International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 11 Issue 09, September 2022

Re-Imaging the Urban Streets for Cycling in the Urban Fabric- the Case of Dewas

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***Abstract*:- Cycling is considered one of the cheapest and most sustainable mode of transport. Though European countries are leading in cycle usage a decade ago India was seen as among the top in using cycle in the world. The introduction of cheaper motorized vehicles in the country changed all the scenarios. Responding to the recent decrease in cycling in Indian cities, the government is trying to promote the use of bicycles and reduce the use of motorized vehicles for sake of sustainability. Now in India cycling is seen more as a health fitness tool rather than a mobility vehicle. The trend has been changing and people are moving more towards motorized vehicles. To encourage people to use cycles, the cities need to develop an infrastructure for cycling that is safe and secure and also according to the perceived needs of the people. People do follow certain routes for certain activities at a different point in time and therefore the route choice behavior of the people needs to be respected and the infrastructure needs to be planned accordingly. To create an infrastructure the perception of people towards cycling, the willingness of people to use cycle, travel behavior of the cyclist, and route choice of the existing users need to clarify accurately. The paper aims to analyze the perception of people and propose a cycle infrastructure network with required intervention in the Dewas city of India. This study would help several policymakers and stakeholders to use the developed method to analyze the perceived needs of people and propose and promote cycling culture in the future.**

Key Words- Cycling; Cycle Infrastructure; Cycling Perception; Public Bike Sharing System (PBSS)

1. INTRODUCTION

As a result of climate change, a need for a healthy lifestyle, and energy security; people have started thinking about sustainable transportation (Yan, 2017). The promotion of bicycling as a mode of transportation to reduce the environmental impact, traffic congestion and provide a better quality of life; is excessively being done by municipals all over the World (Pucher, 2011). A slow change can be witnessed in metropolitan cities and mid-sized cities where sustainable mobility plans have been developed and focused on implementation by public participation (Consortium, 2017). Until the beginning of the new millennium, the cycle was only used for recreational purposes or daily commutes by low-wage & socially marginalized workers. The trend is getting changed, today bicycle is seen as an attractive and healthy alternative to motorized vehicles and now is being used by all sections of society, across all gender & age groups for all kind of purposes like commuting, shopping, business or education trips, etc. in the western world (al., 2018). Countries like the Netherlands, Denmark, the Scandinavian countries and Germany, have an excellent bicycle share in all journeys of approximately 50% to 60% in the most cycle-friendly cities, such as Copenhagen (DK), Utrecht, and Amsterdam (NL) and are considered in the highest level of bicycling infrastructure and usage (Haustein, 2020). Bicycle share trips are as high as 27 percent in the Netherlands, followed by 18percent in Denmark, 10 percent in Germany compared to 1 percent in the USA, UK, and Australia (Pucher, 2011).

The following factors influence the cycle share: the presence of bicycle infrastructure, land use, parking facilities, block size and density, safety and storage facilities (Basu, 2013). India highly lacks bicycle infrastructure facilities and policies. Though a decline can be seen in the modal share of the bicycle in India, it still shares 13-21% (medium and large cities) and 6-8% (megacities) which is quite good when compared to the global scenario. Bicycle ownership in India is seen higher in the lower-income group as compared to the higher-income group and the average trip length varies from 5-10km. So, these data suggest that there's an ample opportunity to promote cycling in India (Tiwari, 2008). Although initiatives are being taken in a few cities like Bangalore, Mumbai, Pune, Delhi, Chennai, etc. but these are limited to Tier-I cities. No major interventions can be seen in mid-sized cities (Basu, 2013). Thus, the gap to evaluate perceived needs of mid-sized cities and promotion of cycling culture needs to be addressed. This research addresses the issue of lack of bicycle infrastructure and the perceived needs of the people to reimagine the urban streets for cycling in mid-sized cities of India. The paper aims to assess the need and propose Public Bike Sharing System (PBSS) Network in Dewas city. Therefore, the perception of people in Dewas city towards cycling has been assessed and the cycling infrastructure network has been planned accordingly.

The paper is structured as follows. In the next section, theoretical background and previous research have been outlined with regards to the perception of people towards cycling, cycling infrastructure network planning, and PBSS (public bike-sharing system). Section 3 comprises the outline of the case study area i.e., Dewas city. The methodology along with the variables used for analysis, the survey, and the survey results have been addressed in section 4. Section 5 covers the analysis of the survey results, followed by cycle infrastructure network planning in the study area and deriving optimal locations of public bike-sharing system stations on the planned infrastructure network. The paper closes with some discussions and conclusions in section 6.

International Journal of Engineering Research & Technology (IJERT)
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2. THEORETICAL BACKGROUND

2.1 Perception of People Towards Cycling

Much research has been made on individual perceptions of cycling. One of the studies identified four main perception dimensions namely cycle infrastructure, traffic environment, non-built cycling environment, and public space quality (Blitz, 2021). Cycle infrastructure relates to the presence and condition of cycle-related facilities, be it segregated tracks, safe crossings, colored paths, etc. Many studies show that the perception of cycle infrastructure in an area positively promotes and encourages cycling and contribute to bicycle use by increasing safety. (Iwi´nska, 2018). Traffic environment refers to the travel behavior of people around and the traffic volume in it. Perception denotes the positive impact of others being physically surrounded nearby while it also denotes a negative impact of motorized vehicles in surrounding as a matter of individual safety (Manton, 2016). Few studies also deal with the non-built environment and research shows that lack of respect towards cycling by vehicle traffic and lack of cycle-related policies by the government gives a negative perception (Frater, 2020). Pleasant public space and aesthetics are involved in the perception of public space quality. Studies show that people positively perceive the green and aesthetically appealing spaces for cycling. People generally prefer to ride in less built-up and more green space which also relates to a high frequency of cycling in fewer traffic spaces. (Iwi´nska, 2018). All the above dimensions interrelate and affect cycling in several ways.

The cities with good cycle infrastructure are better perceived by bicyclists. Even within cities, spaces with improved cycle infrastructure are perceived safer by a cyclist (Lawson, 2013). Cycling in a city is perceived safer by a cyclist who is male, younger, has low income, and has young children. They also prefer cycling more when compared to other classes of society. By increasing the cycle infrastructure and facilities, the perception towards safety can be enhanced but one should also focus on the individual character which plays an important role in safety perception (Michael Branion-Calles, 2019).

Multiple types of research have been done towards the perception of barriers to the use of the cycle. Studies suggest that barrier perception can be analyzed on various factors like lack of cycle infrastructure, lack of safety, distance to be traveled by the user, physical fitness of cyclist, the slope of the route, and climate conditions about an area (Adriana A. de Sousa, 2014). It also suggests that for policies and campaigns to be successful in reducing car use largely depends on the factors of how the individual's modal choice is being influenced. However, generally, to encourage people to use cycles, negative consequences of the use of automobiles are focused on campaigns (Adriana A. de Sousa, 2014).

