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Effects of non-motorized vehicles on urban Indian roads

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ABSTRACT

The aim of the study is to improve the roads conditions in Nagpur City. For study purpose, four areas of Nagpur city are selected where the flow of Non-Motorized Vehicles (NMV) is high. The survey was taken on Non-motorized user perception about safety, visibility, crossing, comfort, convenience. The survey was done by asking questions to non-motorized users and their view was collected as data, and analysis was done in MS Excel. Further by using the Inverse Variance Method, the value of the Bicycle Compatibility Index (BCI) is found. With the help of BCI, each road Level of Service (LOS) is known. Further, the improvements measures with suggestions are discussed in this paper for proper planning and designing of roads for Non-Motorized Transport (NMT).

Keywords— *Non-motorised vehicles, Bicycle compatibility index, Level of service, Non-motorized transport*

1. INTRODUCTION

In India, Non-motorized transportation plays a vital role in transits system to carry people and goods from one place to another. Non-motorized is totally dependent on human resources but, it affects the traffic stream flow. Non-motorized transportation is very effective transits system because it provides numerous benefits of Non-motorized transport to people like providing health benefits, providing comfort in travelling, solving problems if traffic congestion, reducing pollution problems in the environment, increase economic growth etc.

In India, the conflicts are increasing between motorized and non-motorized vehicles due to lack of management of Non-Motorized Vehicles and Motorized Vehicles Movements. As separate lane is not provided for NMVs, due to this the traffic flow on roads are disturbing. To avoid conflict it is important to segregate Non-motorised vehicles and motorised vehicles as soon as possible. And allowing Non-motorized vehicles to mix with a motorised vehicle to avoid motorised vehicle speed.

In Nagpur, the amount of accidents of pedestrians and bicyclists is increasing day by day. A proper study is needed to overcome accidents of Non-motorized vehicles on urban roads as the flow of non-motorized vehicles is more on Nagpur roads. Due to Non-motorized user, the traffic flow is disturbed in Nagpur as there is a need for separate lane for safety and efficient flow of traffic stream. So, a proper study is needed by traffic agency to discuss the issues of Non-motorized transport.

2. OBJECTIVES

(a) To recognize the factors that affect Non-motorized transport in Nagpur city.
(b) To calculate Bicycle Compatibility Index (BCI) to find the Level of Service (LOS) of the study area for Non-motorized transport.
(c) To suggest improvement measures for the betterment of Roads conditions by increasing the level of service.
(d) To provide suggestions to improve non-motorized transport parameters on Indian Urban roads.

3. PURPOSE OF THE PROJECT

(a) For a better understanding of factors that Non-motorized transport.
(b) To provide suggestions to improve the parameters like Safety, Visibility, Crossing, Comfort, Convenience for Non-motorized transport.
(c) To implement an appropriate method for improving the Level of Service for Non-motorized transport on Indian Urban Roads.
(d) Communicate the primary factors affecting non-motorized transport by motorized transport in Indian Urban Roads.

4. LITERATURE REVIEW

The traffic volume in India is increasing rapidly which increase in traffic accidents and congestion on Urban India Roads. Due to this, Non-motorized Vehicles get affected. The study is important to make the flow more proper which will be beneficial for the users. The researcher work of some researcher which is helpful for work is discussed below:

Md. Mizanur Rahman, Izumi Okura, and Fumihiko Nakamura (2003) Conducted a study on "Analysis of effects of Non-motorized vehicles on urban road traffic characteristics**"** for is research study he had taken Bangladesh's rickshaws and rickshaw-van. In many cities, Rickshaws plays an important role to carry people and goods from one place to another. In Dhaka, 70 per cent of total traffic is Non-motorized vehicle and the uses of bicycles are more than any other Asian countries. There is no methodology provided in Highway Capacity Manual for Non-motorized Vehicles in mixed traffic flow considering traffic parameters. Due to this reason, the study is done on the factors affecting of non-motorized vehicles on traffic parameters, the aim of this study is to present analytical procedure of heterogeneous traffic flow and to develop models of passing/overtaking and lane-utilization for heterogeneous traffic flow.

M. R. Mat Yazid, R. Ismail, R. Atiq (2011) Conducted a study on "The Use of Non-Motorized for Sustainable Transportation in Malaysia" In this paper, Non-motorized play vital role for sustainable living. In India, the Transit system is no longer sustainable which had affects the mobility of life. For the betterment of the future, sustainable transport is needed to be designed. The objective of this paper is to provide methods by transportation planning to choose the right transport modes by users who used motorcycle to non-motor vehicles by the integration of land use. By doing this improvement there will be increased in the amount of percentage of pedestrians and bicyclists will result in reduction of the use of motor vehicles users and this will lead to the reduction of carbon. In addition, it will improve healthy lifestyles and physical activities.

