ACCESSIBILITY OF PEDESTRIANS AFFECTED BY A NON-ACCESS CONTROL MULTILANE HIGHWAY – A CASE STUDY OF NH-8, INDIA

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ABSTRACT:

There is a growing optimism in using accessibility as the entry point in rural transport intervention in developing countries. The methodology of such planning is still evolving and there is scope for a more detailed method to identify appropriate measures aimed at addressing accessibility needs. In India, most of the highways are non-access control multilane highway providing median-cut as an only road crossing facility. Most of them are having some adjacent activities along the corridor. These adjacent activities play important role in socio-economic life of villagers living adjacent to such highways. Apart from the mobility of highway commuters, accessibility of such people living in adjacent village s is very much important for activity-based transportation planning. This paper describes the study which consists of two different sections on National Highway No.8; one with 4 lane wide roads (at village *Vav*) and other at 6 lane wide road (at village *Pipodara*) in *Surat* District, Gujarat, India. Both the locations are non-access control highway providing median-cut as an only road crossing facilities to the villagers. To understand how the people of these two villages access their neighbourhood area of the other side of the national highway; households and pedestrians' surveys have been carried out at both locations. Apart from this; speed data, accidents information, traffic volume count on highway and crossing pedestrians' counts have been collected. Descriptive analysis shows different factors may have an impact on accessibility i.e. landuse, road crossing facilities, width of road, speed of different vehicles, portion of village built up area on the other side of the road along with the type of activities, distance from highway, etc. Neighbourhood Accessibility of Pedestrains (NAP) has been measured considering many variables including the number of road crossings made for different purposes and by different modes. A binary logit model has been developed to see the difference in accessibility at both locations considered for this study. At the end, an understanding regarding interrelationship of accessibility and mobility has been included based on the characteristics of traffic flow and of highway commuters and vehicle ownership of adjacent villagers included in present study.

Keywords: Accessibility, Pedestrians, Mobility, Highways

INTRODUCTION

In the growing economy of India, most multilane highways are designed for fast traffic. However, it would be equally important to consider the accessibility of others i.e. people/villagers living adjacent to such multilane highways. The highway's design affects not only to the mobility of highway commuters but also the accessibility of such villagers who cross the road to access the area on the other side of such highway for different purposes. This accessibility is very important part of villagers as it helps in providing a good social and economic life which includes visiting the places, different places for shopping, recreation, working and everything a human being does meeting people surrounded by them. However, in present scenario, this accessibility is also dependent on road crossing facilities as crossing the multilane highway is one of the most essential and at the same time one of the most dangerous activities undertaken by villagers/pedestrians.

A new infrastructure like a multilane highway brings change to the people's access to the area including the neighborhood area. In country like India, major share of infrastructural changes are the transportation related infrastructural projects. Most of such transportation infrastructural projects have focused only on mobility part, as a result mobility has been increased (in terms of vehicle ownership, vehicle kilometer travelled, etc.) and as Cervero (1997) mentions "The increasing 'automobility' due to the focus on increasing mobility has, of late, led researchers to query whether increasing accessibility rather than increasing mobility should be the ultimate aim of transport policies". Any road infrastructure related action of the area should be taken based on the activities around that area. Vandenbulcke (2010) also says "any action must be taken by giving more importance to the quality of life than to road infrastructure". Since, good quality of life also depends on the accessibility of other areas and more importantly neighborhood area, it is very much important to know the change in accessibility while planning for such infrastructural changes. Marki (2001) says "greater accessibility means an increased quality of life for the individual (greater freedom to choose activities and more time to devote to them), and it is even more important for people with limited opportunities (e.g. low income) or physical disabilities".

This study addresses such people/villagers who are living adjacent to a non-access control multilane highway and their access to the area on the other side of the highway which is very essential for their daily social and economic life. Study has been carried out for two specific locations i.e. Vav (a village adjacent to 4 lane highway) and Pipodara (a village adjacent to 6 lane highway). Through utility equations, study compares pedestrians' accessibility to the neighborhood area for both selected locations, which are primarily villages adjacent to the same non-access control multilane national highway 8 of India.

