

Analytical study of Non-Motorized Traffic Count and its Characteristics at Road Intersections in Nagpur City, India using Statistical Methods

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Abstract:

Mixed traffic on roads and at crossings have been exacerbated by the dramatic increase in road vehicles. It is due to urbanization and thereby rising modal conflicts between Non-Motorized Traffic (NMT) and Motorized Traffic (MT) as well as within the modes itself. At times there is no consideration of NMT while road design and division making. Considering it the goal of a research was formulated to examine the features of NMT in Nagpur. For that, data collection through primary and secondary sources was done at seven intersections during the years 2020, 2021 & 2022 for comparing it with the Nagpur Improvement Trust (NIT) surveyed data of 2012 as its basis. To comprehend NMT characteristics, the comparative analysis using statistical method Two way ANOVA with repetitions was adapted. The F tests carried for repetition of counts at selected seven roads' intersections of Nagpur marks the results that there wasn't observed any significant difference in NMT counts during its repetitions, but there was observed variation amongst the intersections. It deliberated the need for further study of its characteristics along the major and minor roads of the city and also to formulate the strategies for development with maintenance of NMT lanes and its related infrastructure to raise the NMT use for making life of city dwellers healthy.

Keywords: Mobility, Road Intersections, Non-Motorized Traffic, NMT lanes, Road Design Interventions.

1. INTRODUCTION

Urban Transport And Traffic

Since historic period the Non-Motorized Traffic (NMT) has been the main fragment of road traffic in any settlement. With passing of time and increase in distance between activities, modal shift was witnessed from walking to cycling and further shift to motorized vehicles. NMT users started using motorized vehicles as a consequence to growth in its tenure. The vehicles ownership count in India is raised to 29,05,27,669 numbers as on July 6th 2022 as per vahan parivahan website data (RTO, 2022). The increased ownership of all types of vehicles and especially upsurge in private motorized vehicles, has elevated the traffic on road; thereby increasing road accidents and devising injuries and deaths of the individuals. (MoRTH, Vahan parivahan website) The increase in fatalities due to road accidents was seen as 9.4% in 2022. (GoI, Road Accidents in India, 2022)

NMT considerations in Road Design: Need and Implementation

The introduction of fast moving motorized vehicles has continued to increase road accidents in India with number of injuries and fatalities affecting the slow traffic under NMT. (MoRTH, 2019) (Singh, 2016) (Z, 2013) With the rise of conflict based accidents, the Ministry of Road Transport and Highways (MoRTH), India has identified the need to segregate the slow and fast moving traffic on road. It has given a need for NMT lane considerations in road design to avoid the conflicts between the types of road users. Thus, existing roads were suggested modifications with tactical urbanism, demarking the traffic lanes for different vehicles and users. The MoRTH also proposed for new roads which are to be designed with incorporation of NMT lanes. Accordingly, to prevail over the circumstances, the Sustainable Urban Transport Planning (SUTP) solution is made for showing the concern towards NMT usage with requirement of separate lane/s which would give a feasible and safe solution for all economic groups. (Awari) (EPC, 2013)

As per the guidelines of design and development for new and existing roads with incorporation of NMT lanes main and subsidiary roads in selective cities are being developed considering their importance. Similarly, modifications are also expected to have done at the road intersections by the Urban Local Bodies (ULB's) for the safety of the users under Smart Cities Mission (SCM), Jawaharlal Nehru National Urban Renewal Mission (JNNURM) and National Sustainable Urban Transport Development. (MoUEPA, 2015). Majority of the Indian cities have adapted to design and development guidelines for main and district roads. But, the design considerations are still lacking its implementation as NM Traffic lanes design is not seriously & compulsorily done for the secondary/ internal roads and also it does not match with the volume of users.

NMT provisioning, usage and its issues:

The cities were categorized for planning and implementing NMT provisions under Sustainable Urban Transport Planning Mission. The implementation of NMT provisions was carried out in various Indian cities viz. New Delhi, Pune, Bangalore, Ahmedabad, Kolkata, Chennai, Nanded, Hyderabad, Raipur and Nagpur at two levels viz. along newly designed roads and modified designs of the roads. The corrections while modifications in design of roads were a compromise and therefore could not follow all the guidelines for NMT separation. The newly designed/ Modified road designs are not feasible to be used by an individual due to discontinuation of the NMT lanes at intervals. The maintenance of NMT lane is missing at times which stops/ demotivates the use of it. The NMT lane area is encroached for various purposes viz. Parking of 2-4 wheelers, dumping of waste, keeping construction materials, small vendors, electrical and telephone service poles and boards, hoardings, neighboring households etc. In case of new urbanism the NMT lanes are marked on the roads compromising width of motorized vehicular traffic. The road space which was used for various functions is observed with change for NMT use which is inappropriate.

STUDY AIM, OBJECTIVES AND METHODOLOGY:

The basis of this study was laid on the understandings from the literature study on NMT provisioning, review of Comprehensive Mobility Plan and the primary studies conducted at road intersections. The research was aimed to analyze the trend of NM Traffic Count and its characteristics at road intersections in Nagpur city, India. The study was comprised of understanding background study under CMP in 2013,2018 based on May-June 2012 surveys. It was followed by the primary surveys carried out by the researcher in March 2020, December 2020 - January 2021 and July 2022. Thus comparing the NM Traffic count in June 2012 with 2021 (i.e. during precovid March 2020 and postcovid December 2020 and January 2021) and July 2022 at selected road intersections. The scope of the study included primary survey for all the thirty-two intersections as studied by Nagpur Improvement Trust (NIT) in 2012. But 2020,21 and 2022 study was limited to selective seven intersections considering main roads with NMT lanes executed as per the proposals in CMP 2013 and its revision 2018. Second limitation in the study was about the survey hour which was not maintained as same as in 2012 for surveys in 2020-21 and 2022. Further, March 2020 was the spreading period of COVID-19 though the restrictions were not mandatory in Nagpur during the study period. And December 2020-January 2021 was the ending period of COVID 2019. This might have difference due to initial and last stages of COVID-19 in India. Therefore the study of intersections was continual in July 2022.