A.K.M. Abir & Md. Sami Histamine (2016) Conducted study on "Traffic volume study" In this study engineering methods and techniques are used by traffic engineers to achieve free flow of people and goods on from one place to another. The free flow depends on the traffic parameters. The three main traffic parameters of traffic flow are volume, speed and density. For the future need of the city, traffic management of the city needs effective planning. The amount of pedestrian and bicyclists are increasing day by day. In this paper, the study is related to traffic parameters in the Dhaka city at the selected junction. In this project, stress was given on traffic volume. The analysis was done by dispensed through the primary traffic flow survey. Traffic flow is examined by manual methods. For a better understanding of the present status of traffic flow at the junction, traffic survey is taken. With the help of the survey and data collection, the study was done to understand the traffic patterns with respect to different time periods which mostly depend on traffic flow parameters. Hence the help of results from the project is useful in dominant the traffic at the intersection. In future, it will provide measures in the improvement of traffic safety within the region.

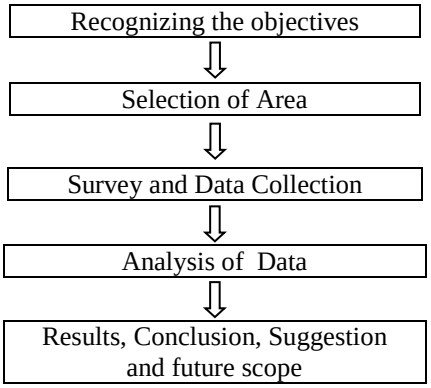
P. Baji Babu, M. Srinivasa Reddy (2017) Conducted research on "Non-Motorized Vehicle Characteristics and Its Effect on Mixed Traffic" In this paper, a methodology is developed for Non-Motorized vehicle routing in the mixed traffic stream. In India, South Africa, Srilanka etc. we mostly find mixed traffic flowing such as developing countries. We observe that in India traffic flow consists of all the vehicles like cars, cycles, pedestrians, bullock cart, heavy vehicles etc. and still uses Non-Motorized vehicles (NMT) for transportation of goods and for travelling. In peak hours, the NMT flow is very high. For the simulation results on roads, the study of NMT is done. By using square measure virtually, speed worth is obtained experimentally. According to the research, speed affects all the three traffic parameters on mixed traffic flow. It was seen that speed decreases with increase in the number of PCUs in the same strip, speed decreases with increase in the number of PCUs in the adjacent strips and speed increase when the distance from the road edge increase.

5. METHODOLOGY

For the research work, the four areas were of Nagpur city where the flow of Non-motorised vehicles is high was taken. The following are four areas were survey were carried out by asking questions by paper format to the public which includes pedestrians and bicyclists only.

- G.H.Raisoni to Hingna T Point
- Shubhash Nagar to Jhansi Rani Chowk
- Sita Birdi to Indora Chowk
- Cotton Market to Railway station

A systematic diagram of the methodology that was developed for the project.



In this project, a survey was taken by asking questions on paper. The questions were designed in such a way that was understood by the public. The question consists of problems facing by Non-motorized users on the selected study area in Nagpur city. The questions were rated from 1 to 5 ranges. The questions are divided into five parameters that is Safety, Visibility, Crossing Comfort and Convenience and these parameters are used to calculate BCI. Below is questions pattern ask for research work-

AREA- NAME – AGE –
Questions are rated from 1 TO 5
1- Very Poor, 2- Poor, 3- Normal/Ok, 4- Good 5- Excellent

5.1 Safety
(a) Is this carriageway is good for pedestrian and bicycle?
(b) How would you rate the pedestrian traffic on the road?
(c) How would you rate the bicycle traffic on the road?
(d) How would you rate the motor vehicle traffic on the road?
(e) In terms of safety, how would you rate the width of the road?
(f) Do you think specifying a speed limit for the road will make it safer?
(g) According to you do you feel that drivers are following driving rules and regulations?
(h) In terms of accident frequency, rate the road?

5.2 Visibility
(a) Is the width of road sufficient for you?
(b) How would you rate the surrounding and cleanliness of the area?
(c) Is there proper lighting during the night to have a clear view of the road?
(d) Are the turnings at intersections sharp /curved and rate it?
(e) Can you view the bus stop clearly?
(f) How would you rate the visibility of signal board from one end of the intersection to others?

5.3 Crossing
(a) While crossing or turning are you able to clearly see the approaching vehicles?
(b) Are there speed bumps before crossings?
(c) How dangerous do you feel the crossing is?
(d) How comfortable do you feel when a heavy vehicle like bus/truck is approaching while crossing?
(e) How comfortable do you feel when a lighter vehicle like car approaches while crossing?
(f) How comfortable do you feel when a bicycle/bike approaches while crossing?
(g) How would you rate time provide for crossing at an intersection?

