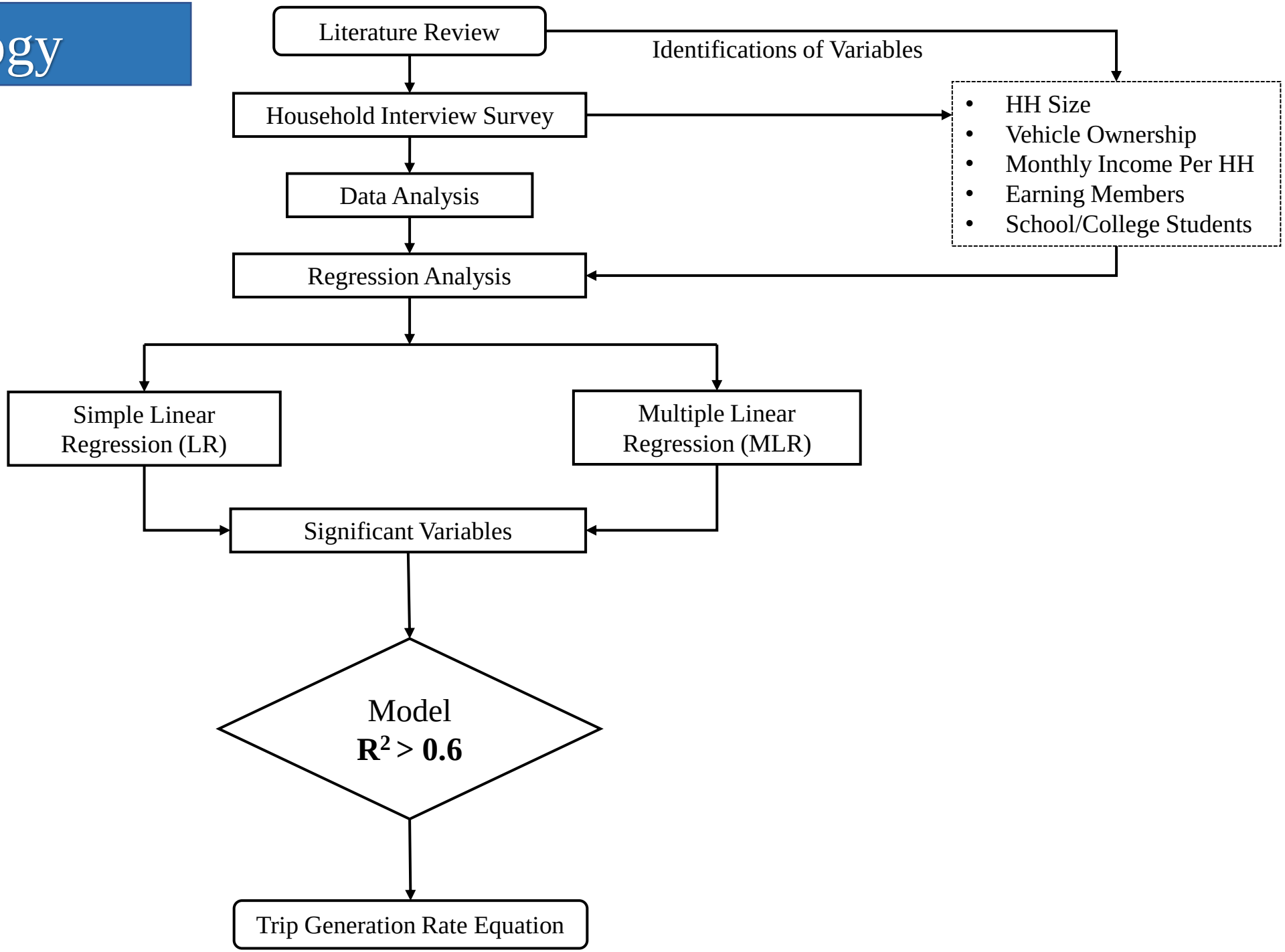
India is lacking in a set of guidelines or manuals for trip estimation for the Per Capita Trip Rate (PCTR).