ACCESSIBILITY, MOBILITY AND MEASURING VARIABLES

Before comparing the accessibility in terms of utility/disutility, it has been understood through different definitions. Definition of accessibility varies with the purpose of measuring. David et al. (1998) says 'Accessibility is a way of measuring the ease with which a particular category of persons can reach a defined set of destinations, from a given origin (origin accessibility), or the ease with which a given destination (destination accessibility) can be reached by a particular set of potential individuals. Accessibility is mostly understood as the easiness of reaching somewhere. This involves what mode provides easier and safer reaches, what destinations are

easy to reach compare to others, how infrastructure changes this easiness of reaching along with the other parameters like money, comfort, time, and distance etcetera. Black (1981) writes that accessibility is a function of land-use intensity and transport supply. According to Black (1992), accessibility is "a description of how conveniently land-uses are located in relation to each other and how easy or difficult it is to reach these land use activities via the transport network of both public and private transport modes." SEU report (2003) defines accessibility as the ability of people being able to get to key services at reasonable cost, in reasonable time and with reasonable ease. According to Litman (2003), accessibility refers to the ability to reach desired goods, services, activities and destination (collectively called opportunities). Access is the ultimate goal of most transportation. This perspective considers all access options as potentially important, including motorized and non-motorized modes. According to Geurs et al. (2001) accessibility is the extent to which the land-use transport system enables (groups of) individuals or goods to reach activities or destinations by means of a (combination of) transport mode(s). Handy (2004) simply defines accessibility as the ability to get what you need, ideally with a choice of destinations and using a choice of modes. Most important here is to understand that it is the definition of accessibility, which decides that, which variables to be considered in the measurement of accessibility.

At this point it would be worth noting that the terms "accessibility" and "mobility" are often used together in transportation plans but without clear distinction. Vivier (2001) defines mobility as "motorized mobility, measured by average annual distances traveled by city dwellers in automobiles, motorized two-wheeled vehicles, taxis and public transport". Ross (2000) defines mobility as the "amount of travel people undertake" and measures it by per capita vehicle kilometers traveled. He shows (Ross, 2000) that accessibility and mobility has a relationship of reciprocity and if planners aim to increase accessibility then car use and personal mobility must be restricted. According to Litman (2003), mobility is "the movement of people or goods. It assumes 'travel' means person-or-ton-miles, 'trip' means person-or-freight-vehicle trip. It assumes that that any increase in travel mileage or speed benefits society. The mobility perspective defines transportation problems in terms of constraints on physical movement, and so favors solutions that increase motor vehicle system capacity and speed….it gives little consideration to walking and cycling except where they provide access to motorized modes". According to Litman (2003), mobility is a subset of accessibility and the latter is a more comprehensive and inclusive definition of the transportation needs of the society.

While Roberts (1988) sees mobility as the number of kilometers traveled, he measures accessibility as the number of trips made. Further he argues that the "number of, and/or the ease of making journeys" are more related to accessibility (Roberts, 1990). He notes that fewer kilometers traveled (that is, less mobility) equates to a higher quality of life. Arora and Tiwari (2007) defines, accessibility is a description of the proximity of destinations of choice and the facilitation offered by the transport systems (including public transport and non-motorized modes) to reach them. Mobility is both ability to travel to destinations of choice and the amount of movement necessary to do so.

DEFINITIONS AND OBJECTIVES OF THE STUDY

In the present case, accessibility has been defined as the easiness of reaching to the area of other side of the highway i.e. from side A to side B and different variables to be considered for measurement of this accessibility have been decided based on the field data/information. Further, present study considers mobility as an easiness to drive motorized vehicles.

- First objective of the study is to understand factors affecting to the pedestrians' accessibility for present scenario and to develop broad understanding of interrelationship between accessibility and mobility.

- Second objective is to compare pedestrians' accessibility to the area on the other side of the highway in case of 4-lane and 6-lane non-access control situation when a median break is the only provision for road crossings.

STUDY AREA AND DATA COLLECTION

Study has been carried out at two locations on National Highway no 8 of India as shown in figure 1. At both the locations highway is non-access control 4-lane and 6-lane road. Two selected locations are village *Vav* (adjacent to 4 lane highway) and village *Pipodara* (adjacent to 6 lane highway). Both the villages of Gujarat state are typical rural settlement which primarily involved in agricultural and allied services.

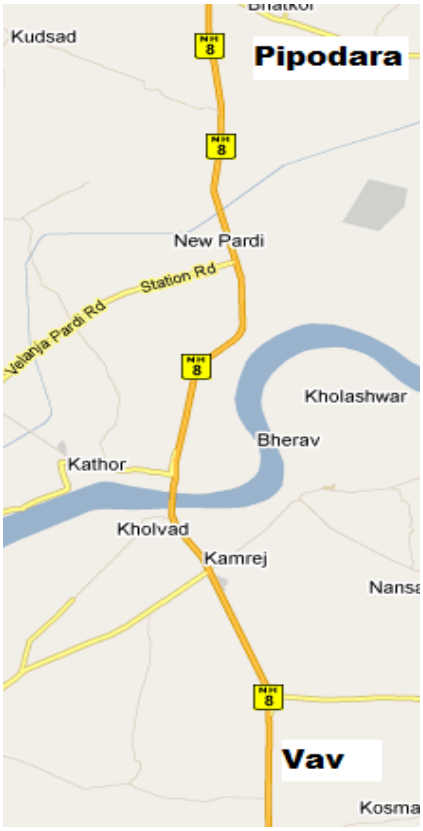

Figure1: Study area on Google map

Table 1 provides primary information of two studied locations. This shows how these two locations differs in terms of population living in these settlements, average distance from the location of the house to the highway, crossing facility, and the broad land use along the highway as observed during field visits.