Methodology The study began with the sorting of intersections out of total 32 road intersections as surveyed in 2012 and listed in the comprehensive mobility plan 2013 and its revision 2018. In view to shortlist the intersections for comparative NMT surveys in 2020,2021 & 2022, sorting based on criteria's viz. location, landuse, type of road & intersection and NMT usage as in 2012 was adapted. The top ten intersections under Total all Vehicles Traffic Volume count and the Total NM Vehicles Traffic volume count data in 2012 i.e. from both

the lists were sorted and seven intersections out of both these lists were considered for further studies. (Please Refer Table 1). In all seven intersections were sorted as above based on the high rank of total traffic volume count and NMT counts with major considerations for land use and location and the Traffic Count surveys were carried further. (Please Refer Table 2) The hash (#) marked are the intersections common in both the lists i.e. Total of All Vehicles Traffic Volume Count and Total of NM Vehicles Traffic Count. Physical surveyed data of NMT count for four numbers of observations for selected seven road intersections was analyzed using statistical analysis Two way ANOVA with repetitions for NMT count at intersections for four observations. It results are compared for the 'F' test significance among the intersections, among repeated counts and within intersections and repeated surveys. The survey results and discussions with comparative charts are prepared for concluding the study.

SELECTION OF CASE CITY NAGPUR FOR NON-MOTORIZED TRAFFIC COUNT

Nagpur city is selected for the NM Traffic count for being an urban agglomeration with population of more than 25 lakhs as per the census 2011. Consequent to development of Highways, MIHAN and Smart City Developments at Nagpur, (MoUD, 2016) it observes continuous growth in its immigrant, floating population and physical expanse relatively adding on road traffic. Increasing traffic on road, rise in conflicts, accidents and black spots of accidents have given the need to study NMT considerations on roads in Nagpur. (UMTC, 2013) (NIT U. w., 2018)

Nagpur Traffic, its division and Transit Provisions:

The city of Nagpur, Maharashtra is having radial planning of roads with Sitabardi as a nucleus of whole city area since the capital of central provinces i.e. during british period. Also, the city is divided into four quadrants based on two major axial roads along North -South (Wardha road) and East –West (Bhandara Road) and all its roads are connected with ring road1 and ring road 2. And now the city is further expanding beyond outer ring road.

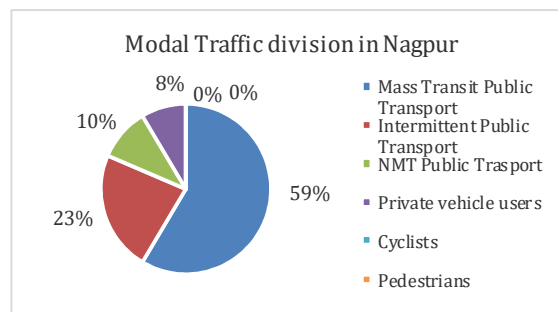


Fig. 1: Modal Traffic Division in Nagpur (Source: (UMTC, 2013 revision 2018) (Maharashtra, 2018))

City traffic includes Public and Private Transport users. Public Transport users traffic includes Bus and Metro rail users, Intermittent public Transport such as cabs, auto-rickshaws, E rickshaws and Cycle rickshaw. The Private Vehicle users include four and two wheeler vehicle users, Bicycle riders and lastly pedestrians. Actually all the transport users are pedestrians at some point of time. Percentage Division of modal traffic in Nagpur gives that Mass Public Transit traffic is maximum with only 10% traffic using NMT mode i.e. NMT IPT and Cycles (Refer Fig 1).

Under transit development Nagpur city mobility plan was prepared together by UMTC and NIT in 2013 (based on surveys in 2012) and revised in 2018. It shows provisions for Bus transit, intermittent public transit (IPT) facilities like parking provisions along with the NMT lanes viz. cycle tracks & docking stations planning, and footpaths for pedestrians. Maha-Metro office had introduced Maha-Metro rail network to move along orange and Aqua lines with its initial lengths of 13 Kms (on 08 March 2019 South-North between Khapri – Sitabuldi) and 9.9 Kms (on 28 January 2020 West-East between Lokmanya Nagar – Sitabuldi) respectively. The phase wise expansion was projected in the length of metro rail corridor along EW and NS corridors. The Maha-metro plan implementation was disturbing the traffic in Nagpur adding inconvenience to NMT users. In this situation the study of NMT and its provisions on roads and intersections was found as essential by the researcher.

The NMT infrastructure layout plans in Nagpur were to consider the NMT as a supportive to the public transport. Footpaths and cycle tracks along the roads were proposed as per the considerations. It is also implemented on all the main traffic roads of the city. It includes Highways, cardinal roads connecting the city along the length and breadth. Four main market areas viz. Itwari, Mahal, Sadar and Sitabuldi are treated as completely pedestrian zones. (UMTC, 2013 revision 2018) Whereas along internal roads, intersections and inside the residential zones are still to be attended for NMT movements inside the city areas. (Kalpana , et.al. 2021)

DATA COLLECTION :

Nagpur CMP report 2013 and its revision 2018 shows the figures of Traffic Volume Count from survey done by NIT, Nagpur in 2012 at a peak hour time for major thirty two intersections of Nagpur. The intersections surveyed in 2012 include intersections as follows:

1.NH7 Somalwada Intersection, 2.Hingna Road and Ring Road Junction, 3.Pratap Nagar Square, 4.Chhatrapati Square, 5.Manewada Square, 6.Dighori Square, 7.Ajni Square, 8.Bhande Plot Square, 9.Subhash Nagar Square, 10. Zansi Rani Square, 11.Cotton Market Square, 12.Jagnade Square, 13.Telephone Exchange Square, 14.Old Pardi Naka Square, 15.Law College Square, 16.RBI Square, 17.Golibar Square, 18.Rajiv Gandhi Nagar Square, 19.Chhaoni Square, 20.Indora Square, 21.Katol Square, 22.Mental Hospital Square, 23.Mankapur Square, 24.Katol & Ring Road Junction, 25.Wadi Square, 26. LIC Square, 27.Medical Square, 28.Shankar Nagar Square, 29.Variety Square, 30.Ashok Square, 31.Kharbi Square, 32.Kamptee and the other networking.

