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Shift from smart mobility to responsive mobility for metro stations in Chennai, India

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ABSTRACT: The responsive city explores citizen as centre of decision making in the smart city ideas, that is "From For the citizen to By the citizen". Last-mile connectivity is the connection between stations transit stops, to the final destination. It is one of the major factors in a successful smart mobility plan. This research is an attempt to explore responsive last mile connectivity. The two newly opened station (Tiruvottiyur metro station and Wimco nagar metro station) of Chennai metro rail phase I extension is selected as the study area, which provide wide scope for research. The issues identified and solved at the early stage of the development of transit network will improve the quality of life of citizens and also increase commuters, which has a relationship with economic development on the other hand. Two park analysis was undertaken in this research, one based on the questionnaire survey on five major aspects i.e. exact location of the commuters, General information about the commuters, trip information, parameters of Chennai Metro rail limited, Suggestions and recommendations of commuters and other is the statistical analysis for predicting the mode choice using multinomial logit regression method. From the findings it was evident that lack of quality infrastructure, pedestrian-friendly facility and high peak hour traffic are the major problems felt by the commuters. From the Multinomial logit model it is found that there is an increase in usage of public transport in one station and decrease in the other station. The pure participatory approach was involved in arriving at the proposal from the finding of the analysis in this research.

KEYWORDS: Responsive mobility, Last mile connectivity, Mode choice model, Multinomial logit regression, Chennai Metro Rail Corridor

HIGHLIGHTS
- Shift from smart mobility to responsive mobility.
- Pure participatory approach in smart mobility.
- Predicting mode choice behaviour using multinomial logit regression.

1. INTRODUCTION

Responsive city is the current globally emerging concept. This approach keeps the citizen as the centre of decision making process in the smart city ideas. In India's smart city mission, citizens played an important role in decision making process as per 73rd and 74th constitution amendment act of India which emphasized on a bottom-up approach i.e., to incorporate citizen engagement in planning (participatory approach).

Last-mile connectivity is the connection between stations, transit stops, to the final destination. Last mile connectivity is one of the important factors in smart mobility plan, which is the chosen research area. Growth of Private vehicles is tremendous in Indian sub-continent in the past two decades due to the lack of last mile connectivity of its public transport system.

A "trip" is generally understood as the entire journey between origin and destination. Peoples use different modes like waking, bicycle, two wheelers, four wheelers, share auto, etc. to complete the journey.

In Chennai, Public transport system is majorly served by Metropolitan Transport Corporation (MTC) buses, Suburban rail networks, Mass Rapid transit system (MRTS) and Chennai Metro Rail Limited (CMRL). CMRL came into operation in 2015, since from 1992-2008 there was decline in usage of public transport. There is a potential variation of modal share of Chennai Metropolitan Area (CMA) between 2008 and 2018, between its seven prominent travel modes i.e., Walk, Bicycle, Auto-rickshaw, Car/van, Two wheeler, Bus, Train. Walk was decreased from 28.0% in 2008 to 25.1% in 2018, Bicycle also decreased from 6% in 2008 to 2.9% in 2018, Auto-rickshaw increased from 4% in 2008 to 7.1% in 2018, Car/van increased from 6% in 2008 to 7.1% in 2018, Two wheeler increased from 25% in 2008 to 29.6% in 2018. Public transport systems i.e., Bus decreased from 26% in 2008 to 22.6% in 2018, and Train decreased from 5% in 2008 to 5.6% in 2018 (Urban Mass Transit Company Limited, 2019). From these data, it's evident that usage of non – motorized transport like walk, bicycle and public transport reduced and there is increase in private transport modes like two- wheelers, car, etc. One of the major reasons for this modal share variation is due to lack of last-mile connectivity.

The Chennai metro rail is the rapid transport system which is covering two color-coded lines (Blue, green) covering the length of 55km. The original blue line starts from Airport to Washermanpet covering the Anna Salai stretch, and the green line which separates at Alandur Station from the blue line covers inner ring road, Poonamalle high road and joins at Central Station with the blue line. Chennai Metro Rail Limited (CMRL) extended the blue line from Washermanpet to Wimco nagar metro station a phase I extension covering a length of 9 km (CMRL, Chennai Metro Rail Corportation, 2021). The last two stations, Tiruvottiyur metro station and Wimco nagar metro station from phase I extension is selected as the study area because it is newly opened station in February 2021 which provide wide scope for research. The issues identified and solved at the early stage of the planning will improve the quality of life and increases the patronage, which will result in the economic development on the region.

The paper is divided into 7 segments, Section 2 present the review of literature, Section 3 presents the area of case studies and methodology of the study, Section 4 presents analysis of the primary and secondary data, and the Section 5 presents statistical analysis using the mode choice model, Section 6 presents recommendation arrived from participatory approach, Section 7 concludes the paper.