2.2 Cycle Infrastructure Network Planning

Higher affordability of motorized vehicles has resulted in a declining rate of bicycling significantly in India. Cycling is becoming more restricted to low-income group families and students, especially in Tier-III cities. (Tiwari, 2008). Urgent initiatives should be taken by policymakers in India to promote the cycle in urban areas across the country. To promote cycling the focus should be equally given to policymaking and dedicated cycle infrastructure. The spaces where it is not possible to provide dedicated lanes for cycling, safety and congestion freeness should be compromised over travel time to some extent. PBS (public bike-sharing) and policies like incentives for bicycle users would further promote cycling and act as supportive measures for cycling infrastructure (Samyajit Basu, 2016). Both quantitative (traffic volume of bicycle) and qualitative (route choice behavior) aspects should be taken into consideration to plan cycle infrastructure network. To analyze traffic volume various bicycle users like work & school commuters, holiday cyclists, fitness purpose cyclists, etc. should be taken into account while route choice behavior can be analyzed on basis of the characteristic of bicycle traveling, distribution of origin, and destination, safety, coherence, and directness. (Chinzan, 2007). The OLIVE method would help in precise and easy “estimation of bicycle traffic volume” and “route choice behavior of cyclist”. This would also help in identifying routes with high demand and analyzing the actual route which would reveal issues in the existing bicycle network. The bicycle should be planned depending on the route choice of the cyclist and the cycle traffic volume assessing the current area (Kiyoshi Suzuki, 2012)

Colored bicycle lanes are one of the good options for bicycle network infrastructure. It provides attention to the unique function of the lane which can be provided in the entire stretch of new or existing lanes. Though color has no legal meaning, different color shades red, blue, and green are being used by different countries as per their policies (Autelitano, 2021).

2.3 Public Bike Sharing System

PBSS is a system where bikes are shared on a rental basis to travel from one point to another. Multiple stations are located in a network where a bicycle can be taken from one station and dropped on another station within the network. For the first time, it was proposed in Amsterdam in 1965, since then it’s been well-known and considered as one of the alternatives of fastest green transportation (PATE S.J., 2019). For the success of the PBS system, optimal locations of PBS stations and their interconnection with trip demands (Lin, 2011). It is important to choose a simple and efficient method to identify optimal BPS station locations. One of the favorable tools to develop PBSS is GIS where optimal locations can be identified on basis of trip demand. For identifying optimal locations, attraction points like government buildings, schools, factories, nodes, etc. should be identified and should be combined with traffic volume (PATE S.J., 2019)

So, can good design encourage cycling? This has been answered by multiple researchers. One of the researches identifies that the people who commute at least once or twice in the week tend to use it more after the infrastructure is provided. Various factors like wide cycle lanes, direct routes connecting all land use, segregation wherever possible, adopting design guidelines, clear signages, and several policies to promote cycling should be considered for a good design of cycle infrastructure (Angela Hull, 2014).

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Vol. 11 Issue 09, September 2022

3. Study Area Profile

Dewas which is a city popularly known for Reserve Bank of India is a city being located in the central part of India in the state of Madhya Pradesh at latitude 22.96^0 N and longitude 76.05^0 E. It is one of the most dynamic cities of M.P. and also one the fastest growing cities due to immigration from rural to urban from various rural areas nearby and close proximity to Indore. It is well connected with all the major cities of India by rail and roads. Talking of the regional setting, it is surrounded by Indore in the South, Ujjain in the West, and Sehore in the East. The municipal limits of Dewas cover an area of 50 SQ KM. As per Census 2011, the population of Dewas city is 3 lacs approx. which has been showing a positive trend of over 25% increase every decade.

Dewas is divided into two Zones i.e., Dewas Junior and Dewas Senior, based on the rulers that ruled over here. Recently the ward boundaries of Dewas were altered at the administrative level, many wards were merged, new wards were created and the ward numbers were changed. This study uses the old ward map due to the availability of data (Census 2011). The old ward distribution had 45 wards in Dewas. The central portion being the oldest part of the city act as CBD and majorly houses the commercial complexes and local market. Dewas has seen its future as an industrial town, the existing industrial area houses many big manufacturing plants which supports the economic growth of the city. Figure 1 shows the municipal boundary and ward boundaries of Dewas city.

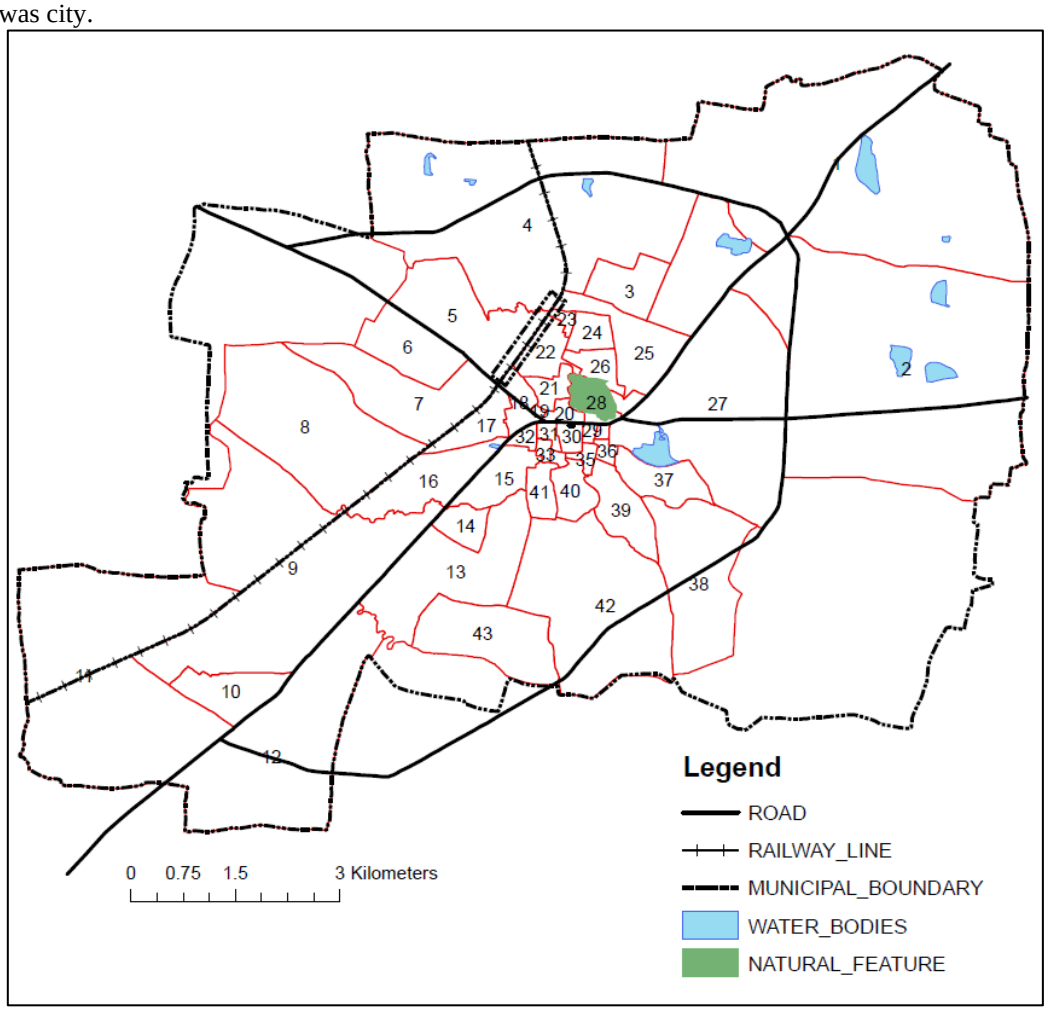

Figure 1 – Ward Distribution of Dewas City

4. METHODOLOGY & SURVEY

4.1 Methodology

This study proposes a method that figures out the perception of people towards cycling in Dewas along with assessing the need for cycling infrastructure in the city. It further also proposes the method to assess the travel pattern & behavior of the cyclist and determine required the cycle infrastructure network and the optimal locations of PBS stations on the proposed network.