Table 1: Basic information regarding two studied locations

Description/Parameters	***Vav* Village**	***Pipodara* Village**
Highway type	4 lane road	6 lane road
Population (persons)	6649	2611
Average distance from individual's house to highway (collected through household surveys)	0.83 km	0.45 km
Highway crossing facility	Median cut	
Land use	Mixed land use in both cases however in case of *Vav*, major part of the area is on one side of the road however, for *Pipodara*, area is nearly half on both sides of the highway	

Photograph 1 shows location of *Pipodara*; buildings adjacent to highway provide information regarding the amount of activities taking place on this stretch of highway. Photograph 2 shows the school children walking along the highway at *Vav* village. This shows how highway has been used for daily trips made by children.

Photograph 1: Buildings adjacent to road and animals crossing the highway at Pipodara village

Photograph 2: School children walking along the highway at Vav village

Further, figure 2 presents the line diagram of studied area. Line spacing on both sides of highway presents density of activities. i.e. closer lines represents more activities (at *Pipodara* towards Kim) and wider spacing shows less activities (at *Vav* in all four arms of the intersection)

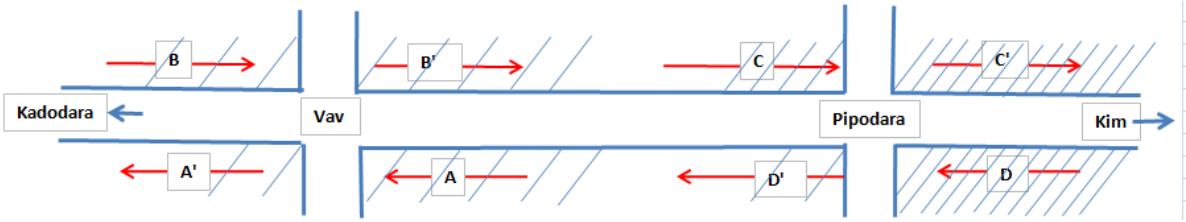

Figure 2: Amount of activities adjacent to Highway at *Vav* and *Pipodara*

Information regarding 'amount of adjacent activities' has been included in studied. Apart from this other information have been collected through different surveys as listed below:

(i) Household Survey - adjacent village residents
(ii) Pedestrians' interview – crossing the highway
(iii) Classified Vehicles Counts and
(iv) Speed survey – spot speed of different vehicles on highway at different locations and directions

Table 2 provides details of sample size carried for each type of survey

Table2: Number of commuters/Households interviewed at *Vav* and *Pipodara*.

Location	Household Survey	Pedestrians' Survey	Shop Keepers' Survey
Vav village	118	288	72
Pipodara village	62	133	32

Household and Pedestrians' Survey

Households and pedestrians' surveys have been carried out to collect socio-economic characteristics of household members and trip information of commuters with the details of trip purpose, mode, distance, etc. Further, year wise vehicle ownership of the households also has been collected during the surveys. Apart from this; household members have been asked if they need to cross the highway mainly to buy/sell vegetables/milk on daily bases and also for going to school purposes. Further, among these household members' trips; total number of trips made involving highway crossing (for all purposes) per family have been collected through personal interviews (Stated data).

Primary analysis of the collected data at both location i.e. *Vav* (sample size 288) and *Pipodara* (sample size 133) shows that average household size is almost the same for both villages i.e 4.76 and 4.82 persons per family for *Vav* and *Pipodara* respectively. Average distance from the household to highway is higher in case of *Vav* compare to *Pipodara* as shown in Table 3. The data shows that more household members are crossing the highway at *Vav* (70%) for buying the vegetables/milk etcetera compare to *Pipodara* (32%). However, there is a less difference in case of trips made for educational purpose in both case i.e. 77% in case of *Vav* and 73% for *Pipodara*. Apart from the absolute number of such trips it has been observed during the survey that most of the school-trips have been made in large groups at both places especially at school closing times.