2. REVIEW OF LITERATURE

The research concentrates on understanding about concept of smart mobility, last mile connectivity, participatory approach, and mode choice model.

2.1 Concept of Smart Mobility

There are many definitions given by various authors about smart city, the most accepted one is by (Bakıcı, et al., 2014) that is "Smart city as a high-tech intensive and advanced city that connects people, information and city elements using new technologies in order to create a sustainable, greener city, competitive and innovative commerce, and an increased life quality". Smart cities has many components, and components widely used in many countries is given by (Lombardi, et al., 2012) which has six components - Smart Governance: People participation and transparent governance, Smart Economy: Competitiveness, Productivity, innovative spirit, Smart Mobility: Transport and ICT, Smart People: Participation in public life, Creativity & Flexibility, Smart Environment: Environment Protection, Pollution, Sustainable Resource Management and Smart living: Quality of life, Health, Safety, housing condition, and Social Cohesion, with different aspects of urban life. Since the research is limited with smart mobility, there are many meaning for smart mobility and few are mentioned below, (Yigitcanlar & Kamruzzaman, 2019) told smart mobility is a significant area in urban planning research and also in smart city plan. Smart mobility is the pinnacle of a smart city and is associated with a municipal verdict and technique grounded in communication, information, and technological instruments (Tomaszewska & Florea, 2018). Smart mobility is not just the embedding of technology into an urban infrastructure, it also calls for citizens to pursue and relate to their urban surroundings in a smart and rational way (Allam & Newman, 2018). Smart mobility is defined as an aspect that consists of the set of acts that encourage traffic flow, either on foot or by bicycle, or via federal or state transportation, all following a shared goal to minimize economic, environmental, and time costs (Aletà, et al., 2017). (Monzón, 2017) has explained about different types of the taxonomy of smart mobility which includes Traffic Management, Public Transport, ICT based Infrastructure Systems, Logistics, Accessibility (last mile connectivity), Multimodality and Clean or Non-motorized. (Frost & , 2019) has classified the smart city based on smart mobility into four types, namely, **Innovative cities** that is cities which are leading in mobility and application for example Singapore; **Dynamic cities** that is cities which are early adopter of smart solution and strategies for example Vienna, Austria; **Proactive cities** that is cities which are proposed smart strategies and implementation plan for example Masdar city, Abu Dhabi; **Passive cities** that is cities which are needed significant work to do, cities suffer from a lack of strategies for example Indian smart cities like Pune & Chennai.

2.2 Last Mile Connectivity

(Safetipin, 2015) presents the analysis and result of last mile connectivity survey in 17 metro stations of the yellow line of Delhi metro rail corridor using SafetiPin app (map- based mobile phone application) based on 9 parameters that is lighting, openness, visibility, crowd, security, walk path, availability of public transport, gender usage of public spaces and feeling. 500m radius around each metro station was studied to improve the last mile connectivity, focusing on female commuters. Each station was rated out of 5 and also recommendation like parking zones within station premises, proper footpaths, creation of zones for hawkers, Integrated Para-transit were suggested to address the issue. (Kanuria, et al., 2019) presents analyzes and the results of last-mile connectivity solutions at Baiyappanahalli metro station in Bengaluru. The Station Access and Mobility Program (STAMP) model was used to bridge gaps in last-mile connectivity to metro rail stations. It is found that there is a modal shift from personal vehicles, when last mile connectivity is achieved. (Sheethal , 2020) presents analyzes and results of last-mile solutions for Jayanagar metro station in Bengaluru. Survey was conducted using ArcGIS mobile app to find out the exact location of commuters and 500m was consider as the buffer zone for study. (De, et al., 2017) conducted survey to understand the last mile connectivity problem in four metro station i.e. Saket, INA, Vishwavidyalaya and Sultanpur metro stations in Delhi. Smart solution like RFID based technology and biometric devices, use of mobile GIS technology in safety and security process, multiuse mobility card, electronic road pricing, Green CAB - dial a rickshaw facility, etc. were used for the integration of modes physically, technically and institutionally to enhance the last mile connectivity. (P.K.Parthiban, n.d.) has done qualitative analysis on 6 metro stations in Chennai to improve patronage, to create awareness, to streamline other modes of transport around metro stations and to utilize resources optimally. The parameters taken for the study are Intermediate Para Transport availability, and how well the transport system is physically integrated with the surrounding community. Availability of other Public Transport to remove passenger anxiety when need to change or transfer and to reduce transfer time. Zones for Hawkers will help in avoiding multiple trips. Availability of Active interfaces, openness and visibility in station premises improves comfort level. Lighting levels improves safety, and concern for women traveling at night or isolated places. Proper footpaths, walk path, foot over bridges and lifts availability aims at reducing walking time and making walking more pleasant which encourages people to use public transports. Police patrolling and security to improve safety. Parking zones within station premises improves passenger convenience. Passenger information to reduce uncertainty for people making a new unplanned trip. These parameters were also taken into account for the study of last-mile connectivity of Wimco and Tiruvottiyur metro stations.