At the initial stage the top ten intersections under two categories were enlisted viz. All Vehicle Traffic Count and NM Traffic Count to select the intersections for comparative study of NM Traffic based on its counts.

Table 1: List of Top Ten intersections sorted on the basis of Total Traffic Volume count and Total NM Vehicle Traffic Volume Count 2012 (Source: CMP 2013)

Rank as per All Vehicles Traffic Volume Count	Road Intersection	Peak hour Total of All Vehicles Traffic Volume Count	Rank as per Total NM Vehicles Traffic Volume Count .	Road Intersection	Peak Hour Total NM Vehicles Traffic Volume Count
1	#Cotton Market Square	11347	1	#Old Pardi Naka Square	4388
2			2	#Telephone Exchange Square	3138
3	RBI Square	10139	3	#Chhatrapati Square	2506
4	#Chhatrapati Square	10078	4	#Golibar Square	2321
5	Katol Road Junction	9722	5	#Jagnade Square	2194
6	LIC Square	9365	6	#Law College Square	1766
7	#Golibar Square	9123	7		
8	#Law College Square	8705	8	Ajni Square	1616
9	#Telephone Exchange Square	8642	9	Indora Square	1493
10	Indora Square	8292	10	Ashok Square	1489
	Bhande Plot Square	8031		Kamptee and other network	1420

The selection of intersection includes Top Six from the Total NM Traffic count for the peak hour i.e. 1.Old Pardi Naka Square, 2.Telephone Exchange Square, 3.Chhatrapati Square, 4.Golibar Square, 5.Jagnade Square and 6.Law College Square. And from the Total Vehicles Traffic Volume Count top one ie. 7.Cotton Market Square is considered based on its vicinity to Railway station and Main Agriculture Cotton and vegetable market area which is active during 24 hours a day. The other four intersections i.e. Chhatrapati square, Golibar square Law college

square and Telephone exchange square are also considered as being common in both the lists and are already selected under the NMV count wise selected criteria. All these selected seven intersections are having located in the central business area of the city with major commercial and mixed uses of land. Thus remaining Eight intersections were rejected for further working. It is to note that the intersections at RBI square, Katol Road Junction and LIC Square are marked under top ten list due to its high count of all vehicles traffic volume but these intersections are skipped for further studies as they are located in major commercial and office areas. Thus, the rejected intersections from top ten list of All vehicles Traffic Count and All NM traffic count are namely RBI Square, Katol road junction, LIC Square, Indora Square, Bhande Plot Square, Ajni Square, Ashok Square and Kamptee and other network etc. The list of finally sorted seven Intersectiuons along with the counts of NMT, PT and PT + NMT together with its readings is shown in the table below.

Table 2 : The traffic count in seven selected intersections as per 2012 survey readings is as follows; (Source: CMP 2013 revision 2018 as done by NIT, Nagpur in 2012)

Sr. no.	Intersection wise count of public transport, PT with NMT, NMV in 2012	Public Transport count	N/M Traffic Count	Vehicle Traffic Count	Total Public + NM Traffic Count
1	Pardi Square	1988	4388		6376
2	Telephone Exchange Square	522	3138		3660
3	Jagnade Square	1338	2194		3532
4	Golibar Square	1009	2321		3330
5	Cotton Market Square	1012	827		1839
6	Law College Square	1653	1766		3419
7	Chhatrapati Square	1897	2506		4403

The traffic count data 2012 is used for checking the significance using T test and ANOVA statistical methods. The counts of NMT amd PT from Table 2 were checked with T test for significance of variance considering NMT and PT counts as independent single variables. Further the Statistical ANOVA Test was applied for comparing the relations between NMT, PT and PT with NMT taken together. Hypothesis and p value assumptions are marked below.

Hypothesis for T test is :

Hypothesis :H0 : There is no significant variation in counts of NMT and PT as in 2012.

H1: There is a significant variation in counts of NMT and PT as in 2012.

p value :0.05 (assumed with 95% confidence level)

If p is >0.05, Null Hypothesis is accepted

If p value = ≤ 0.05, Null Hypothesis is rejected and alternate Hypothesis is accepted.

Hypothesis & p value for ANOVA Two Factor without replication (F Test) is:

Hypothesis :H0 : There is no significant variance in counts of NMT , PT and NMT+PT as in 2012.

H1: There is a significant variance in counts of NMT , PT and NMT+PT as in 2012.

p value :0.05 (assumed with 95% confidence level)

If p is >0.05, Null Hypothesis is accepted

If p value = ≤ 0.05, Null Hypothesis is rejected and alternate Hypothesis is accepted

The surveys were started for all these selected seven intersections from March 2020. The survey was repeated thrice beyond the 2012 figures i.e. in March 2020, December 2020/ January 2021 and July 2022 in order to validate the earlier studies as the intersections might not have been fully utilized due to COVID 19 in March 2020 and January 2021. Thus traffic count surveys were considered for analysis based on repeated 4 counts at selected seven intersections during 2012, 2020, 2021 and 2022. The traffic count data was collected for all PT and NMT modes viz. All Buse PT, Autorickshaw as IPT, Cycle Rickshaw, E Rickshaw, Cycles, Carts and Pedestrians. Non motorized modal Traffic Counts are separated for further analysis from the collected data and is used further for checking the significance of data using statistical methods. The modal distribution of traffic count for NMT data collected after the surveys is given in Table 3 below.