Literature Review

Authors	Country	No. of HH Samples	Age	HH size	HH Income	No. of working member	No. of Students	Vehicle Ownership	Trip Characteristics	Type of Model	Method
(Shbeeb 2022)	Jordan	681		✓	✓	✓	✓	✓		Trip Rates	MLR
(Roorda et al. 2008)	Canada	5 % of total HH	✓	✓	✓			✓		Trip Rates	MLR
(Downes and Morrell 1981)	England	3288	✓	✓	✓	✓	✓	✓	✓	Trip Rates	MLR
(Saad and Al-Hassani 2011)	Bagdad	4000	✓	✓	✓	✓	✓	✓		Trips / HH (Total / Work / Education / Shopping / Other)	MLR
(Abu-Eisheh et al. 2017)	Jericho	713		✓	✓	✓	✓			Trips / HH	MLR
(Prasad and Molugaram 2018)	India	-		✓	✓	✓		✓		Trip Rates / Zone	
(Altaher et al. 2019)	Egypt	5116		✓	✓	✓	✓	✓		Trip Rates / Zone	MLR
(Faghri and Aneja 1986)	US	-		✓	✓			✓		Trips / HH	MLR & ANN
(Aderibigbe and Gumbo 2022)	Nigeria	512	✓	✓	✓	✓	✓			Trips / HH	MLR

* ANN = Artificial Neural Network, CC = Cross-classification, MLR = Multiple Linear Regression.