Table 3: Characteristics of village commuters

Description	***Vav*** **(4 lane wide road)**	***Pipodara*** **(6 lane wide road)**
Sample size	288	133
Average household size	4.76	4.82
Years of staying in village	35	42
Average distance from house to highway	0.83 km	0.45 km
Do you have to cross the highway for buying milk, vegetables?	201-yes (70%) 87-No (30%)	42- Yes (32%) 91- No (68%)
Do you have to cross the highway for going to school?	223-Yes (77%) 65-No (23%)	97 – Yes (73%) 36 –No (27%)
How many times your family crosses the road in a day? (trips per household)	3.87 (average) 5 (85^{th} percentile)	7 (average) 7 (85^{th} percentile)

Data collected from the crossing commuters' volume count shows that majority of pedestrian crossings have been made by school children. During morning hours school children crosses the highway individually or in a very small groups. However, at school closing times, children form big groups to cross the road at *Vav* village (4 lanes). However, at *Pipodara* (6 lanes), pedestrian crossing includes two main group of people. First one is the school children and another one is milk-supplying ladies. As 'Doodh Mandali' (milk collection point) is located at one side of the highway; all milk supplying people have to come on the other side of the road twice a day to deposit milk at collection point. However, it is important to notice that at both places major numbers of pedestrian trips have been made in a group. One of the opinions shared by most of the commuters was that crossing the road in a group is safer than crossing individually. This is considered as an important indicator that accessibility to the area other side of the road is good for a person moving in a group compare to the person moving alone.

Speed Data

Spot speed data have been collected at both studied locations using radar speed gun for randomly chosen vehicles. Table 4 shows the average vehicular speed for different types of vehicles. This shows a higher value of vehicular speed at *Vav* which is a 4 lane wide road for all types of vehicles compare to the 6 lane wide location of *Pipodara*. However, one can expect higher speed at wider road i.e. 6 lane at *Pipodara* but the approach area towards the intersection is quite different in both cases. In case of *Pipodara*, there are more activities adjacent to road compare to *Vav.* These activities have reduced vehicular speed at the location of Pipodara where road geometry provides a median cut for highway crossings and U-turn movements.

Table 4: Classified Vehicular Speed at studied locations

Vehicle Type	Speed (km/hr)							
	Vav (A)	*Vav* (A')	*Vav* (B)	*Vav* (B')	*Pipodara*(C)	*Pipodara* (C')	*Pipodara* (D)	*Pipodara* (D')
2-Axle	57	56	56.5	57	56	52	54	55
3-Axle	59.2	57	58	58	55	52	53.5	55
Multiple	52	51.5	53	52.5	51	49	49	52
Road Dumper	NA	45	NA	NA	NA	NA	43.65	45
Tempo	66.75	65	68	67	64	62	61.1	64
Car, Jeep, Van	82	81.5	83	84	82	80	78.2	81
Bus	64.75	63	65	64	62	60	60.95	62
*Chakdo Rickshaw	50	51	49	50	47	40	45.6	46
Motorised two-Wheeler	68	68	67	68	64	56	58.95	60

** Chakdo Rickshaw is a kind of intermediate public transport*

This indicates that apart from the road geometry, amount and type of activities adjacent to highway plays role for higher/lower speed of vehicles on highway. Highway stretch with more adjacent activities has lower vehicular speed (Figure 2 i.e. D and C') compare to highway stretch with fewer activities (i.e. *Vav* intersection).

Further, at both locations; all type of vehicular traffic (table 4) has been observed including the Motorised two wheeler and Chakdo Rickshaw (a kind of intermediate public transport). Presence of such vehicles on the highway shows that the road has been used for local movements as well.

Accident Data and Analysis

Since, at both locations fatal, grievous and minor accidents have been recorded, accident data have been collected for the period of 15 months (i.e. from April 2009 to June 2010) from Toll Road Patrolling Group (TRPG). (terms fatal, grievous and minor accidents have been kept as defined by TRPG) Each accident has been recorded even if not reached to the police station. Table 5 shows accident data on this stretch of the National Highways.

Table 5: Accident data for Vav and Pipodara

Accident Type	Number of accidents per km	
	Stretch I (4 lane)	Stretch II (6 lane)
Total accidents	13.48	11.70
Fatal accidents	1.19 (9%)	2.22 (19%)
Grievous accidents	3.82 (28%)	4.95 (42%)
Minor accidents	8.44(63%)	4.49 (39%)

Though, data for 15 months may not be sufficient for accident analysis, some analysis and conclusions have been made on available data. The data shows that the total number of accidents per kilometre is higher along the stretch I which is a 4 lane road i.e. 13.48 accidents per km for the period of 15 months compared to stretch II which is a 6 lane road i.e. 11.70 accidents per km. However it is important to note that Population of Vav is 2.5 times more than Pipodara. It has been analyzed that fatal accident rate per km per unit population is higher for Vav village as this may be due to higher vehicular speed has been observed at this location. While comparing the minor accidents rate per km per unit population, it is higher at Pipodara. This may be due higher pedestrians' crossings per unit population at Pipodara.

Traffic Volume

The traffic volume data for the section has been obtained from the toll plaza which is located at middle point of selected two villages. Month wise data regarding the vehicles paying toll has been presented in table 6. This table provides information regarding the amount vehicular activities going on at studied stretch of national highway 8.in addition to this traffic volume, local movements also ply on this section which has not been included in these tabular data.