Table 3: Modewise Distribution of NM Traffic Count in 2012, 2020, 2021 and 2022 at Seven Road Intersections. (Source :1. (NIT, 2013) and 2. Primary Surveys of Intersections, Nagpur by the author during 2020, 2021 and 2022)

NMT and NMV Count at Intersections									
Sr. No.	Intersection	Survey Year	E-Rickshaw Count	Cycle Rickshaw Count	Cycles Count	Carts Count	Pedestrian Count	Total NMT Count	Total NMV Count
1	Pardi Square	2012		199	4168	21		4388	4388
		2020	335	57	758	23	432	1605	1173
		2022	244	46	208	28	260	786	526
		2022	400	87	2437	36	450	3410	2960
2	Telephone Exchange Square	2012		592	2546	0		3138	3138
		2020	247	47	187	26	137	644	507
		2021	116	22	162	9	80	389	309
		2022	213	32	186	9	94	534	440
3	Jagnade Square	2012		378	1806	10		2194	2194
		2020	230	95	290	24	255	894	639
		2021	142	38	216	8	240	644	404
		2022	285	268	676	12	312	1553	1241
4	Golibar Square	2012		437	1863	21		2321	2321
		2020	317	31	546	32	318	1244	926
		2021	430	24	438	40	511	1443	932
		2022	537	43	963	21	345	1909	1219
5	Cotton Market Square	2012		244	583	0		827	827
		2020	274	86	356	6	412	1134	722
		2021	296	38	275	13	289	911	622
		2022	406	47	359	12	428	1252	824
6	Law College Square	2012		66	1700	0		1766	1766
		2020	457	22	26	33	401	939	538
		2021	778	31	475	9	731	2024	1293
		2022	875	42	549	52	646	2164	1518
7	Chhatrapati Square	2012		85	2421	0		2506	2506
		2020	414	47	1387	2	85	1935	1850
		2021	276	32	579	6	164	1057	893
		2022	417	44	1387	3	92	1943	1851

OBSERVATIONS:

Physical Observations :

Physical survey of study area observes that the provisions are made for separation of NM traffic in Nagpur to cover the major city routes. But footpaths and marked lanes for NMT have not been used to its fullest for various reasons as identified. These spaces are encroached by locals for daily activities, to park vehicles, sitting platforms, vegetation, street vendors, statue installation, public services like electric/ phone service poles, dust bins, throwing the garbage, for animals' comfort etc. The construction of NM lanes is observed with gap/ discontinuation of lanes/ paths, sudden shifts of levels, uneven floor finish etc. At times NMT lanes and footpaths are found ill maintained by the local authority (i.e. Maha Nagar Palika) etc. On some roads no separate lane for NMT causes difficulty and so cannot be considered under barrier free movement.

Observations based on analytical Charts :

Analysis of 2012 count figures at the selected seven intersections:

After the selection of intersections the traffic count at these seven intersections was observed for the year 2012 by the researcher under columns viz. 1.Public Transport, 2.NM Traffic count and 3. Total public transport + NMT count as follows;

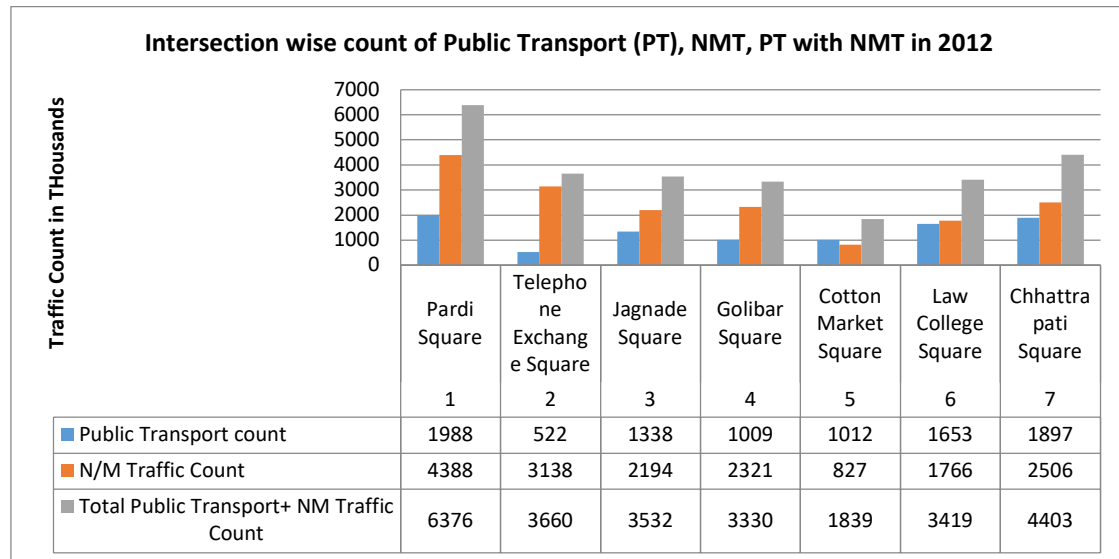


Fig: Percentage of Public Transport and NM Traffic Volume Count in 2012 at Selected 7 road intersections in Nagpur (Source: Chart prepared by author based on CMP Nagpur data 2013)

From the fig. it is obvious that Pardi square is an intersection with the highest percentage of traffic count under NMT+ PT traffic as well as only NM Traffic count as per CMP 2013 i.e. 88.80% and 61.11% respectively out of the total traffic at the intersection. Its count is 6,376 of NMT+ PT traffic and 4,388 numbers of only NM Traffic count respectively. The total traffic count at Pardi Sq is 7,180 numbers. The count of NM+PT and only NM Traffic is lowest in case of Cotton Market Square counting to 1,839 and 827 respectively as against the total traffic volume count of 11,347. Further to check the significance of variance in Counts 2012 of NMT, PT and Total of PT +NMT the T Test statistics and ANOVA method is used. For T test only NMT and PT counts were considered for paired multidirectional results and type 3. ANOVA Two Factor factor statistics was applied for checking the variance between NMT, PT and NMT + Pt taken together. The results of these tests are shown in the results section.

Based on the table 3 containing Modewise Distribution of NM Traffic Count in 2012, 2020, 2021 and 2022 at Seven Road Intersections, the three different charts are prepared for : NMV and NMT count at Intersections with repetitions R1-R4 i.e. for 2012, 2020, 2021 & 2022 and Pedestrians count at Intersections with repetitions R1-R3 i.e. for 2020, 2021 & 2022. These charts are shown in figure nos. 2, 3 and 4 respectively.