Methodology



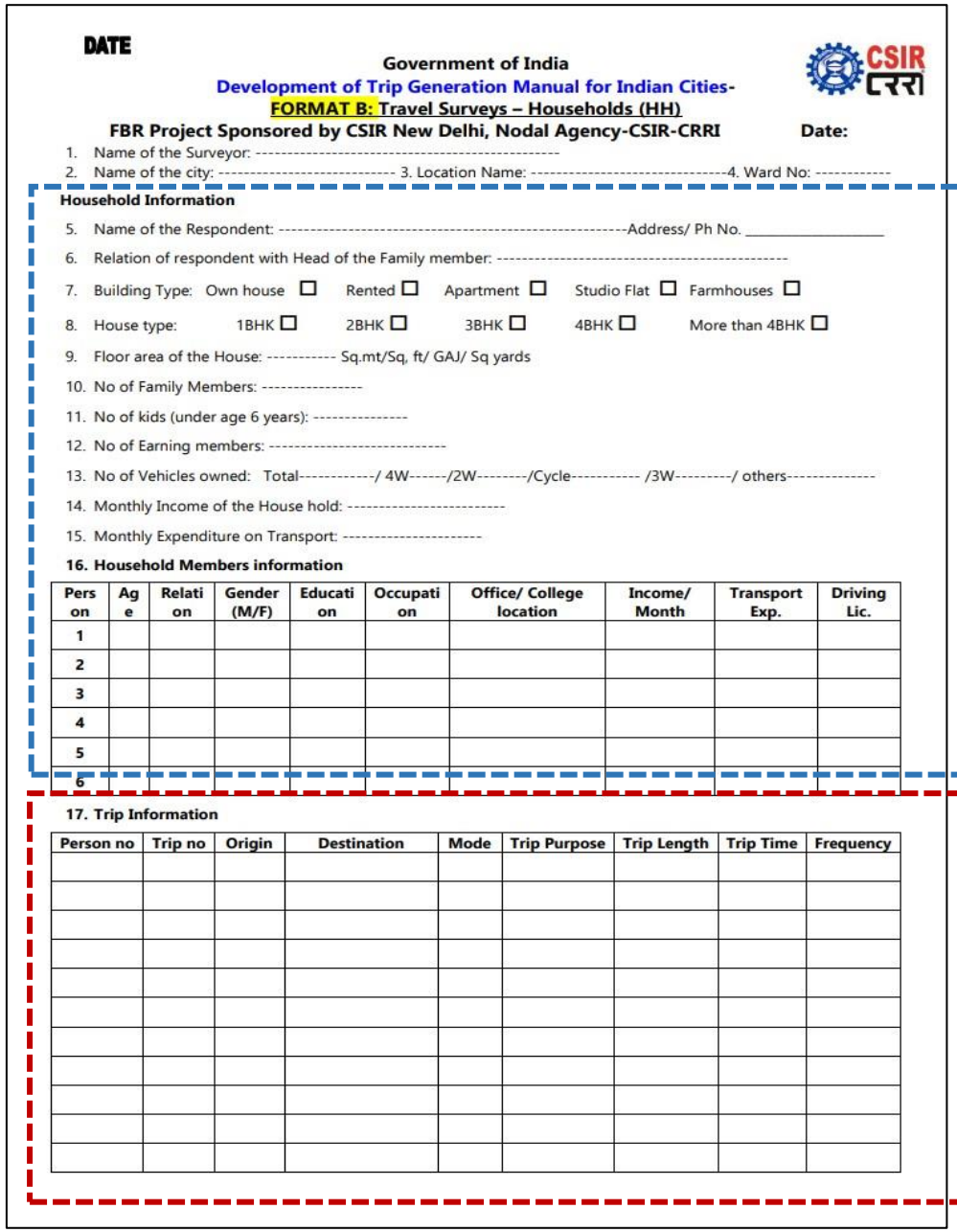
Study Area

(Source: Surat Municipal Corporation (SMC) website)

Category	Variables	Surat
Socio-Demographic Characteristics	Avg. HH Size	4.2
	Male (M) & Female (F) (%)	57 & 43
	Sex ratio (F/1000 M)	758
	Literacy rate (%)	96.62
	Avg. Monthly Income / HH (Rs.)	**31300**
	WPR	**46**
Vehicle Ownership	Avg. Vehicle Ownership / HH	1.36
	2w/1000 population	273
	4w / 1000 population	23
	Vehicles growth % (2017-18)	9
Trip Characteristics		
Mode Share (%)	2w & 4w	37.5
	NMT (walk/cycle)	42.3
	IPT	10.3
	PT & other	9.9
Puposes	Work	43.7
	Education	30.2
	Other	26.1
Avg. Trip Length (Km)	All Modes	5.01
	Including Walk	4.8
	Excluding Walk	5.7
Avg. Travel Time (min)		13-15
Avg. Per Capita Trip Rate (PCTR)	**Total**	**1.6**
	Motorised	0.93
	Excluding walk (0.5 km)	0.96
Road Network		3859

Source: Surat CMP-2046 (September 2018)

Questionnaire



DATE

Government of India

Development of Trip Generation Manual for Indian Cities-

FORMAT B: Travel Surveys – Households (HH)

FBR Project Sponsored by CSIR New Delhi, Nodal Agency-CSIR-CRRI Date:

1. Name of the Surveyor: ----------
2. Name of the city: ---------- 3. Location Name: ----------4. Ward No: ----------

Household Information

5. Name of the Respondent: ----------Address/ Ph No. _____
6. Relation of respondent with Head of the Family member: ----------
7. Building Type: Own house ☐ Rented ☐ Apartment ☐ Studio Flat ☐ Farmhouses ☐
8. House type: 1BHK ☐ 2BHK ☐ 3BHK ☐ 4BHK ☐ More than 4BHK ☐
9. Floor area of the House: ---------- Sq.mt/Sq, ft/ GAJ/ Sq yards
10. No of Family Members: ----------
11. No of kids (under age 6 years): ----------
12. No of Earning members: ----------
13. No of Vehicles owned: Total----------/ 4W------/2W--------/Cycle---------- /3W---------/ others----------
14. Monthly Income of the House hold: ----------
15. Monthly Expenditure on Transport: ----------

16. Household Members information

Person	Age	Relation	Gender (M/F)	Education	Occupation	Office/ College location	Income/ Month	Transport Exp.	Driving Lic.
1									
2									
3									
4									
5									
6									

17. Trip Information

Person no	Trip no	Origin	Destination	Mode	Trip Purpose	Trip Length	Trip Time	Frequency