2.3 Multinominal Logit Regression

(Minal, 2014) has explained about the various types of modeling methods of mode choice analysis, and in particular he emphasizes on statistical mode choice models such as multinomial logit, probit models, Generalized Extreme Value (GEV) Models, Artificial Neural Network (ANN), Fuzzy Logic (FL), Neuro-Fuzzy Models. By comparing the above mentioned models under the category of basic hypothesis, major constraints, Major drawbacks and accuracy, it is found that logit model, Artificial Neural Network (ANN), Fuzzy Logic (FL), Neuro-Fuzzy Models, has high accuracy rate, Probit models & Generalized Extreme Value (GEV) Models has low accuracy rate. (Ashalatha, et al., 2013) had analyzed the mode choice behavior of commuters in Thiruvananthapuram, India using multinomial logistic regression. The findings in her case, revealed that as age increases preference to car increases and preference to two-wheelers decreases in comparison with public transport. Increase in time per distance and increase in cost per distance cause the commuters to switch to car and two-wheelers from public transport. This type of projection helps in enhancing

transport policies that improve the transport corridors within the city. (Soman & Verghese, 2019) explain the mode choice behavior of students in Trissur, India using multinominal Logit regression analysis in Statistical Package for the Social Sciences ((SPSS)) software. The study result presents the predicted mode choice considering the existing mode use. The findings revealed the factors which influence the mode choice of students in rural region are age, gender, level of education, distance, travel time, comfort and travel cost and in urban region it is income, distance, travel time, vehicle ownership, traffic and comfort level. Common variables coming under urban and rural model are distance and travel time. And it is also found that in both rural and urban regions most of the students use bus as their mode of travel.

Multinomial Logit (MNL) Regression analysis using Statistical Package for the Social Sciences (SPSS) software analysis is carried in this research to project mode choice behavior of commuters.

2.4 Participatory Approach

Participatory approach plays the major role in responsive smart mobility and hence few literatures were studied. Kevin Lynch's strategy of mental mapping can be seen as the first Citizen Design Science methods. Mental maps are used in behavioral geography and is presented in "The Image of the City". (Sanders, 2002) has focused on the shift between the User-Centered to Participatory approach using union model of integration of three components namely "Do, Say, Make". (Quium, 2003) explained about the different methods of public participation from the lower level where the citizen participation is less involved are resident informed, response to proposals, etc. to "People's Plan", which is a highest level of public participation where citizen have the advantage to prepare their plan. "People's Plan" - Residents take advantage of legislation to prepare their own plans. This is the highest level of public participation but rare. (Simonofski, et al., 2019) explained about the different types of participatory approach involved in smart cities. The three ways of it are 1. Direct interaction is citizen-oriented approach by conducting interviews to explore the needs of the citizens. 2. Living lab: it is a user-driven open innovation ecosystem which enables the citizen to take an active part in the research, development. 3. Online platform: citizen participation can be enhanced by two means: centralized platforms and social media analysis. (Mohamed, 2020) conducted the participatory approach involved in smart city for area-based development in T. Nagar, Chennai. The three stages of consultation were classified as First stage is **Collective consultation (CC**) is to understand the problems and seek the concerns and corrective measures for reducing or solving the problems in general. Second stage is **target-centered consultation (TOC)** or focused consultation is **closed to specific** groups to address the problems and discuss suitable and alternative solutions and seek consensus. Third stage again is collective consultation is **Roadshow (RS)** is the open meeting with the shoppers was undertaken on one to-one basis to understand the problems and best corrective measures were provided.

3. STUDY AREA

The Chennai metro rail is the rapid transport system covering the length of 55km. The last two station Tiruvottiyur metro station and Wimco nagar metro station from phase I extension is selected as the study area for last-mile connectivity because it is newly opened station in February 2021 which provide the wide scope for research and It is well known for the industries like MRF, Royal Enfield, ITC industry, and many small-scale industries (CMRL, Chennai Metro Rail Corportation, 2021).