To understand the requirement of cycle infrastructure in the city, the perceived needs of people must be captured; and in line with this, a digital survey was conducted to understand the travel demand and route choice behavior of people. A survey was carried out in Dewas city in October 2021 and a total of 276 survey samples were collected from different wards all over the city. Based on the survey household characteristic, the socio-economic character of stakeholders, cycle usage, trip purpose, public space quality, safety, origin-destination travel pattern of the study area, etc. is analyzed to assess the perceived needs of people

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and determine the required cycle infrastructure network in the city and the optimal locations of PBS stations on the proposed network.

To study the perceived needs of people and willingness for cycling, the survey results have been analyzed through a logistic regression model with help of IBM SPSS Statistics 22. Further, the analysis for the cycle infrastructure network has been done through weighted index modeling and route demarcation of O-D survey results on ARC GIS 10.8. Optimal locations of PBS stations have been done through node identification and buffer analysis through ARC GIS 10.8.

4.2 Survey Results

This section discusses the results of the survey which are later analyzed in a later section. These results give us a fair idea of the requirement of a cycle infrastructure network in the city. Table 1 shows the results of the survey.

Variable	Descriptions	Value
Number of Respondents	Total Male and Female	276
	Male	63%
	Female	37%
Age of Respondent	Below 14	10%
	14-18	25%
	19-45	46%
	46-60	13%
	Above 60	6%
Occupation	Job	32%
	Student	27%
	Self Employed	41%
Family Size	1-3	22%
	4-6	62%
	Above 6	16%
Family Income (Monthly)	Below Rs 15,000	30%
	Rs. 15,001-30,000	38%
	Rs. 30,001-50,000	23%
	Rs. Above 50,000	9%
Cycle Ownership	Yes	73%
	No	27%
Existing Users		
Cycle Usage	Regular	35.5%
	Sometimes	18.1%
	Rarely	29.3%
	Never	17.1%
Trip Purpose	Work	16.4%
	School	27.4%
	Health	33.6%
	Leisure	13.3%
	Market	9.3%
Trip Distance	0-2 Km	20%
	2-4 Km	45%
	4-6 Km	35%
	Above 6 km	-
Safety	Met with an accident	64%
	Never met with an accident	36%
Public Space Quality	Aesthetically Appealing	35%
	Green Space	57%
	Built-up Space	8%
Non- Existing Users		
Willingness to use Cycle	Yes	18%
	No	60%
	May be	22%
Reason for not using Cycle	Social Status	12%
	No Cycle at Home	28%
	Use Bike	54%

Table 1: Digital Survey Data and Results

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ISSN: 2278-0181
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5. Analysis and Proposals

5.1 Perception of People Towards Cycling in Dewas

The perceived needs of people have been analyzed through a logistic regression model. This is one of the best methods to determine the relationship between one group to another group. It determines the reason-result relationship of the independent variable with the dependent variable. Here the perception of existing bicycle users has been analyzed. The dependent variable has been taken as cycle use while the question for the dependent variable is "Do you use a bicycle?". Here the answer 'yes' has been marked as '1' while 'no' is marked as '0'. Age, gender, occupation, family size, family income, cycle ownership, trip purpose, trip distance, safety, and public space quality have been used as independent variables for the analysis. Validation of data has been done through Hosmer and Lemeshow Test which shows that the predicted data is significantly high and can be used for further analysis. Table 2 shows the case processing summary where the total number of cases is 276 of which 1 case is missing which though is just 0.4 percent of the whole cases, hence missing cases is significantly low. The beginning block is denoted in Table 3 which acts as a baseline for the predictive model. No variables have been included in this step and the cutoff value is 0.5. This table is highly useful for comparative analysis with the predicted model.

Unweighted Cases		**N**	**Percentage**
Selected Cases	Included in Analysis	275	99.6
	Missing Cases	1	0.4
	Total	276	100
Unselected Cases		0	0
Total		276	100

Table 2: Case Processing Summary 1

Observed			**Predicted**		
			Cycle Use		Percentage Correct
			1	2	
Step 0	Cycle Usage	1	225	0	100
		2	50	0	0
	Overall Percentage				81.8

Table 3: Beginning Block 1

Hosmer and Lemeshow test showcase the significance of the predicted model. The cutoff value is 0.5 which means that if the significance value is above 0.5, the model can be used and higher the significance value higher would be its creditability. Table 4a shows the Hosmer and Lemeshow Test data and Table 4b derives the contingency for Hosmer and Lemeshow Test. In the contingency table, the observed and expected values are similar which indicated that the predicted model is quite validatory in nature.

Step	**Chi-Square**	**df**	**Sig.**
1	0.0	8	1.0

Table 4a: Hosmer and Lemeshow Test 1

		Cycle Use-1		**Cycle Use-2**		
		Observed	**Expected**	**Observed**	**Expected**	**Total**
Step 1	1	28	28	0	0	28
	2	28	28	0	0	28
	3	28	28	0	0	28
	4	28	28	0	0	28
	5	28	28	0	0	28
	6	28	28	0	0	28
	7	28	28	0	0	28
	8	28	28	0	0	28
	9	1	1	27	27	28
	10	0	0	23	23	23

Table 4b: Contingency for Hosmer and Lemeshow Test 1

All the independent variables discussed above have been analyzed in the next step and their relationship with Cycle use has been determined. If Exp(B) is greater than 1, it indicates a higher probability while lower the value than 1, less would be the probability. Table 5 shows the relationship of variables with the dependent variable. The highest cycling trend can be seen between 19-45 years of age. People prefer to use cycle to a certain age and then the trend decreases after it. Gender also plays a major role in cycling; females tend to use cycle less compared to males. Self-employed people and students have a positive perception of cycling. The majority of people use cycling as a tool for fitness and keeping themselves healthy. Similarly, other variables can be analyzed through Exp(B).

Step 1	Variables	B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I. for Exp(B)	
								Lower	Upper
	Age	.054	2247.15	0	1	1	1.05	0	-
	Gender	-1.21	4059.19	0	1	1	.296	0	-
	Occupation	.266	2112.91	0	1	1	1.30	0	-
	Family Size	.131	2957.15	0	1	1	1.14	0	-
	Family Income	.656	2067.49	0	1	1	1.92	0	-
	Cycle Ownership	1.98	4095.33	0	1	1	7.3	0	-
	Trip Purpose	-.863	2324.73	0	1	1	.422	0	-

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ISSN: 2278-0181
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	Trip Distance	-.762	3202.85	0	1	1	.467	0	-
	Safety	-33.3	8466.90	0	1	.997	0	0	-
	Public Space Quality	-1.31	4882.82	0	1	1	.268	0	-
	Constant	16.07	10754.4	0	1	.999	9549788		

Table 5: Logistic Regression Model 1

5.2 Willingness to Use Cycle

Willingness to use the cycle is impacted by psychology due to the conventional mode of transport that provides ease and comfort. Non-existing cycle users have been considered for this study. To study the willingness, the results of the survey have been analyzed through a logistic regression model. The dependent variable in the model is "Willingness to use Cycle" under which the question is "Are you willing to use cycle?". Here the answer "yes and maybe" are considered as "yes" and assigned number '1' while "no" is assigned number '2'. Age, gender, occupation, family size, family income, cycle ownership, trip purpose, trip distance, safety, and public space quality have been used as independent variables for the analysis.

The significance value in Hosmer and Lemeshow Test is 0.853 which indicates good predictability of the model. The observed and expected values in the contingency table are also quite similar to each other which again denotes that the predicted model has a good level of validity. Age has a positive relationship with willingness. Students generally prefer to use the cycle and the willingness to use the cycle increases during the age of 19-45 which suggests the enthusiasm in the young generation. People above 45 years of age do lose their interest in cycling mainly due to health issues and social status. Gender does have less probability which means that males are willing to use cycle more in comparison to females. This might be due to fact that a major portion of females gets married between the age of 19-45 which eventually reduces their probability to use cycle in Indian culture in mid-size cities like Dewas. Self-employed people will use cycle less coz of the conventional use of motorized vehicles. Family income has a negative probability to use cycle, people with higher family income will use cycle quite less coz of higher ownership of motorized vehicles. Owning a cycle has a positive impact on the willingness and people who own a cycle tend to use it.