Socio-Economic (Part-A)

- Household Size & Structure
- Gender
- Age
- Income
- Vehicle Ownership
- Monthly Expenditure on Transportation

Travel Characteristics (Part-B)

- Origin-Destination
- Trip length
- Trip cost
- Travel time
- Travel Frequency
- Trip purpose

Validate the Samples Representativeness to the Population

Mean Trip Rate	Sample Data	CMP	Std Dev.	Z value	P- value
	1.57	1.6	0.59	-0.86	>0.05
Household Size	**Sample Data**	**CMP**	**Std Dev.**	**Z value**	**P- value**
	3.67	4.20	1.08	-1.60	>0.05

CMP: Comprehensive Mobility Plan

The result of the Z-test indicate that there was no significant difference between the mean values, which supports the dataset representing the population of the city

Data Description

Descriptive Analysis of Sampled Data

Variables	Male & Female (%)	Sex ratio (F/1000 M)	Literacy rate (%)	Avg. HH Size	Avg. Vehicle Ownership / HH	Avg. Monthly Income / HH (Rs.)	Avg. Trip Length (Km)	Avg. Per Capita Trip Rate (PCTR)
Surat	55 & 45	800	97.2	3.67	2.35	68380	6.5	1.57

Purpose	WTR	ETR	SHTR	OTR	Total
PCTR	0.82	0.46	0.13	0.16	1.57

Purpose	PCTR
WTR	0.82
ETR	0.46
SHTR	0.13
OTR	0.16
Total	1.57

Income Category-Wise Employment in the Study Area

Income Group	Govt. Sector	Private Sector	Business	Self Employed	Retired	Worker/ Labor	Total
LIG	3%	21%	7%	5%	4%	9%	49%
MIG	4%	15%	9%	3%	4%	2%	37%
HIG	3%	4%	4%	1%	2%	0%	14%
Total	10%	40%	20%	9%	10%	11%	100%

Linear Regression (LR) Results

Dependent Variable	Independent Variable	R Square	Sig.	t	Const.	Coeffi.
TTR	HH Size	0.09	0.05	-2.82	1.73	-0.05
	Earning Members	0.05	0.00	6.49	1.34	0.15
	School/college going	0.02	0.00	3.94	1.48	0.08
	Vehicle Ownership	0.01	0.03	2.15	1.48	0.04
	Income Group	0.01	0.00	3.10	1.44	0.08
WTR	HH Size	0.10	0.00	-9.63	1.29	-0.14
	Earning Members	0.41	0.00	24.46	0.29	0.37
	School/college going	0.25	0.00	-17.19	1.03	-0.24
	Vehicle Ownership	0.01	0.36	-0.93	0.82	-0.01
	Income Group	0.02	0.24	1.18	0.76	0.02
ETR	HH Size	0.11	0.00	10.37	-0.04	0.15
	Earning Members	0.11	0.00	-10.47	0.75	-0.19
	School/college going	0.86	0.00	73.70	0.05	0.44
	Vehicle Ownership	0.00	0.22	1.22	0.45	0.02
	Income Group	0.00	0.74	-0.33	0.49	-0.01
SHTR	HH Size	0.30	0.00	-5.16	0.29	-0.05
	Earning Members	0.01	0.02	-2.44	0.17	-0.03
	School/college going	0.01	0.00	-3.42	0.16	-0.03
	Vehicle Ownership	0.01	0.01	-2.55	0.17	-0.02
	Income Group	0.00	0.59	-0.54	0.44	-0.01
OTR	HH Size	0.00	0.23	-1.21	0.19	-0.01
	Earning Members	0.00	0.27	-1.10	0.16	-0.02
	School/college going	0.02	0.00	-3.63	0.18	-0.04
	Vehicle Ownership	0.00	0.10	1.66	0.10	0.02
	Income Group	0.01	0.05	1.99	0.09	0.03