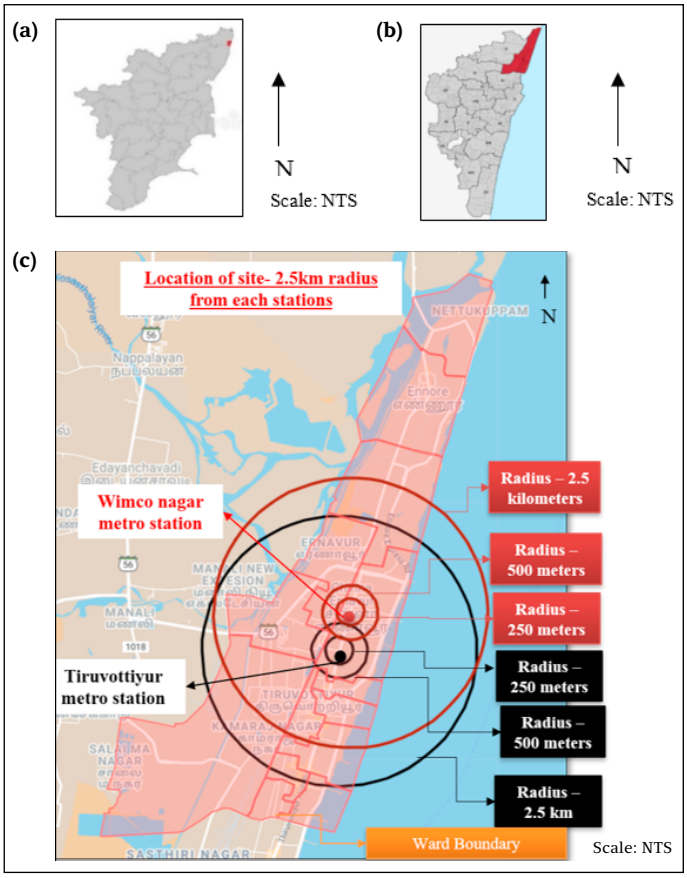

Fig 1: (a) Tamil Nadu state map showing Greater Chennai cooperation (GCC);(b) Greater Chennai cooperation (GCC) map showing zone I;(c) Ward map of zone 1 showing Wimco nagar metro station and Tiruvottiyur metro station and the delineated study area.

The study area is located in north Chennai, close to the boundary of two states – Tamil Nadu and Andra Pradesh. i.e Tada is about 54.2km, Tirupati is about 108km from Wimco nagar metro station. It is also located at the centre of two major ports of Tamil Nadu that is Chennai port which is at 10.6km in the south, and Ennore port which is about 6.5km in the north of the Wimco nagar metro station. Another important landmark like Airport is 26.9 km and Central railway station at 11.3km. The two similar industrial areas like Tiruvottiyur metro station within GCC are Irunkattukottai at 38.4km, and Ambattur at 16.9km.

Generally, in last-mile research and practice walking is preferred within 2 km of a station, bicycling and rickshaws within 4km, and bus park and the ride goes beyond 4 km. but here a radius of 2.5km is taken as the study area because stations are closer in nature. For example, the distance between Wimco nagar metro and Tiruvottiyur metro station is only 800 meters.

Tiruvottiyur metro station got included in Greater Chennai cooperation (GCC) in 2011. The selected study area has a total population of 133625. The delineated study area and location is shown in Fig 1.

3.1 Wimco nagar metro station

The Wimco nagar metro station is well connected with other transport facilities but in poor infrastructure quality. The station is located in Tiruvottiyur high road and in close proximity to the Wimco nagar Suburban station which helps in achieving the needed physical connectivity between the two networks. The road connecting the metro station and Suburban station has a market space which helps in avoiding multiple trips. There is the ground behind the metro station, which belongs to the ITC industry is empty right now. The station premises have two wheeler parking only and the drop-off