5.4 Comfort
(a) How would you rate the vehicular traffic speed?
(b) Is median present?
(c) Do the vehicles pose a threat for you while turning?
(d) How comfortable you're on crossing the intersection by zebra crossing?
(e) How would you rate the comfort zone on the shoulders when vehicles are a park?

5.5 Convenience
(a) How would you rate the time consumption by their own non-motorized vehicle to reach their destination?
(b) Rate the parking facilities for Non-motorized vehicle?
(c) How would you rate the fare cost applicable for your travelling?
(d) How would you rate mechanics near your area?
(e) How would you rate the sidewalk condition?
(f) How would you rate the maintenance of sidewalks, bike lanes, bike routes, and green ways?

Bicycle compatibility index is found by the calculation of answers rated by the public on study area where questions format were distributed. The formula used for Bicycle Level of Service is often used for the analysis of roads as well as bicyclists conditions. The formula was derived by using the inverse variance method from Bicyclist Intersection Safety Index by Daniel L. Carter. According to the rating of surveyed answers are equal to the inverse of the variance. The questions are divided into five parameters i.e Safety, Visibility, Crossing Comfort and Convenience that are mentioned above, and these parameters are used to calculate BCI. Bicycle compatibility index is denoted by "X"

$$\boldsymbol{BCI\ (X) = AY1 + BY2 + CY3 + DY4 + EY5}$$

Where,
A, B, C, D, E, F are the mean of the observation
Y1, Y2, Y3, Y4, Y5 are Inverse Variance of the observations.
All the Calculation and Analysis of Data Collection is done in MS Excel.

By using Bicycle Compatibility Index, Level of service is determined by the range of Compatibility. If "LOS A", the compatibility level is "Extremely High" and the flow is "Free flow". If "LOS B", the compatibility level is "Very High" and the

flow is "Reasonably free flow". If 'LOS C", the compatibility level is "Moderate High" and the flow is "Stable flow'. If "LOS D", the compatibility level is "Moderate Low' and the flow is "Approaching Unstable flow". If "LOS E", the compatibility level is "Very low" and the flow is "Unstable flow". If "LOS F", the compatibility level is "Extremely Low" and the flow is "Breakdown flow".

6. ANALYSIS OF DATA COLLECTION

At the survey area, total of 600 questions were asked that is 150 at each area.

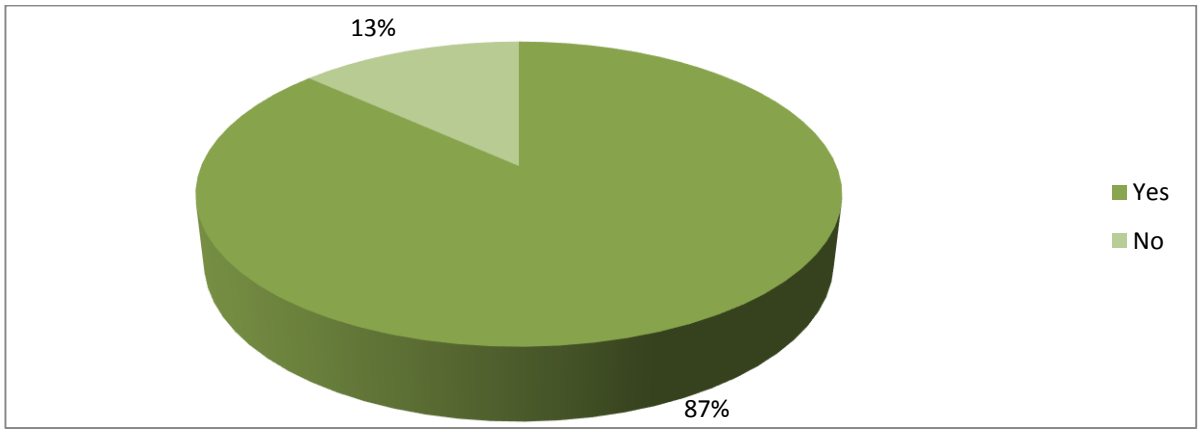


Fig. 1: Specific NMV lane preference

According to survey taken 87% of Non-motorized vehicle users faced problem on Nagpur roads and want separate lane for pedestrian and bicyclists where as13% of Non-motorized public is okay with the condition of roads shown in figure 1.