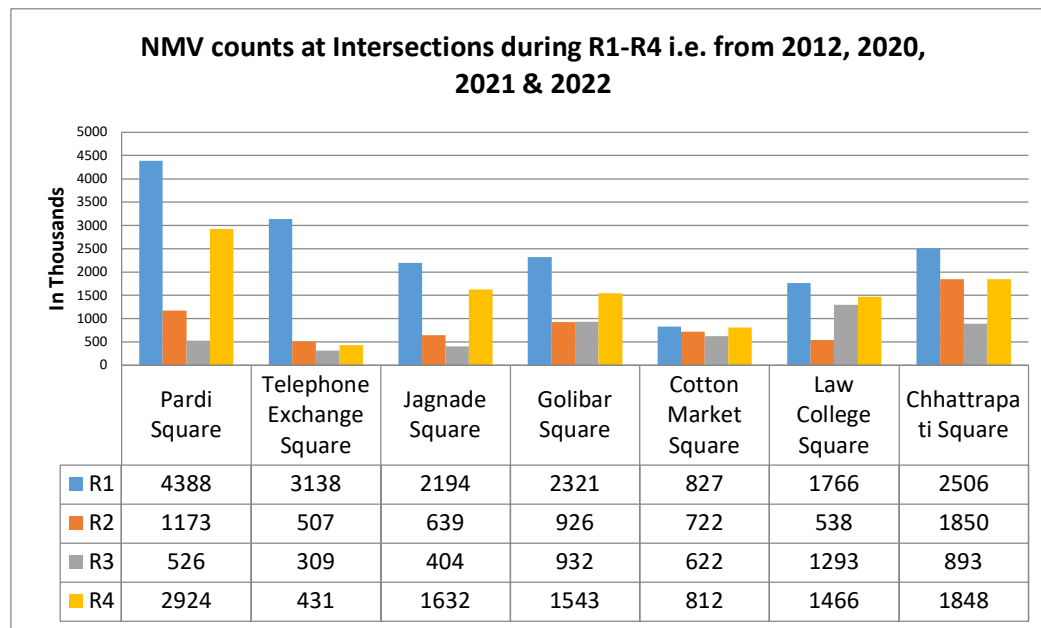


Fig. 2: NMV count at Intersections with repetitions R1-R4 i.e. for 2012, 2020, 2021 & 2022 (Source: Prepared by author based on Table 3)

NMV counts at 4 repeated surveys at all seven intersections mark that Pardi is an intersections which marks the maximum count amongst all other intersections. And the lowest but maintained NMV count during repetitions is observed in cotton Market Square. Telephone Exchange Square gives drastic difference in the figures in R1 compared to R2-R4. To find out the results from NMV Count Hypothesis & p value were set for using ANOVA Two Factor without replication (F Test). These are as below:

Hypothesis :H0 : There is no significant variance in counts of NMV count as in 2012, 2020, 2021 & 2022.

H1: There is a significant variation in counts of NMV count as in 2012, 2020, 2021 & 2022.

The results of the F test are discussed under the results.

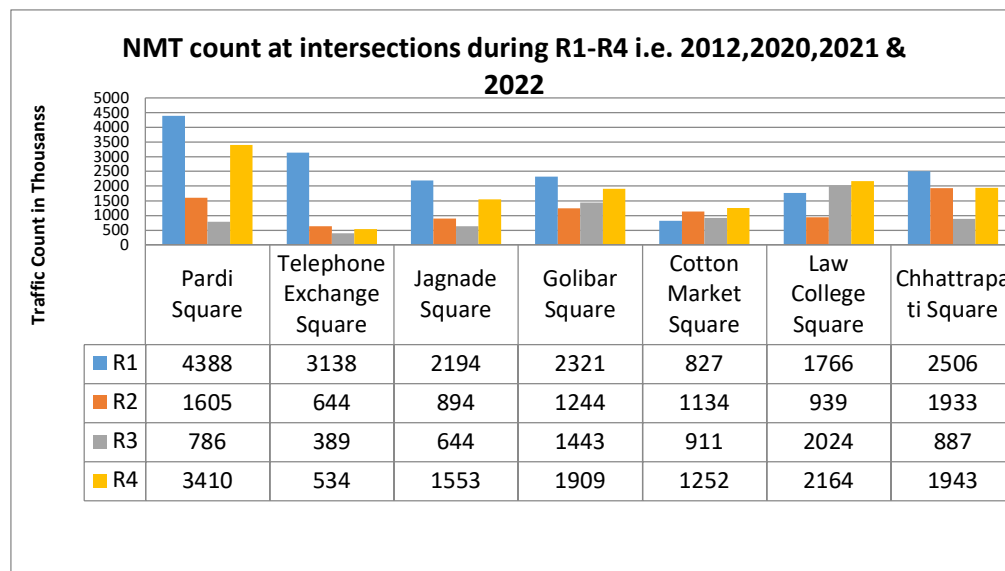


Fig. 3: NM Traffic count at Intersections with repetitions R1-R3 for 2020, 2021 & 2022 (Source: Prepared by author based on Table 3)

NMT counts at 4 repeated surveys at all seven intersections mark that Pardi is an intersections which marks the maximum count amongst all other intersections. And the lowest but maintained NMV count during repetitions is observed in cotton Market Square. Telephone Exchange Square gives drastic difference in the figures in R1

compared to R2-R4. To find out the results from NMV Count Hypothesis & p value were set for using ANOVA Two Factor without replication (F Test). These are as below:

Hypothesis :H0 : There is no significant variance in counts of NMT counts as in 2012, 2020, 2021 and 2022.

H1: There is a significant variance in counts as in 2012, 2020, 2021 and 2022.

p value :0.05 (with 95% confidence level)

The results of the F test are discussed under the results.