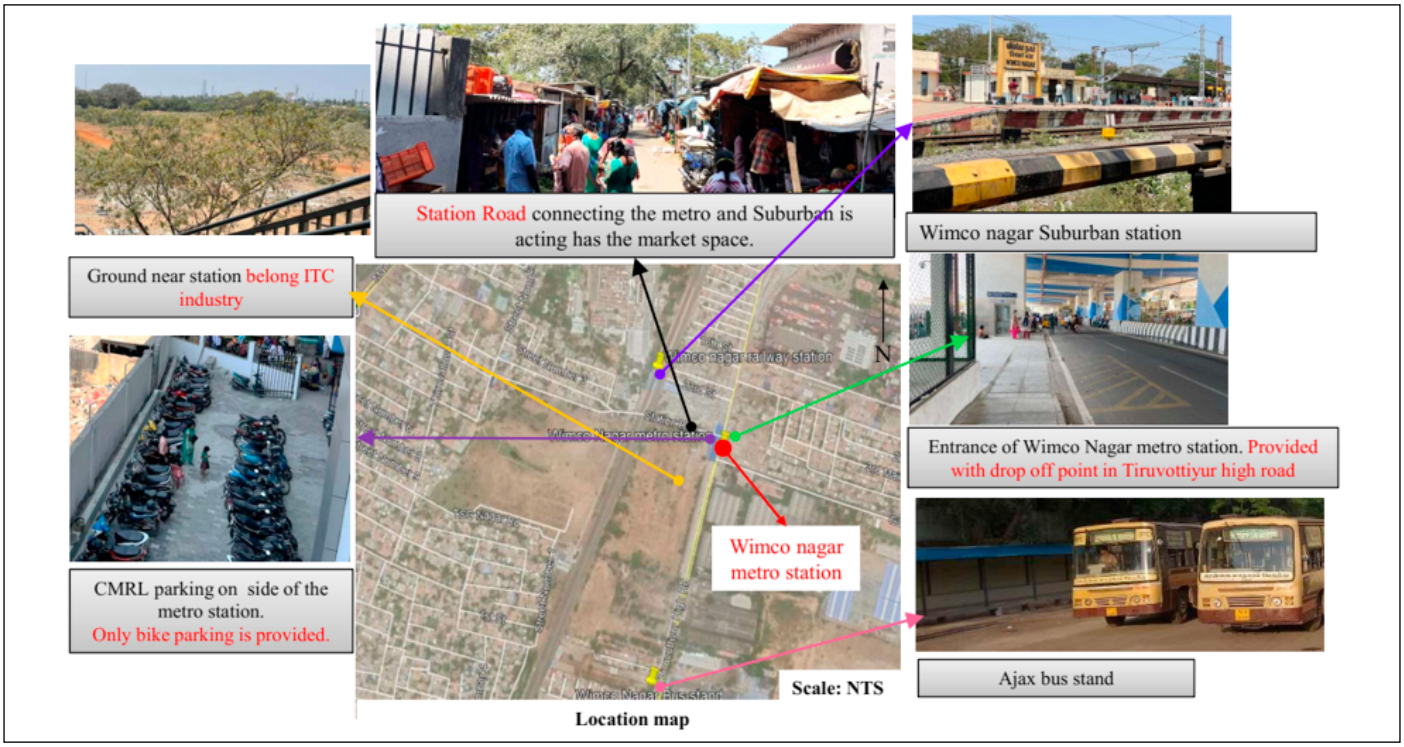

Fig 2 Existing condition around the Wimco nagar metro station

point in Tiruvottiyur high road is causing major traffic disruptions and the bus stop near the station entrance is smaller, and Ajax bus stand is the nearer big bus stand. The station premise is picturized in Fig 2

3.2 Tiruvottiyur metro station

Tiruvottiyur metro station is located in Tiruvottiyur high road achieving easy connectivity via road. And it's located far from the Tiruvottiyur Suburban station. There is old Ajax bus stand which is now relocated and bus depot is located behind the metro station. The station premises have only bike parking and the drop-off point in Tiruvottiyur high road is causing traffic and the bus stop near the station entrance is too small. The station premise is picturized in Fig 3.

4. RESEARCH METHODOLOGY

Both qualitative and quantitative researches have been involved in this research process. From the inference of literature, a total of **13 questions** were framed to question the commuters on 5 different aspects while framing the questionnaire. The five different aspects are **1.The exact location of the commuters** – Point data of the commuters to find the influence zone of each station. **2. General information about the commuters** that is Gender, Age, Trip Purpose, Trip Frequency, etc. **3. Trip information** like Destination, Distance, Mode, Travel Time, Fare, etc. **4. Considering the parameters by the CMRL** example Accessibility, Visibility, etc. (P.K.Parthiban, n.d.). **5. Suggestion and recommendations.**

4.1 Sampling techniques

The sequential random sampling methods are taken for primary data collection. Every 5th passenger departing the station is selected since departing the station is assumed as a random process.

The **total population of the delineated area – 133625,** the sample size is calculated using the formula**:**