Table 6,7, 8, 8a, and 9 shows the complete logistic regression model for willingness to use cycle.

Unweighted Cases		**N**	**Percentage**
Selected Cases	Included in Analysis	49	17.8
	Missing Cases	227	82.2
	Total	276	100
Unselected Cases		0	0
Total		276	100

Table 6: Case Processing Summary 2

Observed			**Predicted**		
			Cycle Use		Percentage Correct
			1	2	
Step 0	Willingness	1	0	20	0
		2	0	29	100
	Overall Percentage				59.2

Table 7: Beginning Block 2

Step	**Chi-Square**	**df**	**Sig.**
1	4.043	8	.853

Table 8: Hosmer and Lemeshow Test 2

		Cycle Use-1		**Cycle Use-2**		
		Observed	**Expected**	**Observed**	**Expected**	**Total**
Step 1	1	5	5.00	0	0	5
	2	5	4.73	0	.268	5
	3	3	2.97	2	2.02	5
	4	2	2.27	3	2.72	5
	5	1	1.61	4	3.38	5
	6	2	1.37	3	3.62	5
	7	0	.970	5	4.03	5
	8	1	.645	4	4.35	5
	9	1	.331	4	4.66	5
	10	0	.084	4	3.91	4

Table 8b: Contingency for Hosmer and Lemeshow Test 2

Step 1	Variables	B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I. for Exp(B)	
								Lower	Upper
	Age	.339	.542	.392	1	.531	1.40	.485	4.06
	Gender	-1.33	.871	2.33	1	.126	.264	.048	1.45
	Occupation	-1.09	.641	2.93	1	.087	.334	.095	1.17
	Family Size	.256	.933	.075	1	.784	1.29	.207	8.05
	Family Income	.366	.456	.644	1	.422	1.44	.590	3.52
	Cycle Ownership	-1.01	1.25	.658	1	.417	.363	.031	4.20
	Trip Purpose	-1.67	8155	0	1	1.00	.187	0	-
	Trip Distance	-15.6	13914	0	1	.999	0	0	-
	Constant	5.07	2.89	3.07	1	.079	160.3		

Table 9: Logistic Regression Model 2

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ISSN: 2278-0181
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5.3 Cycle Infrastructure Network Analysis and Proposals

Origin- Destination survey was carried out to understand the travel demand and behavior of cyclist which eventually helped in route identification for cycle infrastructure network in the city. The center of the ward has been taken as origin point and the wards where maximum cycle is being used is analyzed by weighted index model through GIS. Figure 2 shows the weighted model for cycle usage within the different wards across the city. The higher the diameter of the circle in the ward, the higher is the cycle usage in that ward. It was found that cycle usage is more in the wards that are directly connected to sub-arterial roads. It was also found that core areas of the city with lower monthly income are more active in cycling.

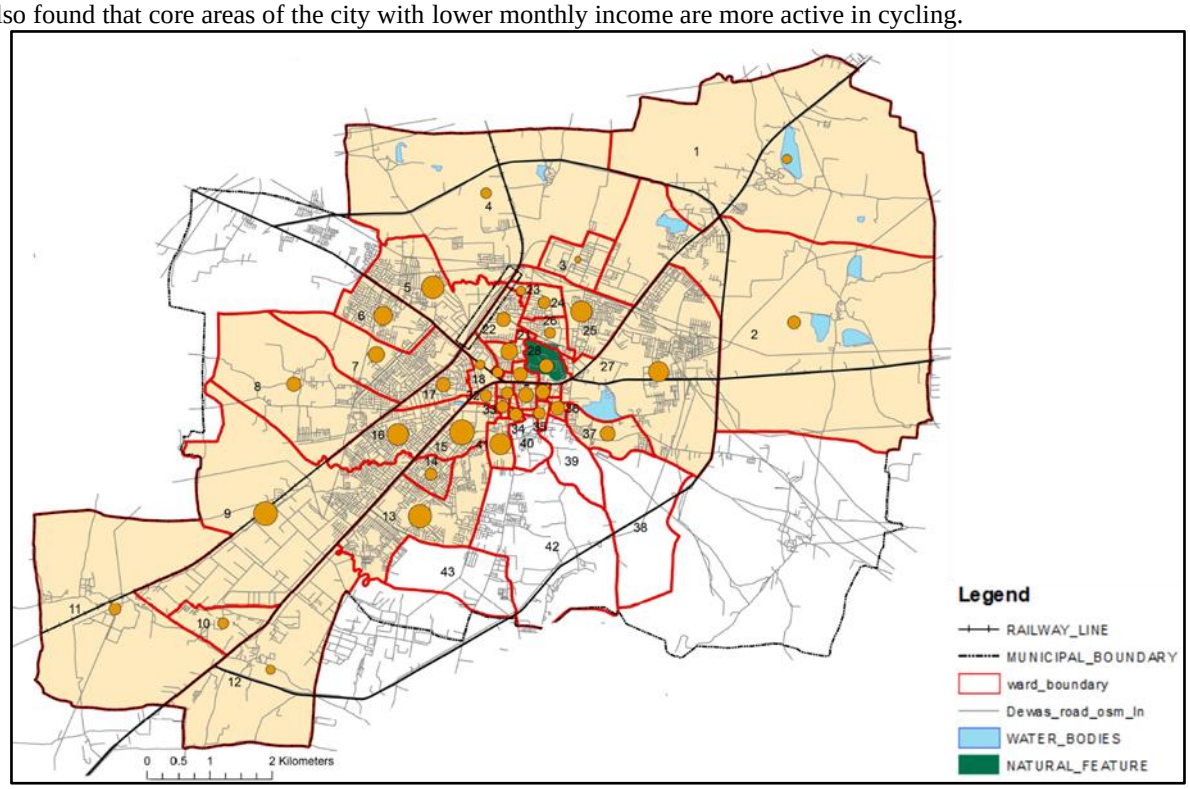

Figure 2: Ward Wise Cycle Usage Weighted Model

Various thematic maps of existing cycle users have been prepared to understand the travel behavior of the cyclist based on the survey. Figure 3 depicts the thematic map that showcases the route choice behavior of the cyclist for different occupations i.e., respondents who are self-employed, student or into jobs. The route has been marked on GIS and different color coding has been done for each indicator. Another thematic map of route choice behavior of cyclist for various trip purposes has been showcased in Figure 4. The indicators used for various trip purposes are: market, school, work, health and leisure. Different routes are being preferred by individual respondents which have been marked using GIS.