Table 6: Counted on toll plaza (Choryasi toll plaza)

Month/Vehicle Type	Car	LCV	Truck	Heavy Truck
Jun-10	171356	85070	160180	228481
May-10	203437	89149	1765084	248928
Apr-10	169389	97009	178458	263276
Mar-10	169110	101759	185786	273093
Feb-10	156039	94362	186709	252104
Jan-10	195228	104999	200851	271281
Dec-09	231443	109903	210947	278754
Nov-09	191597	95346	194058	260533
Oct-09	250948	96817	185257	246103
Average traffic Per month	193172	97157	363037	258061
Average traffic Per day	708	356	1330	945

**This does not include the local traffic movement counts.*

The crossing pedestrian movement at these two locations have been counted on a normal working day. Table 7 provides hourly distribution of pedestrian crossings at selected locations of *Vav* and *Pipodara*.

Table 7 shows crossing pedestrian volume counts

Pedestrians'' Crossing (absolute numbers)		
Location/Time	*Vav*	*Pipodara*
4:00 to 8:00 *	80	250
8:00 to 9:00	40	20
9:00 to 10:00	45	19
10:00 to 11:00	108	50
11:00 to 12:00	24	22
12:00 to 1:00	26	18
1:00 to 2:00	22	16
2:00 to 3:00	22	15
3:00 to 4:00	50	24
4:00 to 5:00	51	23
5:00 to 6:00	179	72
6:00 to 7:00	75	214
7:00 to 8:00	38	26
considering all	760	769
without school and *Doodh mandli* (milk collecting centre) trips	473	397

**Note: values have been estimated based on number of children trips observed at school closing time and number of trips observed in the evening for milk deposit purpose*

It has been observed in the survey that the major purpose of pedestrian crossing the highway is basically to milk deposit and school going purposes. At *Vav* village, initially more number of pedestrian crossings had been expected due to the higher population living in the village. However, more number of pedestrian crossings at *Pipodara* has been observed. In village Pipodara, more number of people crosses the road to deposit the milk at milk collection centre which located on the other side of the highway. Observed pedestrian counts shows that if trips made for school and Doodh mandli have been deducted; then *Vav* has more number of trips. However, the difference is not huge and that may be because of the distance from household to highway is more in case of *Vav* comparing to *Pipodara* which may be acts as an impedance for accessibility.

Based on the study, some observations have been made as listed below:

- Increased mobility of highway commuters has inverse relationship with the accessibility of pedestrians crossing the highway
- Increased mobility also results in reduced safety
- Safety and accessibility have proportional relationship

DEVELOPING MODEL TO MEASURE NEIGHBORHOOD ACCESSIBILITY OF PEDESTRIANS (NAP)

The model for measuring neighbourhood accessibility of the pedestrians (NAP) crossing the non-access control multilane highway has been developed. This model is based on the stated data collected through household survey, pedestrians' survey, traffic volume, speed data and accident data. Based on collected information, accessibility measuring model has been developed which is

based on random utility theory with the limitation lies regarding the data. As the data available for accidents are for 15 months and pedestrian counts are single day observations.

This model measures the accessibility of the area on the other side of the national highway. The utility-based measure is based on an individual's perceived utility for different travel choices. The most general form of this measure is:

$$A_n = E\left[\underset{i \in C}{Max}\, U_{in}\right] = \ln \sum_{i \in C} \exp(V_{in}) \quad \ldots\ldots (1)$$

The method of calculating accessibility for an individual *n*, is the expected value of the maximum of the utilities (U_{in}) over all alternative *i* in choice set *C*. The utility is determined by taking the logsum of V_{in}. This is a linear function with elements representing factors related to accessibility. In present utility based binary logit model, dependent variables is the location i.e. 4 lane road (i.e. *Vav*) and 6 lane road (i.e. *Pipodara*) and independent variables considered are

- Number of trips made by crossing the national highway in a day per household
- If highway has been crossed to buy vegetables/milk or not?
- If highway has been crossed to reach to the educational building or not?
- Amount of activities adjacent to highway – measured in terms of number of shops/houses adjacent to highway
- Age of commuters

As a first step inter-correlation has been checked for each variables and the result have been presented in figure 4. It shows that the correlation among different variables, the correlation factor and significance value in bracket. This indicates highest positive correlation between speed and number of fatal accidents exists i.e. as speed increases, number of fatal accidents increases. Correlation between speed and number of crossings has negative correlation as expected because vehicles plying on higher speed make pedestrian crossings difficult. Number of crossings has a positive correlation with the number of minor accidents and amount of activities adjacent to highway. Interestingly, correlation among amount of adjacent activities and number of fatal accidents has a negative sign. This shows that adjacent activities are playing important role in number of accidents i.e. more adjacent activities are responsible for higher number of minor accidents however at the same time contributing to reduce number of fatal accidents.