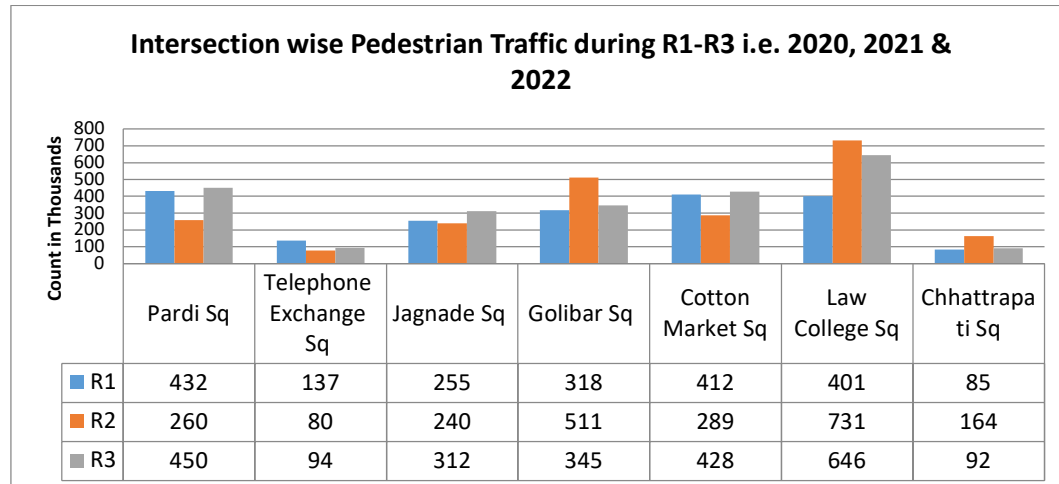


Fig. 4: Pedestrians Traffic count at Intersections with repetitions R1-R3 for 2020, 2021 & 2022 (Source: Prepared by author based on Table 3)

Pedestrians count at 3 repeated surveys at all seven intersections mark the different pattern of its count. The maximum pedestrian count was observed at Law College Square amongst all other intersections. And the lowest pedestrian count was observed at Telephone Exchange Square and Chhatrapati Square intersections. To find out the results from pedestrian Counts Hypothesis & p value were set for using ANOVA Two Factor without replication (F Test). These are as below:

Hypothesis :H0 : There is no significant variance in counts of pedestrians as in 2020, 2021 and 2022.

H1: There is a significant variation in counts of pedestrians as in 2020, 2021 and 2022.

p value :0.05 (with 95% confidence level)

The results of the F test are discussed under the results.

NMT count Survey Analysis 2012-2022 :

According to the comparative analysis from the survey data and site studies of the seven intersections it is understood that Pardi square is having major NM Traffic but no provisions for NMT has been observed till march and January 2021 whereas the progression of Maha-Metro project work is disturbing the traffic movements during July 2022.

At other intersections viz. Law college Square and Telephone Exchange Square the provisions are made for NMT users though here volume is lowest under NMT. It shows the tactical urbanism used for marking the NM Traffic especially for bicycle ride.

Highest and Lowest Traffic Volume Count Intersection in 2012, 2020 and 2022 for Total Traffic Count, Total NM Traffic and Total NM Vehicular Traffic Volume Count is enlisted in Table 4.

Table 4: The Maximum and Minimum Traffic Volume Count Intersection in 2012, 2020 , 2020 and 2022 for Total Traffic, Total NM Traffic and Total NM Vehicle Traffic Volume Count.

	Count at Intersections in June 2012	Count at Intersections in March 2020	Count at Intersections in January 2021	Count at Intersections in July 2022
Max of Total Traffic Count	Cotton Market Sq.(11347)	Chhatrapati Square (2497)	Law college Square (2448)	Pardi Square (4702)
Min of Total Traffic Count	Jagnade Square (5154)	Telephone Exchange Sq.(954)	Telephone Exchange Sq.(674)	Telephone Exchange Sq.(812)
Max of NM Traffic Count	Pardi Square (4388)	chhatrapati Square (1933)	Law college Square (2024)	Pardi Square (3410)
Min of NM Traffic Count	Cotton Market (827)	Telephone Exchange Sq.(644)	Telephone Exchange Sq.(380)	Telephone Exchange Sq.(534)
Max of NM Vehicle Traffic Count	Pardi Square (4388)	Chhatrapati Square (1850)	Law college Square (1293)	Pardi Square (2924)
Min of NM Vehicle Traffic Count	Cotton Market Sq. (827)	Telephone Exchange Sq (506)	Law college Square (293)	Telephone Exchange Sq.(431)

Analysis of NM Traffic At Intersections:

There is a decrease in number of NMT users and underutilization of NMT lanes in case of both, newly designed and modified existing roads since 2012 till 2022.

Main arterial roads have footpath but cycle track is missed on majority of the roads. Subarterial roads and internal roads hardly observe any division of NMT and Motorized traffic.

The mixed traffic on vehicular lanes is creating conflict between slow and fast movements due to difficulty in orientation by the NMT user thereby resulting in accidents and sometimes fatalities too.

At times with preoccupied NMT lanes, NM users are compelled to use the motorized vehicular lanes on the roads thus ultimately road width has not been fully utilized for the pedestrian movement.

At cross road intersections the urgency to move forward by all users does not give preference to NMT users for being slow in speed.

In city like Nagpur there is no special signal provision for NM traffic. They have to cross the intersection by keeping in mind the time interval available. Disables and elders also find it difficult to cross the road intersections in normal crossing time normally available i.e. 20-30 seconds in majority of the road intersections depending on the intersection. It becomes too short interval to cross the intersection with ease.

*Four Zones Itwari, Mahal, Sadar and Sitabuldi are marked as NMT zones with restrictions for motorized traffic. As per the public opinion this really helps controlling the traffic but also need to have sufficient vehicular parking and transit provisions to cater to needs of the users.

RESULTS:

1. The results for all statistical Test's calculations are described in this section.

T Test for checking the variance in NMT and PT count of 2012:

The traffic count in seven selected intersections as per 2012 survey readings were put to test the significance of NMT counts, Public Transport Count as independent variables. For that T test was used. It was performed using Microsoft Excel for counts Data Analysis of seven intersections for 2012 counts. The results of NM Traffic Counts at seven intersections in 2012 was derived thereon.

Table 5: T test results of NM Traffic Counts:

T Test for checking the significance between the NM Traffic Count and PT Count at seven intersections in Nagpur	Probability p value	Confidence value
with tails 1 and type 2	0.021670883	< 0.05
with tails 1 and type 3	0.021670883	< 0.05
with tails 2 and type 2	0.035683152	< 0.05
with tails 2 and type 3	0.043341765	< 0.05
Result : It is observed that in all presumed tails and types p value is less than 0.05. Therefore, it can be said that there is no significant difference between the Public Transport count and NMT count in 2012 at 0.05 confidence.		