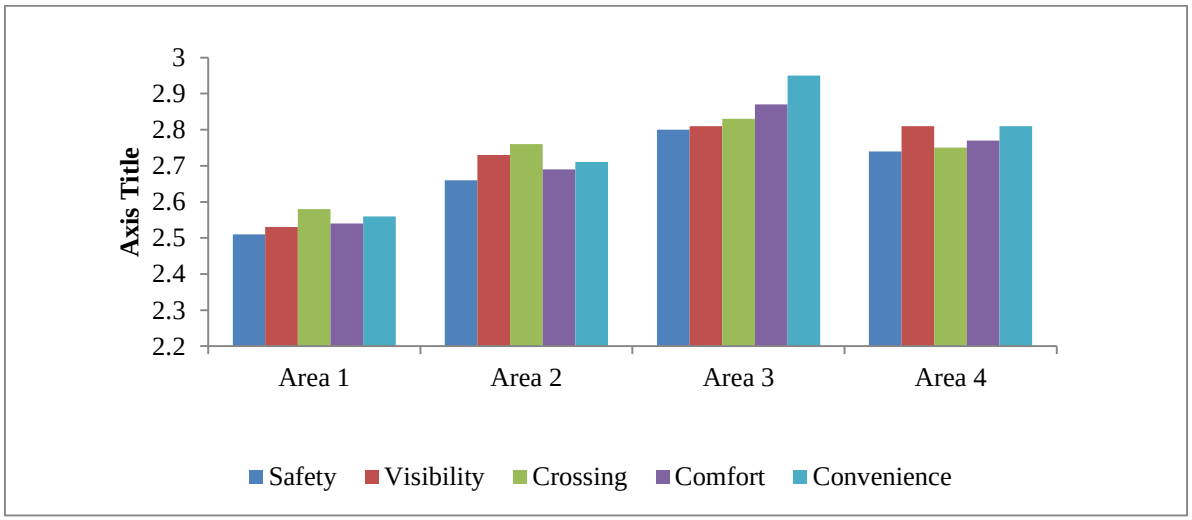


Fig. 2: Area wise data comparison

Figure 2 shows a graphical representation of research work. As comparing all areas with their parameters, none of the areas is above value 3, this means the improvement is needed in Nagpur city for Non-motorized transport.

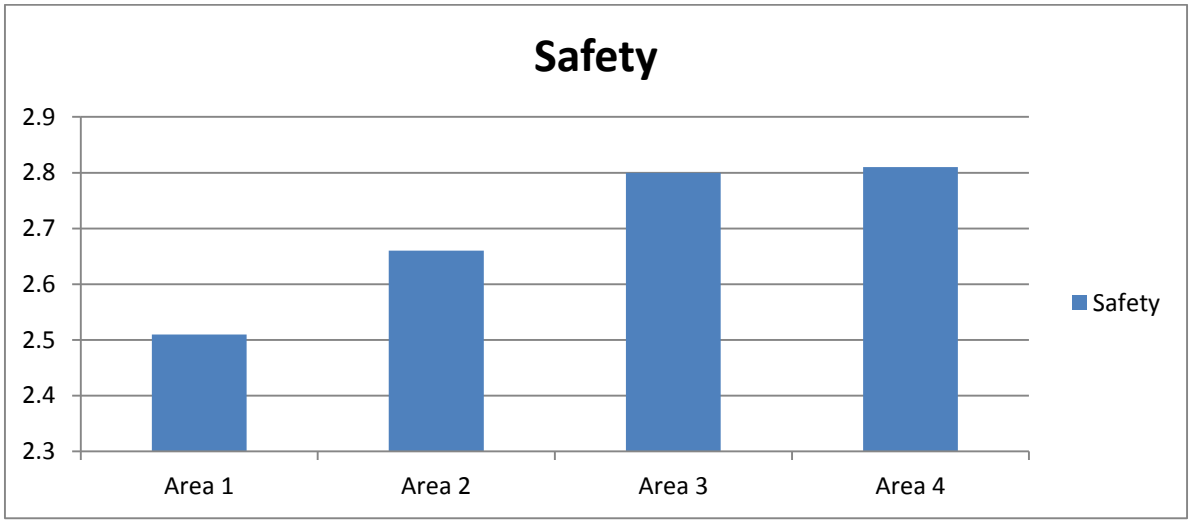


Fig. 3: Comparison safety parameter area wise

According to figure 3 comparing safety parameters of all Areas, the results show that improvements in needed in all areas. Area 1 shows needed more safety as compared to other areas.