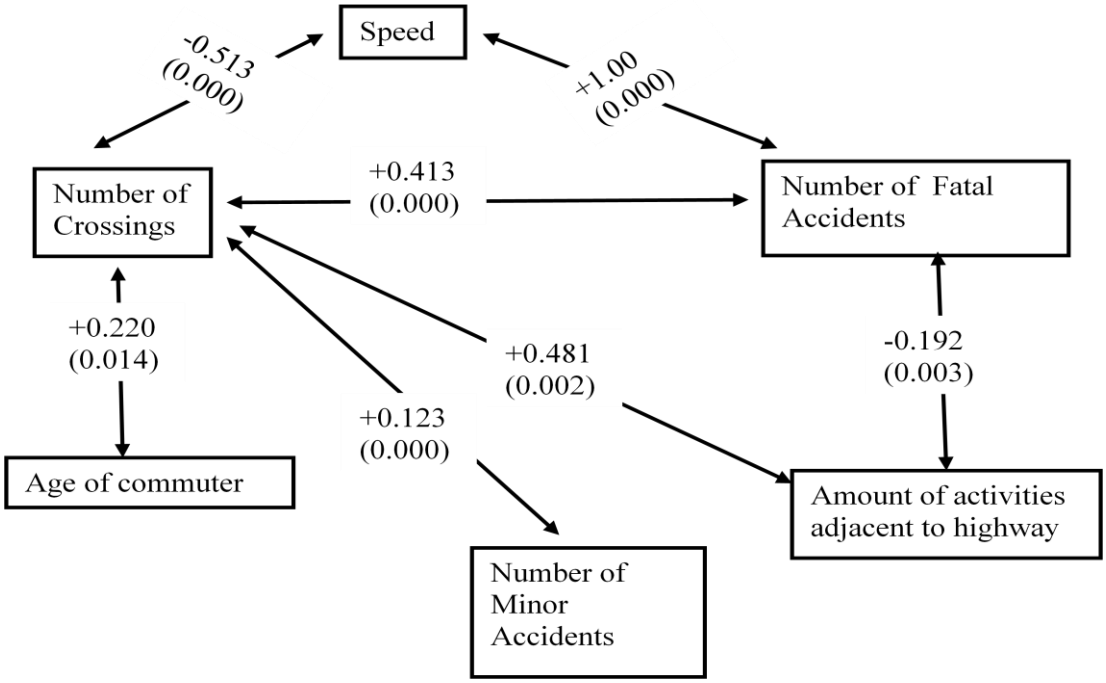

Figure 4: Correlation among different variables

To check the significance of different variables in utility equations Table 8 presents the p-value for each variable. Seven significant variables have been considered to measure the accessibility , viz., X_1= age of the people, X_2 = gender, X_3 = distance of home from highway, X_4 = number of crossings made for purchase of vegetable and/or milk per household, X_5 = total number of crossings made by all members of a household, X_6 = owned number of motorised two wheelers, X_7 = cars ownership and an alternative specific constant.

Table 8: Binary Logit Model parameters and Interpretation

Variables	B	S.E.	Wald	Significance	Exp(B)
X_1 age of the people	.031	.008	14.049	.000	1.031
X_2 gender	-.729	.304	5.728	.017	.483
X_3 distance of home from highway	-1.074	.247	18.897	.000	.342
X_4 number of crossings made for purchase of vegetable and/or milk per household	1.794	.292	37.632	.000	6.012
X_5 total number of crossings made by all members of a household	.321	.059	29.100	.000	1.378
X_6 owned number of motorised two wheelers	-.744	.321	5.369	.020	.475
X_7 cars ownership	-1.371	.529	6.726	.010	.254
Constant	-1.612	.840	3.678	.055	.200

Highest coefficient of 1.794 is for the number of crossings made for buying milk/vegetables. This indicates, crossing for this purpose play major role in accessibility. This is obvious as this purpose can decide the accessibility importantly. Distance of origin and/or destination from the highway has negative coefficient value of 1.074. As pedestrian trip starts and/or end away from the highway; chances for crossing the road decreases. Car and MTW owning pedestrians are less likely to cross the road by walk. Further, this chances are even lesser for car owners (as coefficient value is 1.371) compare to MTW owner (coefficient value is 0.744).