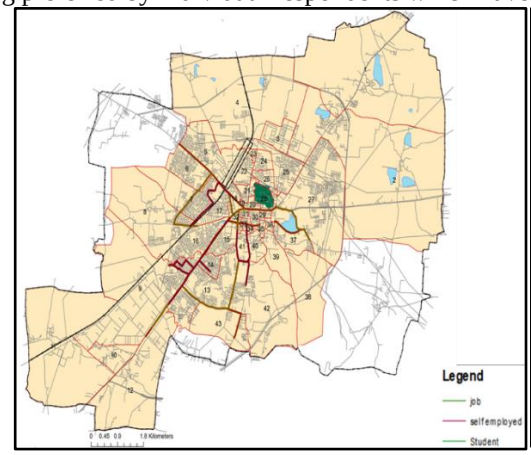

Figure 3: Route Choice Behavior for Various Occupation

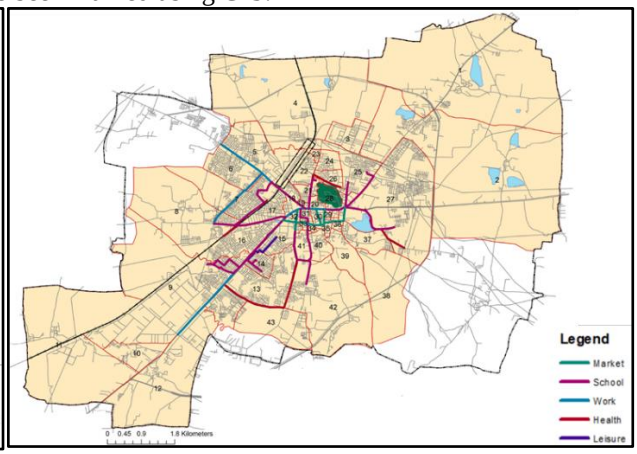

Figure 4: Route Choice Behavior as per Trip Purposes

Figure 2, 3 and 4 have been overlayed to identify the route that shall be proposed for infrastructure network. Maps made after analysis from survey are overlayed and final proposal for required cycle infrastructure network in city has been derived. Majorly all the main sub-arterial roads and major collector roads have been proposed for the infrastructure. Total of 17.1 KM length of road has been considered in proposal. Available road width has also been taken into account while determining the route and the routes connect majority of wards and market area and also the industrial area where cycles are majorly used. The

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ISSN: 2278-0181
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proposed route would not encourage the cycling trend in city but would also help to achieve sustainability and reduce the motorized vehicular usage in the city. Figure 5 shows the proposed cycle infrastructure network in the city.

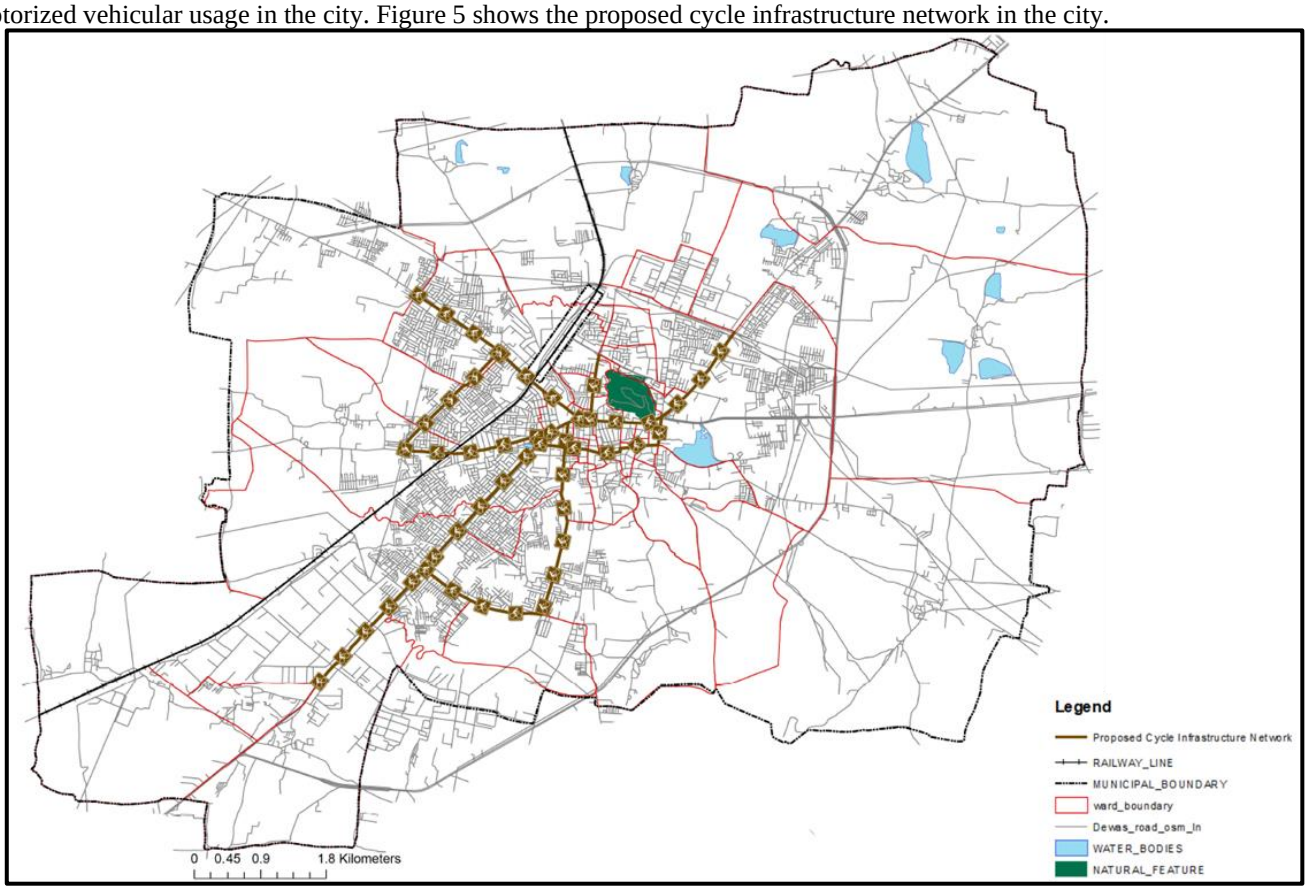

Figure 5: Proposed Cycle Infrastructure Network Route in Dewas City

The proposed route for cycle infrastructure needs some interventions so that the accuracy of proposed path can be determined. Total nine patches on the whole proposed network of varying ROW have been selected to detail out the required interventions. Figure 6 shows the patches that have been detailed out and Table 10 shows the existing ROW of those patches.

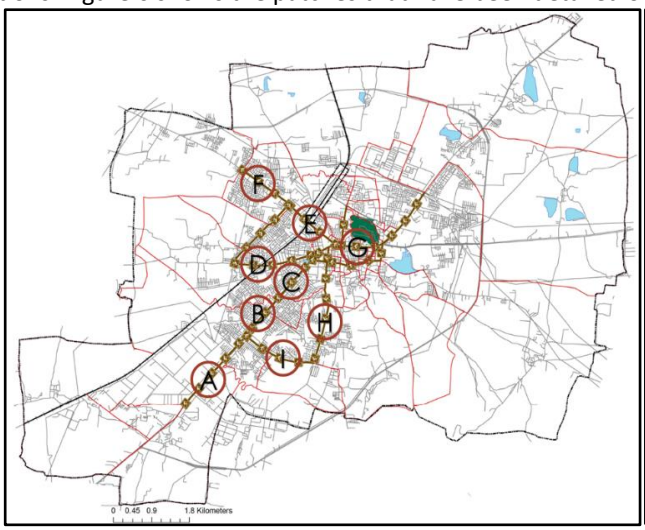

Figure 6: Segments of Proposed Network for Interventions

Stretch	Area Name	Row
A	Industrial Area	30m
B	Jawahar Nagar	54m
C	Ram Nagar	54m
D	Civil Lines	30m
E	Abhinav Theatre	20m
F	Itawah	20m
G	Tekri	30m
H	Balgarh	20m
I	MR10	20m