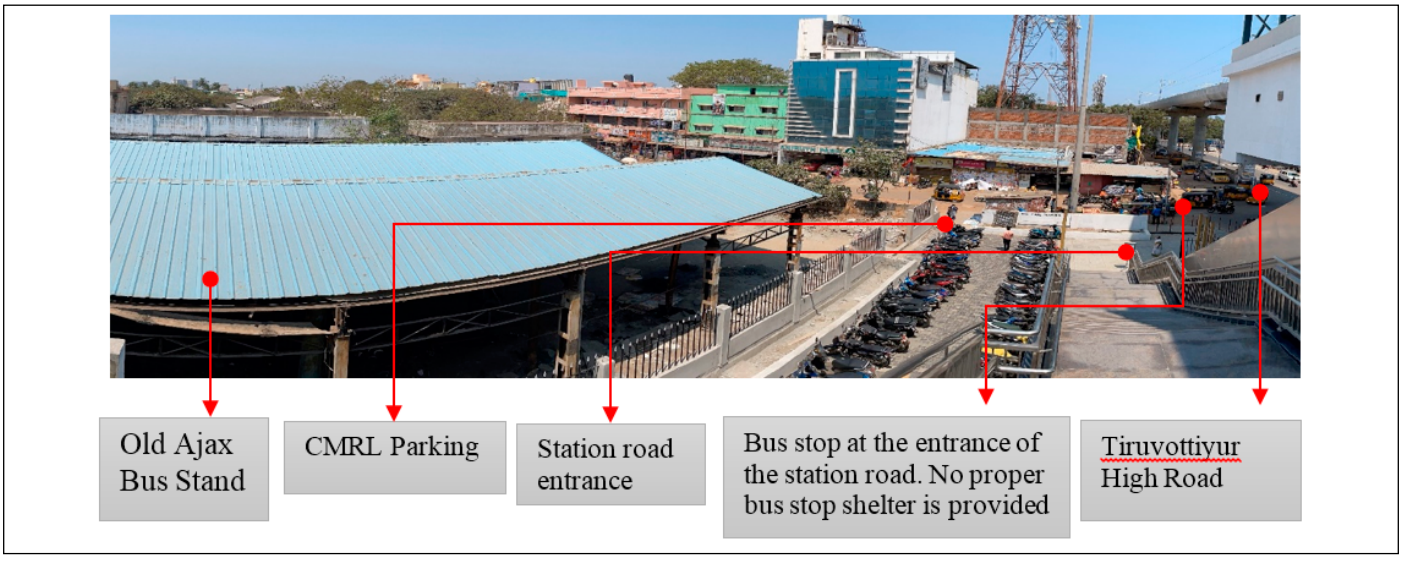

Fig 3 Existing condition around the Tiruvottiyur metro station

$$n' = \frac{n}{1+\frac{z^2 * p(1-p)}{\varepsilon^2 N}}.$$

Where n′ is finite population, z is the z score, ε is the margin of error, N is population size, p is the population proportion.

Sampling size is 384. 384 questionnaire surveys are taken in both stations together. That is 192 questionnaire survey is taken in each station.

4.2 Participatory approach

20 commuters are involved of which 10 males and 10 females of ages 10 to 20 – 15% (3), 21 to 30- 25% (5), 31 to 45- 25% (5), 46 to 55- 20% (4), Above 56 age – 15% (3) in framing the proposal. These commuters are of different profession i.e housewife, doctor, retired government officers – Port trust, BSNL employ, entrepreneurs, students, IT employee and labors. SW Maps – GIS Data Collector app and QGIS are used to mark the proposal and for discussion. The commuters were split in 4 groups and then individual groups information were collected for each issue in person and then overall final discussion happened via Google meet.

4.3 Multinomial logit model

The commuter's mode choice behaviour plays an important role in transportation planning. The commuters pick a mode for many reasons from the different available modes. The mode choice model is the travel demand analysis of the study area. This analysis comes after trip generation analysis as the third step of the four-step transportation planning process.

Generally, the mode choice modes are of two categories namely **Aggregate Behaviour** and Disaggregate behavior. In Aggregate Behavior, the approach of the model is to treat behavior of the group as a whole for analysis, which is widely used in large-scale studies. In **Disaggregate Behaviour**, the approach of the model is to treat each individual or each commuter separately for the analysis. In this approach, many data are required on different characteristics of each individual and hence it's widely used for a sample of a smaller population. The model is further split into two categories namely **logit and probit model.** The logit model is used in many mode choices analyses as the probit model relay on the theoretical basis whereas the logit is analytical oriented.

The logit model is of three types: Binary logit model – it is developed only when two options are available. Multinomial logit model (MNL) - it is developed when there are more than two available options. Nested logit model – it is developed when there is a break in the journey i.e. More than one transfer is done in the journey. Hence, the multinomial logit model is chosen because available modes are more than two and also there is no transfer in the journey.

The MNL model gives the choice probabilities of each alternative as a function of the systematic portion of the utility of all the alternatives. The expression for the probability of choosing alternative *i* from a set of *j* alternatives is as follows:

$$P_r(i) = \frac{exp(V_i)}{\sum_{j=1}^{j} exp\,(V_j)},$$

Where $P_r(i)$ = probability of the decision-maker choosing alternative i; V = systematic component of the utility of alternative i, j.

Multinomial logit regression is done using the Statistical Package for the Social Sciences, (SPSS) software.

5. ANALYSIS

In both the station male commuters are the major travelers, i.e., 70% in Wimco nagar metro station and 60% in Tiruvottiyur metro station. Five age groups was split from 10-20, 21-30, 31-45, 46-55 and above 56 and its observed that 21-30, 31-45, 46-55 are major age group traveling in both stations which is above 25% in each category. Four tip purpose categories was split as work, education, shopping, and other, and its observed that work was the major purpose of travel which is above 50% in both station and education is the second highest with 32% in Wimco nagar metro station and 16% in Tiruvottiyur metro station, other categories were found to be very less i.e., below 10%.