Neighbourhood Accessibility (NA) = (-1.612) + (0.031*Age) + (-0.729*Gender) + (-1.074*Dist_hwy) + (1.794*Crs_veg/milk) + (0.321*Crs_total) + (-0.744*Own_MTW) + (-1.371*Own_car)

Based on developed NAP model, values have been calculated for commuters of *Vav* and *Pipodara*. Table 9 shows 85th percentile and average accessibility value for three different distance ranges i.e. distance of any household from highway is less than 0.5 km, distance between 0.5 and 1 km and when distance is more than 1 km. Figure 5 show comparison of average accessibility for both locations. This indicates that accessibility is higher for *Pipodara* in all ranges of distances. Further, the decrease in accessibility with the increase of distance between house and highway reduces the accessibility in both cases.

Table 9: Accessibility value for different distance ranges

PIPODARA	Dist < 0.5 km	0.5 km < Dist < 1.0 km	Dist > 1 km
Pipodara_Average	3.008	2.129	1.394
Pipodara_85th percentile	4.726	2.905	1.690
Vav_Average	2.623	1.725	1.119
Vav_85th percentile	1.048	2.814	2.201

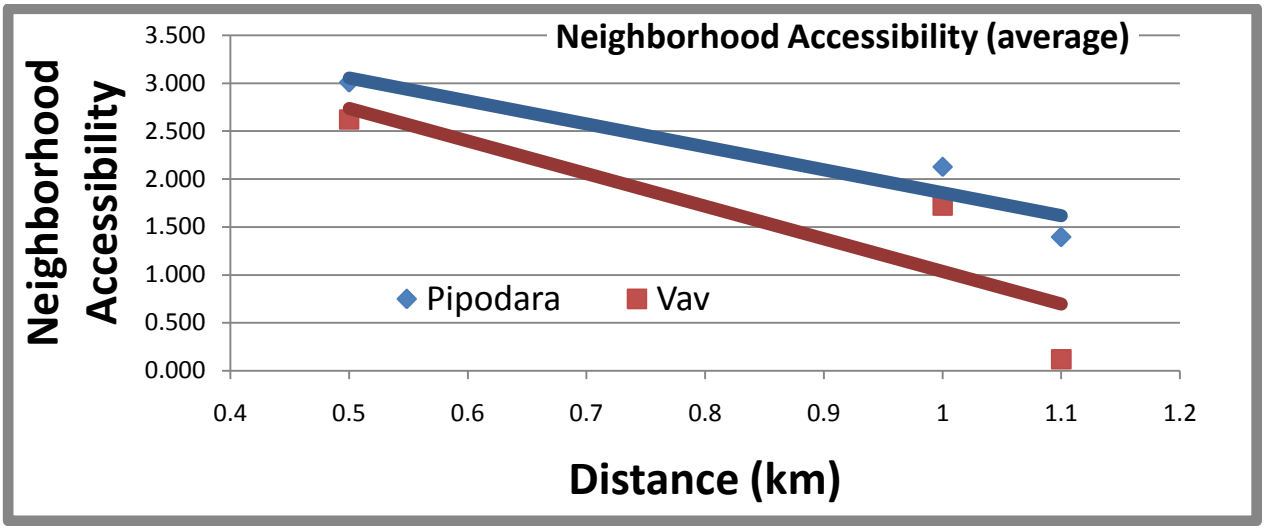

Figure 5: Comparison of accessibility index at *Vav* and *Pipodara*

UNDERSTANDING OF MOBILITY INDICATORS

Mobility based strategies generally focuses on improving the flow of traffic and performance of the system. Road building i.e.construction of new roads and the expansion of existing roads, has long been the dominant mobility based strategy. However, change in mobility also leads to change in accessibility upto some extent. present study includes mobility as well as accessibility of villagers living adjacent to a national highway at *Vav* and *Pipodara*.

Figure 6 shows comparison of two wheeler ownership per household in *Vav* and *Pipodara* which is collected during household and pedestrians' interview. This figure 6 also shows that two wheeler ownership is higher for *Vav* compare to *Pipodara* during most of the time except for the year 2001 where marginal higher ownership has been seen for *Pipodara*. This may be one of the indicators of increased mobility of the locals where accessibility of neighbourhood area is low.