Table 10: List of Selected Segments for Detailing

International Journal of Engineering Research & Technology (IJERT)
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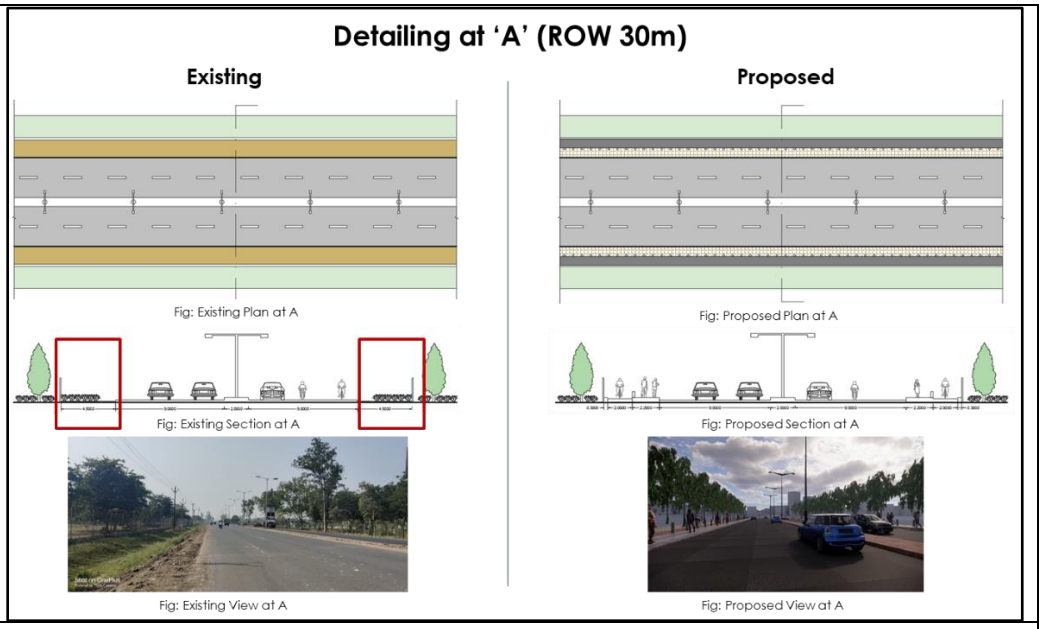
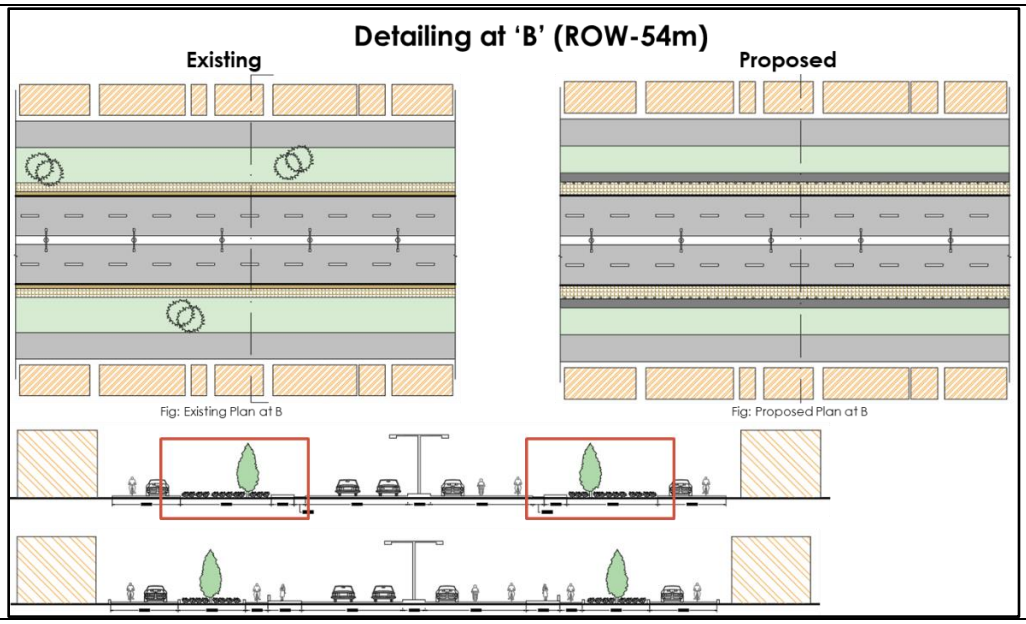
ROW 30m has been used completely to proposed cycle infrastructure and pedestrian facility. There was no provision for cycling or pedestrian in this segment, so the leftover space at sides of road has been utilized for the provision.	
In this segment the ROW is 54m and has the provision for pedestrian in the existing scenario. The existing green belt has been reduced in the proposal and provision for cycle path has been made.	

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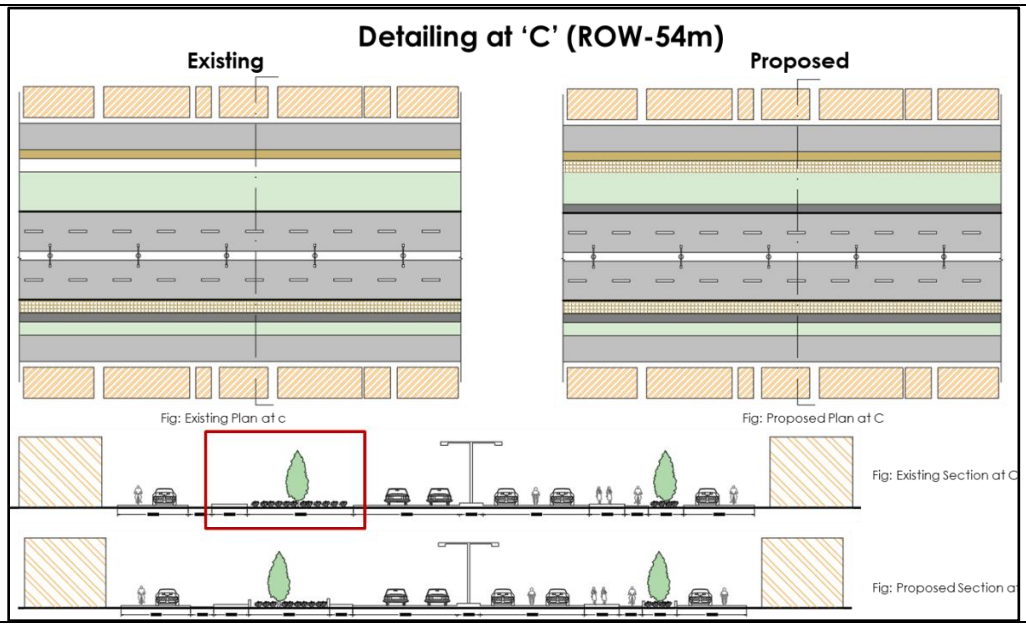
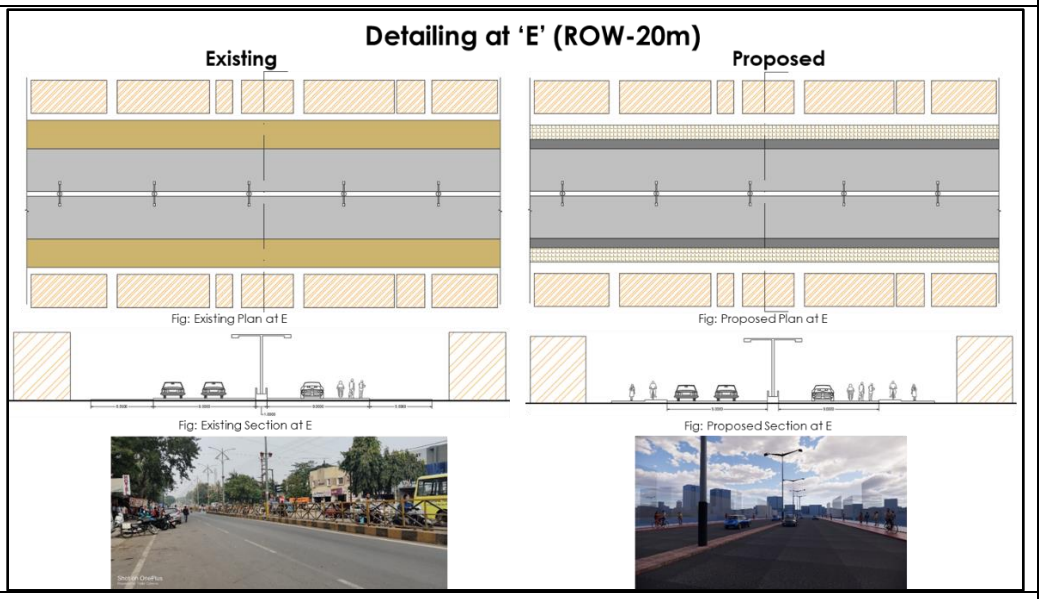
This segment lacks the provision of cycle path on one side of the road. Therefore, the green belt of that side has been reduced and provided with cycle infrastructure. Here the cycle path and pedestrian have a green belt in between. This is due to the reason of existing trees which are not being disturbed in the proposal.	
Even though the existing ROW is 20m but there's about 10m space at both sides of this segment. So, the space at sides has been used for provision of cycle infrastructure and the pedestrian facilities.	