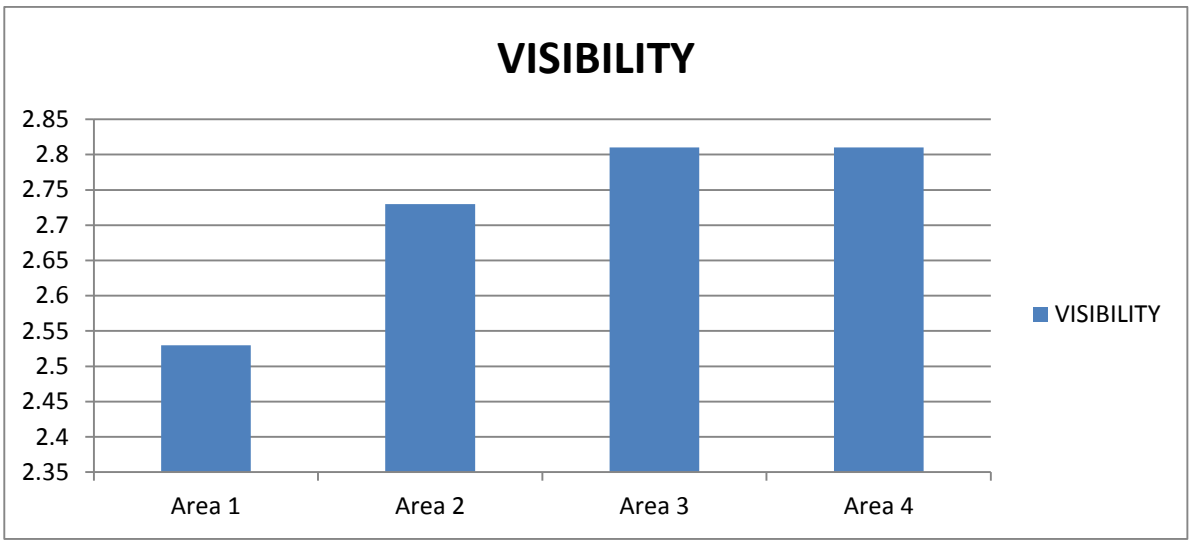


Fig. 4: Comparison visibility parameter area wise

According to figure 4 comparing visibility parameters of all Areas, the results show that improvements in needed in all areas. Area 1 shows needed more visibility as compared to other areas and Area 3 and Area 4 is more convenient regarding visibility issues.

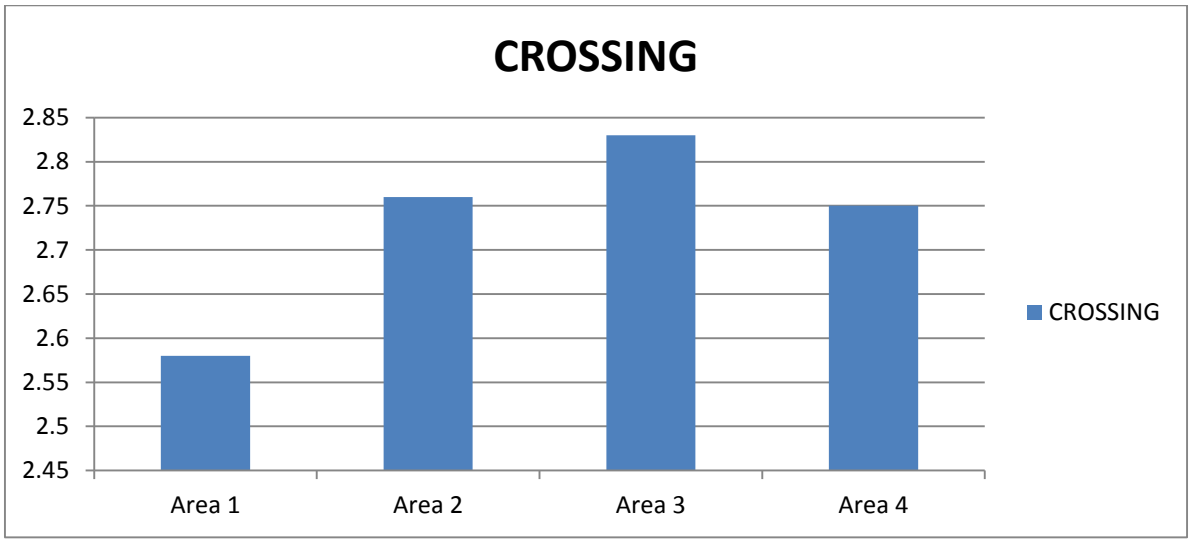


Fig. 5: Comparison crossing parameter area wise

According to figure 5 comparing crossing parameters of all Areas, the results show that improvements in needed in all areas. Area 1 shows needed more crossing as compared to other areas whereas Area 3 is more convenient as compared to other areas.