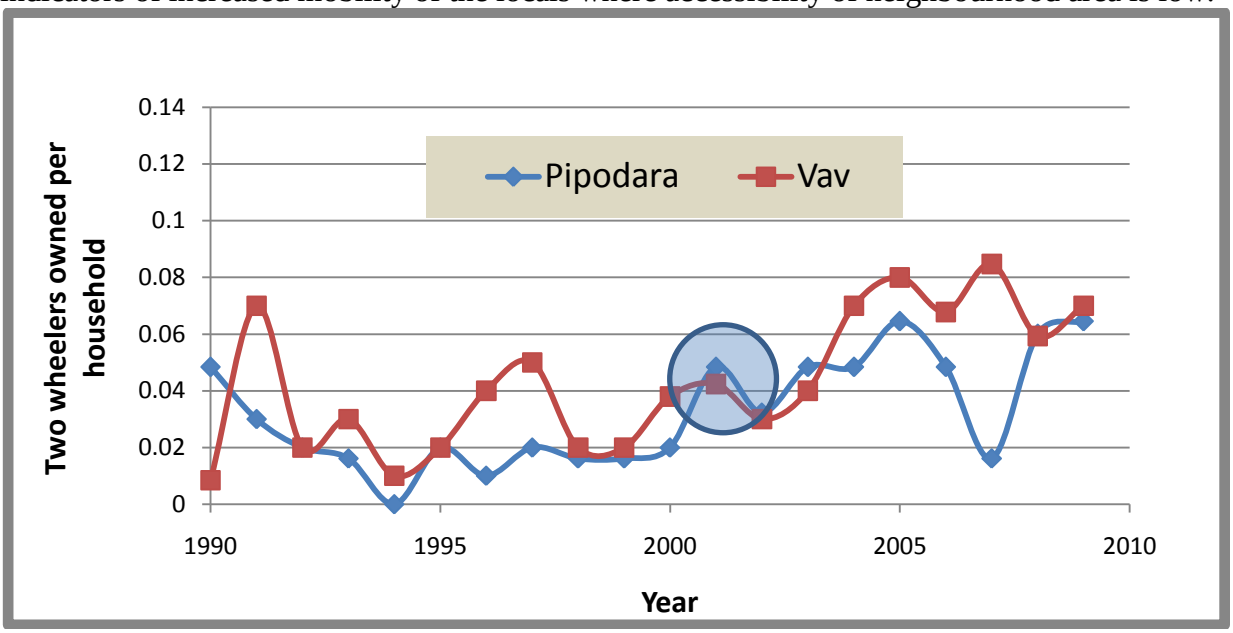

Figure 6: Motorised Two Wheeler ownership at Vav and Pipodara

Mobility of highway commuters which are primarily the motorised vehicle users can be compared in terms of speed, delay and number of vehicles passing per hour. Data regarding the number of vehicles passing per hour (Table 6) is for a location of toll plaza located between two studied villages (*Vav and Pipodara*) collected and presented to understand the traffic volume of the section of the National Highway. Since, the traffic volume data is not representing both locations, the vehicular speed collected at the two locations were consider for developing mobility indicators. Therefore, mobility compared for present case is based on speed only. Data shown in table 4 indicates that mobility is higher in case of Vav compare to Pipodara. Further, numbers of motorised vehicles crossing at Vav and Pipodara have been compared. Number motorised vehicles (car, jeep, van, tempo, chakdo, motorised two wheelers & bus) crossing the road at Vav and Pipodara are 0.28 vehicles/person and 0.18 vehicles/person respectively. While comparing the ownership of the motorised modes (alternate accessible mode to pedestrian trips) and the speed (mobility) on highways we can arrive a kind of relationship and shifting nature of the mode based accessibility of the local pedestrian. This situation may create conflict zones on

the high crossing points and warrant for alternative design to accommodation the pedestrian crossings and also the motorised vehicular crossing on the highways to improve safety measures.

CONCLUDING REMARKS

Vehicles passing on highways get affected by the crossing movements of pedestrians/vehicles when it passes through village/habituated area. Similarly, accessibility of people living adjacent to highways also gets affected due to vehicular movement of highway. These conflicts may result in accidents, speed reduction of vehicles, change in accessibility, vehicle ownership, etc. Since, highway improvement projects generally been justified based on the time saving of vehicles passing through the highway, it hardly calculates the changes happen in the people living adjacent to such highways.

Descriptive and primary analysis of collected data for present study indicates that not only the road geometry but also the amount of activities taking place adjacent to the highway changes the speed of vehicles on road. Further, this change in speed effects to the crossing movement made by pedestrians.

Since, more conflicts also contribute towards more number of accidents. Interestingly this share more towards non-fatal accidents compare to fatal accidents happening where speed is high in absence of activities adjacent to highway.

Present study has focused on the issue of pedestrians' neighbourhood accessibility. Therefore, it has been recommended that road passing through village/habituated area should be treated as an arterial road rather than as a highway if amount of adjacent activities is high. However, if there is very less crossing activities on a stretch of road then that can be treated as a highway with the provision of suitable crossing facilities and/or service lanes to maintain and improve the accessibility of neighbourhood area.

For specific case of present study locations following recommendations have been made:

- At *Pipodara,* since amount of adjacent activities is high, suitable crossing facilities i.e. a well ventilated underpass which handles animal crossings and pedestrian crossing is recommended. Median opening is not sufficient for safe accessibility.
- At *Vav,* amount of crossing trips for a day is high but most of the trips take place in huge groups. Therefore, a signalised crossing facility by providing 'press the button to cross the road' or 'sensors' may be installed.

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