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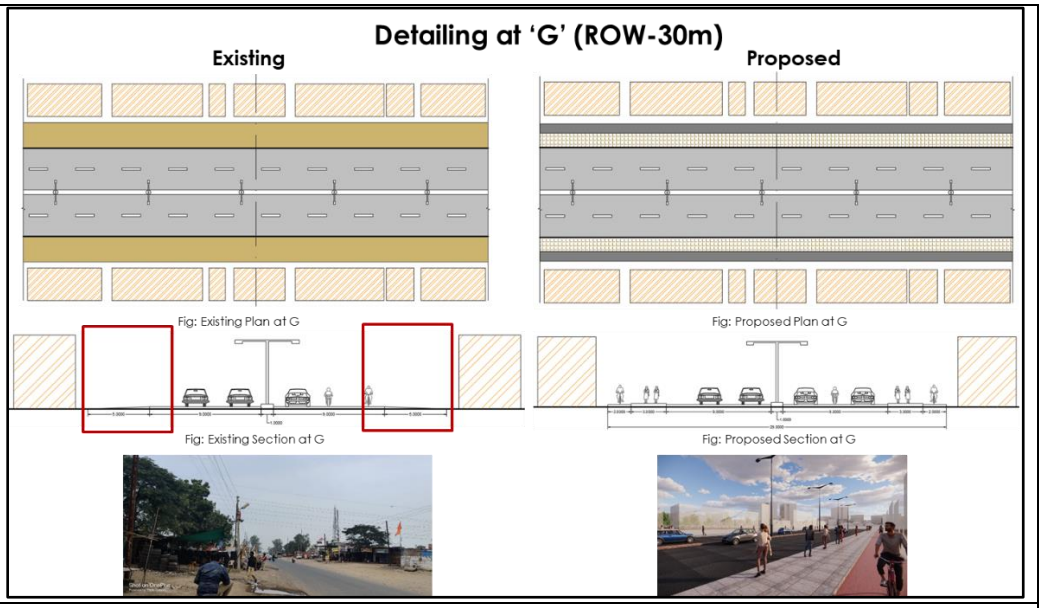
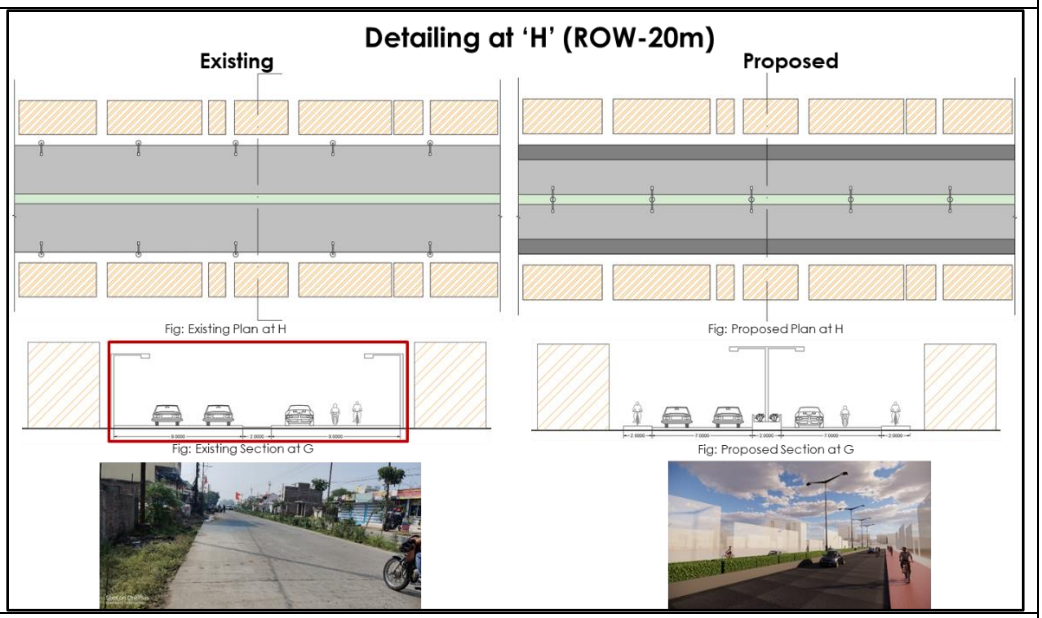
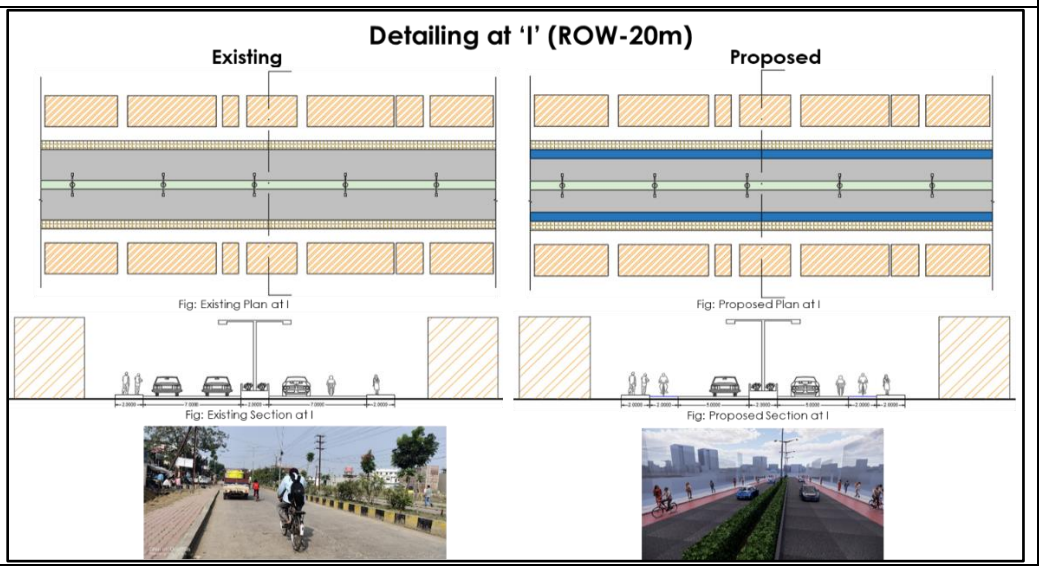
This segment has ROW of 30m. Although being an arterial road it is a double lane road which has been approved for four lanes by administration. So, the proposal has been made to integrate cycling and pedestrian along with lane doubling by the administration.	
Many interventions have been proposed in this segment. Firstly, the provision of streetlights in the center would help in equal lighting along the street and also help in utilization of side space for other purpose. Secondly, the provision of cycle infrastructure along both sides of roads has been proposed for safe and secure cycling by users.	
Since the available ROW is just 20m. Therefore, colored cycle lane shall be used in this segment of proposed network. No segregated lane shall be provided for cycling but in the existing motorized lane, colored lane for cycle infrastructure has been proposed.	