2. ANOVA Two factor without replication, i.e. F test was used to compare the significance of variance for the Traffic Count at seven intersections in 2012 under NMT, PT and NMT+PT. it gave the results as below:
Table 6: ANOVA test results:

Anova: Two-Factor Without Replication				
SUMMARY	Count	Sum	Average	Variance
Pardi Square	3	12752	4250.667	4827781.33
Telephone Exchange Square	3	7320	2440	2827164
Jagnade Square	3	7064	2354.667	1222769.33
Golibar Square	3	6660	2220	1354411
Cotton Market Square	3	3678	1226	290383
Law College Square	3	6838	2279.333	977322.333
Chhatrapati Square	3	8806	2935.333	1708254.33
Total Public Transport count 2012	7	9419	1345.571	285696.286
Total Public+NM Traffic Count 2012	7	26559	3794.143	1883691.81
N/M Vehicle Traffic Count 2012	7	17140	2448.571	1236078.62

ANOVA							
Source of Variation	SS	df	MS	F	P-value	F crit	
Counts in Readings of NMT, PT and NMT+PT	15069534.48	6	2511589	5.619537	0.005509955	2.996120378	
Counts at Intersections	21052904.86	2	10526452	23.55233	7.00417E-05	3.885293835	
Error	5363265.81	12	446938.8				
Total	41485705.14	20					

Results: ANOVA: Two Factor without replication NMT, PT analysis at Seven Intersections for 2012

Result F test

Result on significance

Counts in Readings of NMT, PT and NMT+PT	Fstat > F crit,	There is a significant difference in values between rows i.e. NMT count at seven selected road intersections.	The Test is significant.
Counts at Intersections	Fstat > F crit,	i.e. There is a significant difference in values between columns i.e. NM Traffic, Public Traffic and PT +NMT taken Together.	The Test is significant.
Counts in Readings of NMT, PT	p value is smaller than significance value	null hypothesis is rejected and alternate hypothesis is accepted	Not significant
Counts at Intersections	p value is greater than significance	null hypothesis is accepted	Significant

3. ANOVA Two factor without replication, i.e. F test when used to compare the significance of variance for the NMT modewise counts at seven intersections in four repetitions in 2012, 2020, 2021, 2022, it gave the results as below:

Table 7: ANOVA test results

NM mode wise analysis at Seven Intersections for survey counts in 2012, 2020, 2021 and 2022.					
Anova: Two-Factor With Replication					
SUMMARY	E- Rickshaw Count	Cycle Rickshaw Count	Cycles Count	Carts Count	Total
Pardi Square					
Count	4	4	4	4	16
Sum	979	389	7571	108	9047
Average	244.75	97.25	1892.75	27	565.4375
Variance	30716.91667	4901.5833	3199670.3	44.666667	1280056.9
Telephone Exchange Square					
Count	4	4	4	4	16
Sum	576	693	3081	44	4394
Average	144	173.25	770.25	11	274.625
Variance	12296.66667	78039.583	1401594.9	118	389738.38
Jagnade Square					
Count	4	4	4	4	16
Sum	657	779	2988	54	4478
Average	164.25	194.75	747	13.5	279.875
Variance	15458.91667	24488.917	539110.67	51.666667	198429.18
Golibar Square					
Count	4	4	4	4	16
Sum	1284	535	3810	114	5743
Average	321	133.75	952.5	28.5	358.9375
Variance	53864.66667	40932.917	419691	85.666667	239889.26
Cotton Market Square					
Count	4	4	4	4	16
Sum	976	415	1573	31	2995
Average	244	103.75	393.25	7.75	187.1875

Variance	29794.66667	9176.25	17516.25	36.25	33931.096
Law College Square					
Count	4	4	4	4	16
Sum	2110	161	2750	94	5115
Average	527.5	40.25	687.5	23.5	319.6875
Variance	155577.6667	361.58333	509025.67	555	224913.16
Chhatrapati Square					
Count	4	4	4	4	16
Sum	1107	208	5774	11	7100
Average	276.75	52	1443.5	2.75	443.75
Variance	38366.25	526	569750.33	6.25	488486.6

Total

Count	28	28	28	28
Sum	7689	3180	27547	456
Average	274.6071429	113.57143	983.82143	16.285714
Variance	51738.32143	20579.069	973182.82	189.7672

ANOVA	of	SS	df	MS	F	P-value	F crit
Source							
Variation							
Sample		1491966.17	6	248661.0	0.9735379	0.448310	2.20855
		9		3		5	4
Columns		16090006.0	3	5363335.	20.998105	3.05E-10	2.71322
		7		4			7
Interaction		5286385.67	18	293688.0	1.1498243	0.321734	1.72795
		9		9		7	5
Within		21455277.5	84	255419.9			
				7			
Total		44323635.4	111				
		3					

Sample	p value is greater than significance value i.e. 0.05	null hypothesis is accepted			Test is significant
Columns	p value is smaller than significance	null hypothesis is rejected	& Alternate Hypothesis is Accepted		Tets is Not Significant
Interaction	p value is greater than significance	null hypothesis is accepted			Test is significant
Within					

4. ANOVA Two factor without replication, i.e. F test when used to compare the significance of variance for the NMT and NMV Count at seven intersections in four repetitions in 2012, 2020, 2021, 2022, it gave the results as below:

Table 8: ANOVA test results

Results : Anova: Two-Factor With Replication
NMT & NMV Count Total for four repetitions

SUMMARY	Survey Year	Total NMT Count	Total NMV Count	Total
Pardi Square				
Count	4	4	4	12
Sum	8076	10189	9047	27312
		2547.	2261.	
Average	2019	25	75	2276
	22.66	27075	30688	16262
	66666	11.58	98.91	37.63
Variance	7	3	7	6
Telephone Exchange Square				
Count	4	4	4	12
Sum	8075	4705	4394	17174
				1431.
Average	2018.	1176.	1098.	16666
	75	25	5	7
	20.91	17213		11649
	66666	33.58	18554	13.06
Variance	7	3	55	1
Jagnade Square				
Count	4	4	4	12
Sum	8075	5285	4478	17838
		2018.	1321.	1119.
Average	75	25	5	5
	20.91	48553	63737	46817
	66666	6.916	7.666	7.545
Variance	7	7	7	5
Golibar Square				
Count	4	4	4	12
Sum	8075	6917	5398	20390
				1699.
Average	2018.	1729.	1349.	16666
	75	25	5	7
	20.91	23329		26506
	66666	4.916	43816	0.878
Variance	7	7	7	8
Cotton Market Square				
Count	4	4	4	12
Sum	8075	4124	2995	15194
				1266.
Average	2018.		748.7	16666
	75	1031	5	7
	20.91	38488		33651
	66666	.6666	9522.	9.606
Variance	7	7	25	1
Law College Square				
Count	4	4	4	12
Sum	8075	6893	5115	20083
				1673.
Average	2018.	1723.	1278.	58333
	75	25	75	3
	20.91	30052	28118	25956
	66666	8.916	8.916	5.174
Variance	7	7	7	2