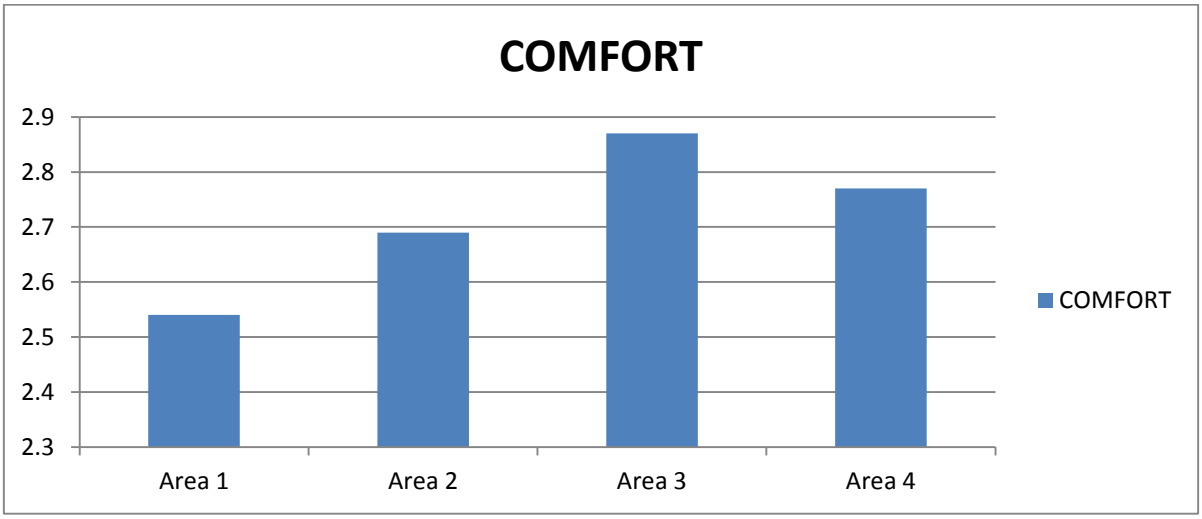


Fig. 6: Comparison comfort parameter area wise

According to figure 6 comparing comfort parameters of all Areas, the results show that improvements in needed in all areas. Area 1 shows needed more comfort as compared to other areas. Area 3 is more convenient regarding comforts as compared to other Areas.

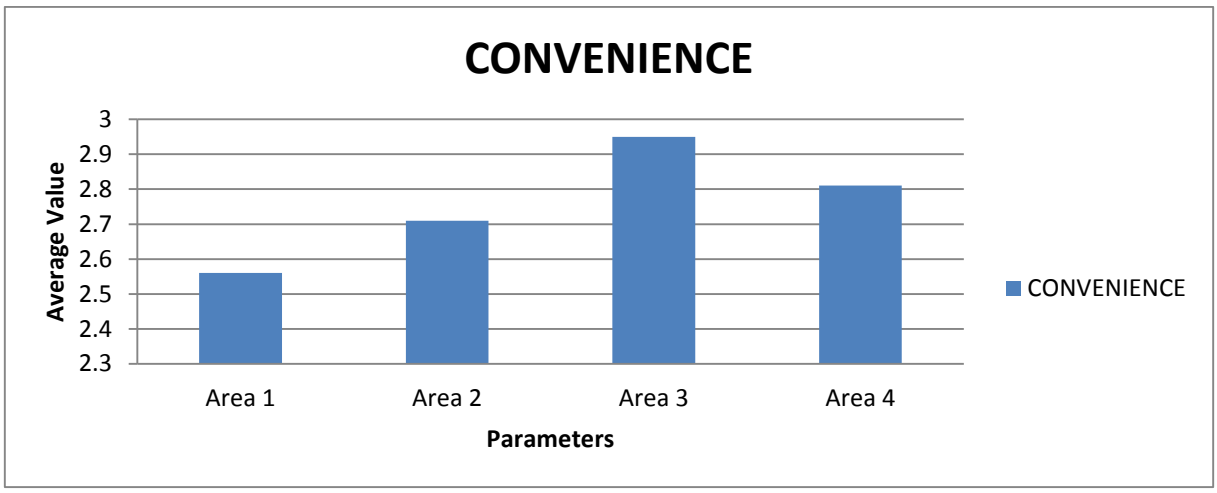


Fig. 7: Comparison convenience parameter area wise

According to figure 7 comparing convenience parameters of all Areas, the results show that improvements in needed in all areas. Area 1 shows needed more safety as compared to other areas. Area 3 is more convenient than in other areas.