Table 11: Detailing of Segments in Proposed Infrastructure Network

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5.4 Optimal Locations of Public Bike Sharing Stations

The need for PBS system in the city has been determined by the survey. 86% of respondents who are existing users or are willing to use cycle have shown their interest in PBS system. To determine the optimal locations of PBS stations on the proposed cycle infrastructure network, nodes were identified. These nodes were mainly based on the locations of offices, schools, public/ semi- public buildings and major squares which generally attract people for work, studies or leisure were identified and marked on the digitalized map of Dewas city with help of GIS software. These nodes were then analyzed using buffer tool of 500m radius. 500m distance is considered as a walkable distance and thus the distance to the nearest PBS station shall not be more than 500m for maximum people residing in proximity to proposed cycle infrastructure network in the city. Few nodes have to be omitted after the analysis and few special locations had to be added for the stations on the network. Thus, the final optimal locations for the PBS stations were obtained. Figure 7 shows the proposed optimal locations of PBS stations and Figure 8 shows the buffer analysis of the proposed PBS stations with radius of 500m from the center of PBS stations.

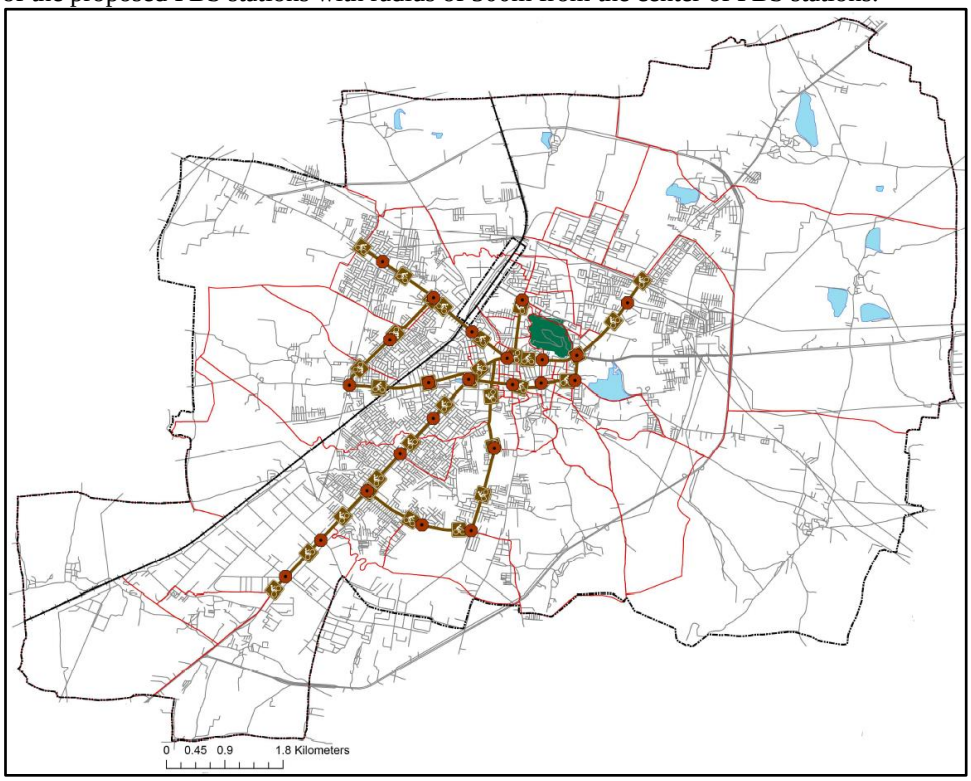

Figure 7: Proposed Optimal Locations for Public Bike Sharing Stations

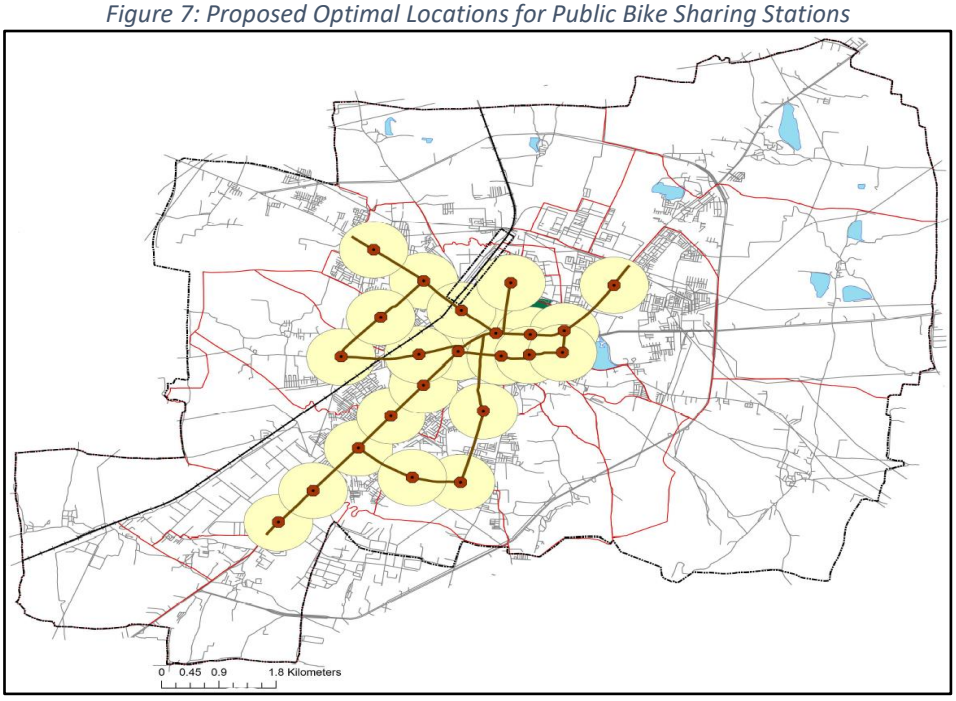

Figure 8: Buffer Analysis of Proposed PBS Stations

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6. Conclusion

The study analyzed the perception of existing and non-existing cycle users through logistic regression model. The method definitely helped in understanding the perceived needs of people in the city and various factors that contribute to positive and negative perception of people towards cycling. The bicycle route choice of the people was obtained from the survey where each respondent marked his/her preferred route that is being used. This data was analyzed on GIS and the required network of cycle infrastructure was determined.

Apart from being an easy vehicle, a high degree of freedom is given to people by cycling. Thus, to create a safe, secure and sustainable infrastructure the perceived needs of people need to be analyzed so that the public participation enhances to a great extent and the proposal comes out to be made for the users. If PBS system is being proposed then the locations of the stations play a major role in the success of the whole system. These stations should be accessible by all the individuals and the study proposes the method to identify the optimal locations of the PBS station the cycle infrastructure network with help of buffer analysis to ensure the accessibility of it by all.

These findings and methods can be used to other medium sized cities and changes shall be made as per the city needs coz every city has a diverse identity which should be respected and maintained to make the world sustainable.

Funding Sources

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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