Variables	HH size	Earning members	School-college Students	Vehicle ownership	IG	TTR	WTR	ETR	STR	OTR
HH size	1.00									
Earning members	0.39	1.00								
School-college Students	0.43	-0.20	1.00							
Vehicle ownership	0.38	0.27	0.10	1.00						
IG	0.22	0.22	0.05	0.52	1.00					
TTR	-0.21	0.09	0.07	0.03	0.09	1.00				
WTR	-0.31	0.49	-0.46	-0.02	0.08	0.46	1.00			
ETR	0.20	-0.31	0.90	0.02	-0.03	0.13	-0.44	1.00		
STR	-0.14	-0.09	-0.10	-0.08	-0.03	0.49	0.08	-0.07	1.00	
OTR	-0.07	-0.03	-0.13	0.06	0.10	0.53	0.08	-0.14	0.09	1.00

- **HH size and Trip Rates show a negative relation except for ETR**
- **No of Students in HH are more with increasing HH size shows the positive correlation**

Multiple Linear Regression (MLR) Results

Model	Independent variable	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	R^2
		B	Std. Error	Beta			
Enter	(Constant)	1.635	0.066		24.952	0	**0.22**
	Income Group	0.058	0.025	0.078	2.274	0.023	
	HH Size	-0.265	0.022	-0.479	-11.846	0	
	Earning members	0.305	0.025	0.439	12.41	0	
	School/college Students	0.281	0.023	0.482	12.243	0	
	Vehicle Ownership	0.03	0.018	0.058	1.629	0.104	
Backward	(Constant)	1.635	0.066		24.934	0	**0.21**
	Income Group	0.076	0.023	0.102	3.322	0.001	
	HH Size	-0.257	0.022	-0.464	-11.773	0	
	Earning members	0.308	0.025	0.443	12.546	0	
	School/college Students	0.281	0.023	0.48	12.2	0	

Backward Elimination MLR Results

Dependent variable	Independent variable	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	R^2
		B	Std. Error	Beta			
TTR	(Constant)	1.64	0.07		24.93	0.00	0.21
	Income Group	0.08	0.02	0.10	3.32	0.00	
	HH Size	-0.26	0.02	-0.46	-11.77	0.00	
	Earning members	0.31	0.03	0.44	12.55	0.00	
	Sch-clg students	0.28	0.02	0.48	12.20	0.00	
WTR	(Constant)	0.98	0.03		28.46	0.00	**0.64**
	HH Size	-0.23	0.01	-0.50	-23.65	0.00	
	Earning members	0.44	0.01	0.76	36.17	0.00	
ETR	(Constant)	0.31	0.02		15.32	0.00	**0.89**
	HH Size	-0.08	0.01	-0.18	-13.12	0.00	
	Income Group	-0.01	0.01	-0.02	-2.05	0.04	
	Sch-clg students	0.49	0.01	1.02	77.02	0.00	
SHTR	(Constant)	0.30	0.04		8.55	0.00	0.04
	HH Size	-0.03	0.01	-0.12	-2.64	0.01	
	Earning members	-0.03	0.01	-0.08	-1.93	0.05	
	Sch-clg students	-0.02	0.01	-0.08	-1.78	0.08	
OTR	(Constant)	0.19	0.03		6.13	0.00	0.03
	Earning members	-0.04	0.02	-0.10	-2.76	0.01	
	Sch-clg students	-0.06	0.01	-0.16	-4.50	0.00	
	Vehicle Ownership	0.03	0.01	0.09	2.68	0.01	

- Work and education purposes showed higher R-square values, likely due to their daily nature

Equations for predicting future trip rates are to be Generated

$WTR = 0.98 - 0.23X_1 + 0.418X_2$	($R^2 = 0.64$)
$ETR = 0.31 - 0.08X_1 + 0.487X_3 - 0.014X_4$	($R^2 = 0.89$)

Where,

WTR = Work Trip Generation Rate

ETR = Education Trip Generation Rate

X_1 = Household Size

X_2 = Number of Earning members in the household

X_3 = Number of school/college students in the HH

X_4 = Monthly Income group of households

Thank you……..