7. CALCULATIONS

7.1 Area- 1

7.1.1 Calculation for BCI (for Area 1):

Table 1: Calculation for BCI (for Area 1)

Constant	Variables	Mean	Variance	Inverse Variance
A	Safety	2.51	2.44	0.04
B	Visibility	2.53	1.31	0.76
C	Crossing	2.58	1.24	0.8
D	Comfort	2.54	1.26	0.79
E	Convenience	2.56	2.24	0.44

X = 8.12

7.1.2 BCI (ymin):

Table 2: BCI (ymin)

Constant	Variables	Mean	Variance	Inverse Variance
A	Safety	3	4	0.25
B	Visibility	3	4	0.25
C	Crossing	3	4	0.25
D	Comfort	2.6	3.8	0.26
E	Convenience	3	4	0.25

X =3.6

7.1.3 BCI (ymax):

Table 3: BCI (ymax)

Constant	Variables	Mean	Variance	Inverse Variance
A	Safety	0.75	0.18	5.55
B	Visibility	0.066	0.22	4.54
C	Crossing	0.57	0.24	4.16
D	Comfort	0.6	0.24	4.16
E	Convenience	0.66	0.22	4.54

X= 15.02

7.1.4 Calculation for BCI:

INTERVAL= 1.90

Table 4: Calculation for BCI

C	7.4-9.3	Moderately High

The BCI Range for Area-1 lies in the LOS-C range

7.2 Area- 2

7.2.1 Calculation for BCI (y) (for Area 2):

Table 5: Calculation for BCI (y) (for Area 2)

Constant	Variables	Mean	Variance	Inverse Variance
A	Safety	2.66	1.29	0.34
B	Visibility	2.73	1.43	0.69
C	Crossing	2.76	1.36	0.73
D	Comfort	2.69	1.41	0.7
E	Convenience	2.71	1.47	0.68

X= 8.52

7.2.2 BCI (ymin):

Table 6: BCI (ymin)

Constant	Variables	Mean	Variance	Inverse Variance
A	Safety	3	4	0.25
B	Visibility	3	4	0.25
C	Crossing	3	4	0.25
D	Comfort	2.6	3.8	0.26
E	Convenience	3	4	0.25

X= 3.6

7.2.3 BCI (ymax):

Table 7: BCI (ymax)

Constant	Variables	X-mean	Variance	Inverse Variance
A	Safety	0.75	0.18	5.55
B	Visibility	0.066	0.22	4.54
C	Crossing	0.57	0.24	4.16
D	Comfort	0.6	0.24	4.16
E	Convenience	0.66	0.22	4.54

X=15.02

7.2.4 Calculation for BCI:

INTERVAL= 1.9

Table 8: Calculation for BCI

C	7.4-9.3	Moderately High

The BCI Range for Area-1 lies in the LOS-C range

7.3 Area- 3

7.3.1 Calculation for BCI (y) (for AREA 3):

Table 9: Calculation for BCI (y) (for Area 3)

Constant	Variables	Mean	Variance	Inverse Variance
A	Safety	2.68	1.8	0.55
B	Visibility	2.72	1.6	0.62
C	Crossing	2.73	1.51	0.66
D	Comfort	2.72	1.54	0.64
E	Convenience	2.76	1.87	0.53

X= 7.1

7.3.2 BCI (ymin):

Table 10: BCI (ymin)

Constant	Variables	Mean	Variance	Inverse Variance
A	Safety	3	4	0.25
B	Visibility	3	4	0.25
C	Crossing	3	4	0.25
D	Comfort	2.6	3.8	0.26
E	Convenience	3	4	0.25

X=3.6

7.3.3 BCI (ymax):

Table 11: BCI (ymax)

Constant	Variables	Mean	Variance	Inverse Variance
A	Safety	0.75	0.18	5.55
B	Visibility	0.066	0.22	4.54
C	Crossing	0.57	0.24	4.16
D	Comfort	0.6	0.24	4.16
E	Convenience	0.66	0.22	4.54

X=15.02

7.3.4 Calculation for BCI:

INTERVAL= 1.90

Table 12: Calculation for BCI

B	5.5-7.4	Very High

The BCI Range for Area-1 lies in the LOS-B range

7.4 Area- 4

7.4.1 Calculation for BCI (y) (for Area 4 Observation):

Table 13: Calculation for BCI (y) (for Area 4 Observation)

Constant	Variables	Mean	Variance	Inverse Variance
A	Safety	2.68	1.8	0.55
B	Visibility	2.72	1.6	0.62
C	Crossing	2.73	1.51	0.66
D	Comfort	2.72	1.54	0.64
E	Convenience	2.76	1.87	0.53

X=10.16

7.4.2 BCI (ymin):

Table 14: BCI (ymin)

Constant	Variables	Mean	Variance	Inverse Variance
A	Safety	3	4	0.25
B	Visibility	3	4	0.25
C	Crossing	3	4	0.25
D	Comfort	2.6	3.8	0.26
E	Convenience	3	4	0.25

X=3.6

7.4.3 BCI (ymax):

Table 15: BCI (ymax)

Constant	Variables	Mean	Variance	Inverse Variance
A	Safety	0.75	0.18	5.55
B	Visibility	0.066	0.22	4.54
C	Crossing	0.57	0.24	4.16
D	Comfort	0.6	0.24	4.16
E	Convenience	0.66	0.22	4.54

X=15.02

7.4.4 Calculation for BCI:

INTERVAL= 1.90

Table 16: Calculation for BCI

D	9.3-11.2	Moderately low

The BCI Range for Area-1 lies in the LOS-D range.