5.1 Modal Splits

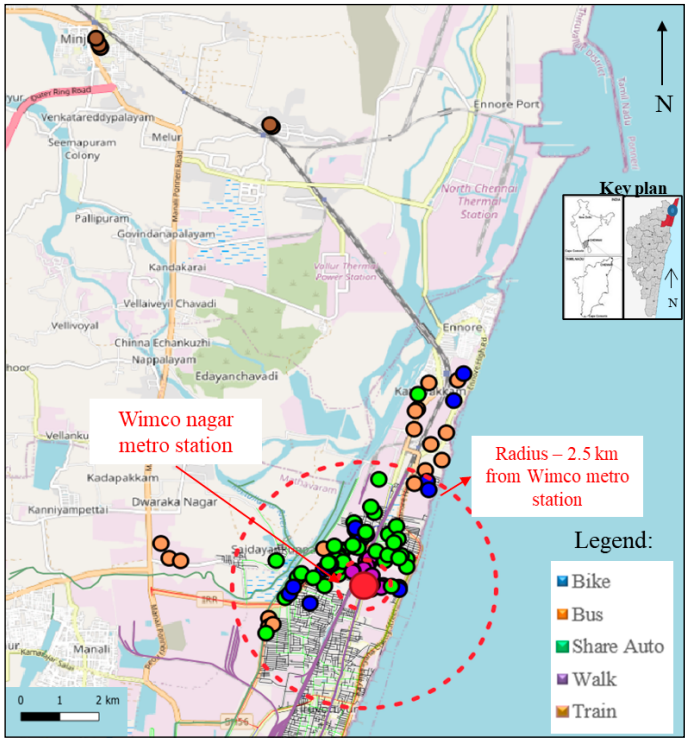

Fig 4 Mode Split of the commuters - Wimco nagar metro station

384 questionnaire sampling was done in both stations, with each 192 samplings and are marked during the survey using SW Maps – GIS Data Collector app.

Each 192 sampling of Wimco nagar metro station point data was marked to know the exact location of commuters departing from of Wimco nagar metro station, which is shown in Fig 4 and Each 192 sampling of Thiruvottiyur metro station point data was taken to know the exact location of commuters departing from of Tiruvottiyur metro station, which is shown in Fig 5.

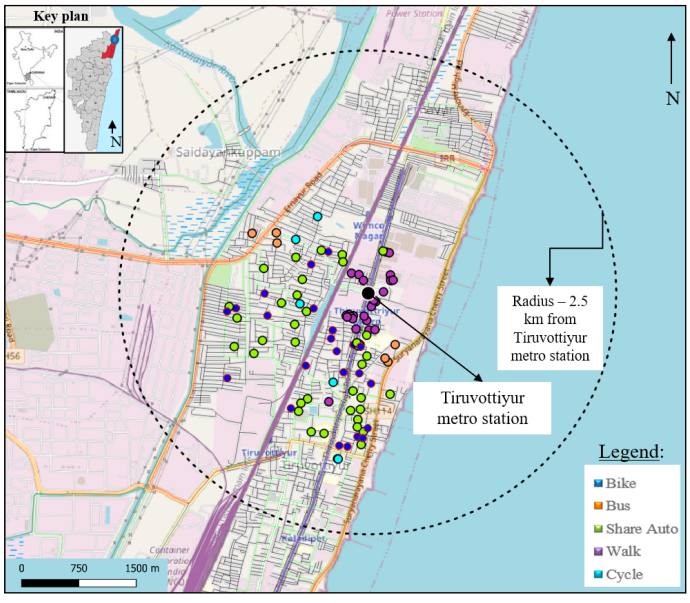

Fig 5 Mode Split of commuters - Tiruvottiyur metro station.

It is found in Wimco nagar metro station commuters travel 41% using share auto, 19% using bus, 18% using bike, 17% by walk, and 5% using train. And in Tiruvottiyur metro station it is found that 38% using share auto, since the station is located near residential area, 26% by walk, 25% by bike, 6% by bus and 5% by cycle. Share auto is the major mode of travel in both stations then followed by walk, bike and bus.

From the point data it's found that the distance travelled by the commuters is within 2.5 km for Tiruvottiyur metro station and for Wimco nagar metro station it is more since, it's the last station in that corridor.