Chhatrapati Square				
Count	4	4	4	12
Sum	8075	7441	7100	22616
		1860.		1884.
Average	2018.75	25	1775	7
		35821	44122	22916
		2.916	8.666	2.969
Variance	20.91666667	7	7	7

Total				
Count	28	28	28	
Sum	56526	45554	38527	
		1626.	1375.	
Average	2018.785714	92857	96428	
		1	6	
		88245	96874	
		0.365	5.739	
Variance	16.47089947	1	4	

ANOVA						
Source of Variation	SS	df	MS	F	P-value	F crit
			13357	2.230	0.05	2.24
			40.40	32398	151	640
Sample	8014442.452	6	9	9	9	8
				4.907	0.01	3.14
			29388	08905	045	280
Columns	5877708.5	2	54.25	1	7	9
			35313	0.589	0.84	1.90
			4.569	63889	245	932
Interaction	4237614.833	12	4	7	5	5
			59889			
			9.718			
Within	37730682.25	63	3			
Total	55860448.04	83				

5. ANOVA Two factor without replication, i.e. F test when used to compare the significance of variance for the Pedestrian Count at seven intersections in four repetitions in 2012, 2020, 2021, 2022, it gave the results as below:

Table 9: ANOVA test results

Results: ANOVA: Two Factor with replication Test for NMV and NMT Count Analysis						
		Result F test	Result on significance			
Sample	Fstat < F crit,	i.e. There is no significant difference in values between groups and within groups.	The Test is Not significant.			
	Fstat > F crit,	i.e. There is a significant difference in values between groups and within groups.				
Columns	Fstat < F crit,	i.e. There is no significant difference in values between groups and within groups.	The Test is significant.			
Interaction Within						
Sample	p value is greater than significance value i.e. 0.05	null hypothesis is acceted	Test is significant			
Columns	p value is smaller than significance	null hypothesis is rejected and Alternate Hypothesis is Accepted	Tets is Not Significant			
Interaction Within	p value is greater than significance	null hypothesis is accepted.	Test is significant			
Results : Intersectionwise Pedestrian Traffic Anova: Two-Factor Without Replication						
SUMMARY	Count	Sum	Average	Variance		
Pardi Sq	3	1142	380.6667	11001.3333		
Telephone Exchange Sq	3	311	103.6667	882.333333		
Jagnade Sq	3	807	269	1443		
Golibar Sq	3	1174	391.3333	10922.3333		
Cotton Market Sq	3	1129	376.3333	5784.33333		
Law College Sq	3	1778	592.6667	29358.3333		
Chhatrapati Sq	3	341	113.6667	1912.33333		
2020	7	2040	291.4286	19132.9524		
2021	7	2275	325	49687.3333		
2022	7	2367	338.1429	39380.8095		
ANOVA						
Source of Variation	SS	df	MS	F	P-value	F crit
Rows	534723.2	6	89120.54	9.34150365	0.0006071	2.9961204
Columns	8124.667	2	4062.333	0.42580871	0.66273628	3.8852938
Error	114483.3	12	9540.278			

Total	657331.2	20	
Results: ANOVA: Two Factor with replication Test for Pedestrian Traffic Count Analysis			
		Result F test	Result on significance
Rows Columns	Fstat > F crit,	i.e. There is significant difference in values between groups and within groups.	The Test is significant.
	Fstat < F crit,	i.e. There is a significant difference in values between groups and within groups.	The Test is Not Significnt.
Rows	p value is greater than significance value i.e. 0.05	null hypothesis is acceted null hypothesis is rejected	Test is significant
Columns	p value is smaller than significance	and Alternate Hypothesis is Accepted	Tets is Not Significant

CONCLUSION AND REMARKS:

Conclusion:

The study marks that there is observed a significant difference in the NM traffic count at different intersections, it may be due to its location and users. But it has no significant difference in the counts of intersection during the course of time.

The study research derives the lessons that roads and their intersections need clear demarcations for NM Traffic lanes/ provisions and at times traffic calming techniques should be used. Sufficient time for elders and the disabled should be given to cross the intersections. These measures can create confidence among the NMT users further feeling safe while moving into their neighborhood areas. The efforts to sustainable transport can be achieved thereby justifying the NMT lane infra-structure provisions on all roads.

Suggestive Remarks:

Considering the low degree of motivation for NMT use in study area following suggestive remarks are made to improve on the number of NMT users:

1. All the main roads and road intersections should have separation of NMT and Motorized Vehicle lanes: This will allow all traffic to use the crossing with equal opportunity.
2. On main roads' intersection the signal crossing time should be sufficient for elders and disables to cross the road. In case of 24 meters wide roads 30 Seconds signal time is in sufficient for elders and disables. Therefore, the signal crossing time should be increased to 60 seconds and above for 24m and above wide roads. This will facilitate elders and disabled NMT Users to cross the signal with less or no help of others with in extended signal crossing time gaining confidence amongst them.
3. Internal roads should be provided with Traffic calming techniques and separate NMT lanes. This will be most helpful for all residents of the zone to approach the nearest public transport facility from the residence/ work centre etc.

The recommendations if implemented can create confidence among the NMT users thereby feeling safe while moving in their neighborhood areas. The efforts to Urban Sustainable Transport can be achieved by justifying the NMT lane provisions on all roads supporting High Speed Public Transport provisions.

FUTURE SCOPE

Detailed Study of intersections and Main Roads and Internal Roads Traffic arrangements and statistical study of available infrastructure in these areas may be included in the future scope of study under this topic.

ETHICAL DECLARATION

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