8. RESULTS

Table 17: Result 1

Parameters	Safety	Visibility	Crossing	Comfort	Convenience	Los
AREA 1	2.51	2.53	2.58	2.54	2.56	C
AREA 2	2.66	2.73	2.76	2.69	2.71	C
AREA 3	2.8	2.81	2.83	2.87	2.95	B
AREA 4	2.74	2.81	2.75	2.77	2.81	D

Table 18: Result 2

S no.	Parameters	Average value	Problem discussed	Improvement measures
1	Safety	2.68	Carriageway, Pedestrian and Cyclists traffic on the Road Speed limit for the Road, Drivers behavior, Accident frequency	Proper design of the road, Setting up a dedicated radio station to continuously broadcast traffic conditions, Install traffic signs in hazardous places, Strictly implement the driving license for paratransit driver, speed limit 30km/hr to avoid accidents.
2	Visibility	2.72	Width of Road, Surrounding and Cleanliness, Lighting during Night, Bus stop and Signal Board Visibility	Increase service- more routes, increased frequency and longer operating hours, a specific lane for pedestrian and bicyclists, traffic lights in the bus-stop and at the intersection
3	Crossing	2.73	Turning for approaching vehicles, Speed bumps before crossing, Safety near the crossing, Motorized vehicle approaching while crossing, Time provide for crossing at the intersection	Stay alert, and follow Safe road crossing like - STOP, LOOK, LISTEN AND THINK. STOP if there is no footpath from shoulder Always use sidewalks. THINK before crossing the road- like traffic has stopped or road is clear to move from one place to another.
4	Comfort	2.72	Vehicular traffic speed, median, Safety while turning and at Zebra crossing, Comfort zone on the shoulders	Know and follow your signals, Always use bicycle lane, different lane markings- to turn, merge or change lanes, providing turning lane near stop-controlled intersections, providing lanes near the right turn and left turn will lead to reduce in crashes.
5	Convenience	2.76	Time Consumption, Parking facilities, fare cost for travelling, Availability of Mechanics, Sidewalk Condition, Maintainenance of sidewalks, bike lane, bike routes and greenways	Coordination and management of road, funding for road maintenance and road safety include maintaining road condition, victims first aid in traffic accidents

9. SUMMARY AND CONCLUSION

From the above Analysis and Results, all the Nagpur area which was taken for project study needs improvement. Area 1 that is G. H. Raisoni to Hingna T. point needs more parameters to update. As all the areas LOS is low, level of service has to be increased to LOS A. With the improvement of the parameters like safety, visibility, crossing, comfort and convenience following changes will take place:

- Reduction of risks, and so the number of accidents.
- Reduction of traffic complexity for NMT-users in urban traffic.
- Increasing the number of route options for cyclists/pedestrians
- Improving the competitive position of the bicycle/pedestrians in relation to car traffic
- Road Safety Measures like speed control, road design, vehicle design.
- Education and awareness raising.

10. SUGGESTIONS FOR IMPROVEMENT IN NMT

In Nagpur, one of the major reasons that concerns of pedestrians and bicyclists that affects the traffic stream flow are ignored. There is a need for non-motorized planning to avoid accidents and congestion problems because of these reasons the flow of the traffic is disturbed. Due to the proper planning of NMT, there will be the safe and convenient use of non-motorized modes of transportation. Therefore the Steps should be taken by higher authorities like the police, the department of public works, the department of transport, the road traffic agency, city council, the city planning agency and also from civil society has to design and implement the development of facilities for non-motorized vehicles, and public education, promotion and safety programs.

The Non-motorized planning should be followed in the following steps:

(a) Establishment of community to carry out the project of Non-motorized transport task.
(b) Selection of area where Non-motorized transport flow is high and to be improved.
(c) Inventory of existing rules and regulations to be followed.
(d) Development and prioritization of planned regulations and conditions to be improved.
(e) Selection and design of facilities for pedestrians and cyclists example by newly built or rebuilt of the lane for non-motorized users.
(f) Testing after Implementations whether the policy applied had reduced the problems of non-motorized users.

11. FUTURE SCOPE

From the above research study, it is cleared that proper planning and designing is needed for Non-motorized transport in Nagpur cities for safe and free flow to avoid accidents and congestion problems.

The following points can be considered for future scope:

(a) For Improvement of Road, the Sample size of the Study area can be increased for approximate results. This will leads to Road safety for Non-motorized Vehicle User.

(b) Detail Analysis of Nonmotorized considering all more parameters, the study should be done for the accommodation of motorized and Non-motorized transport modes.

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