5.2 Travel time

Since both the stations are close to each other, four categories of travel time was taken i.e., within 10 min, 10-15 min, 15-20 min and above 20min. It is found that within 10 min is highly opted by Wimco nagar metro commuter which is 62% because of its better connection with other transport facilities. 12% of commuter opted for 10-15 min, 21% commuters opted for 15-20 min, and 5% opted for above 20 min. whereas in Tiruvottiyur metro station commuters 48% opted for 15-20 min travel time because of traffic, insufficient road width and unavailability of public transport in inner residential areas. 27% opted for 10-15 min, 25% opted for within 10min, and no one opted for travel time above 20min.

5.3 Average waiting time

Four categories of average waiting time was taken, i.e., within 5 min, 5-10 min, 15 min and above 15 min. It is found that 15 min is highly opted in both station which is 23% in Wimco nagar and 36% in Tiruvottiyur metro station commuters. 20% of Wimco nagar commuters opted for within 5 min whereas in Tiruvottiyur no one opted it. 8% of Wimco nagar commuters opted for 5-10 min whereas in Tiruvottiyur no one opted it. 14% of Wimco nagar commuter and 8% Tiruvottiyur commuter opted for above 15 min. The main reason for more waiting time is due to the less frequency of the Intermediate Public Transport (IPT) in the surrounding residential areas.

5.4 Connection with other transport facilities

65% of Wimco nagar metro station commuters and 75% of Tiruvottiyur commuters opted for improving the connection with other transport facilities. Both the stations are connected with other transport facilitates, but in poor quality and quantity in terms of frequency, which needs to be improved.

5.5 Infrastructure facilities in station premises

No proper drop off zone is provided and less amount of bike parking provision is the major problem in both the station premises. There are proper streetlights, availability of active interfaces and visibility in both the station premises. Wimco nagar metro station is well connected with shops, whereas the Tiruvottiyur metro station is located near industries and only few shops are found in station premises.

5.6 Trip Information

The influence of each metro station is mapped by considering the radius of increasing order from 0.5km to 2.5km from the metro station with the relationship with the mode of travel of each station. It is shown in Table 1, Fig 6 & 7.

It is observed that in Wimco nagar metro station, **within a radius of 0.5km**, the major mode of travel is walk. **In radius 0.5km -1km**, mode of travel is the bike, share auto, and cycle. **In radius 1km -1.5km**, mode of travel is the bike, share auto. **In radius 1.5km -2km**, the mode of travel is share auto, bus. **In radius 2km -2.5km**, the mode of travel is the bike, bus, share auto and **above 2.5km radius,** the mode of travel is the bus, train, and bike.

It is observed that in Tiruvottiyur metro station, **within a radius of 0.5km,** the mode of travel is walk. **In radius 0.5km -1km,** the mode of travel is the bike, share auto, and cycle**. In radius 1km -1.5km**, the mode of travel is the bike, share auto. There is no preferred mode after 1.5 Km is due to the availability of the other metro stations running in this corridor.

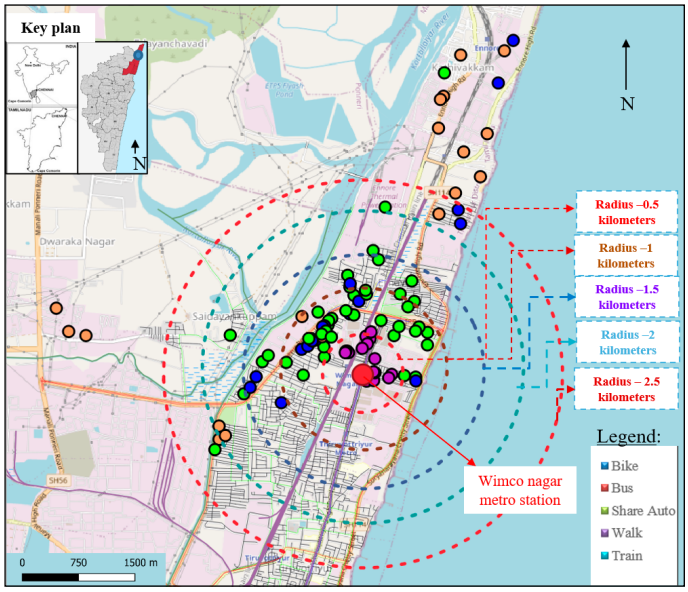

Fig 6 Influence zone of Wimco nagar metro station

Influence Zone		
Distance	**Preference**	
Radius from station	**Wimco Nagar metro station**	**Tiruvottiyur metro station**
Within 0.5km	Walk	Walk
0.5km – 1km	Bike, Share Auto, Cycle	Bike, Share Auto, Cycle
1km – 1.5km	Bike, Share Auto	Bike, Share Auto
1.5km – 2km	Share Auto, Bus	-
2km – 2.5km	Bike, Bus, Share Auto	-
Above 2.5km	Bus, Train, Bike	-

Table 1: Influence Zone

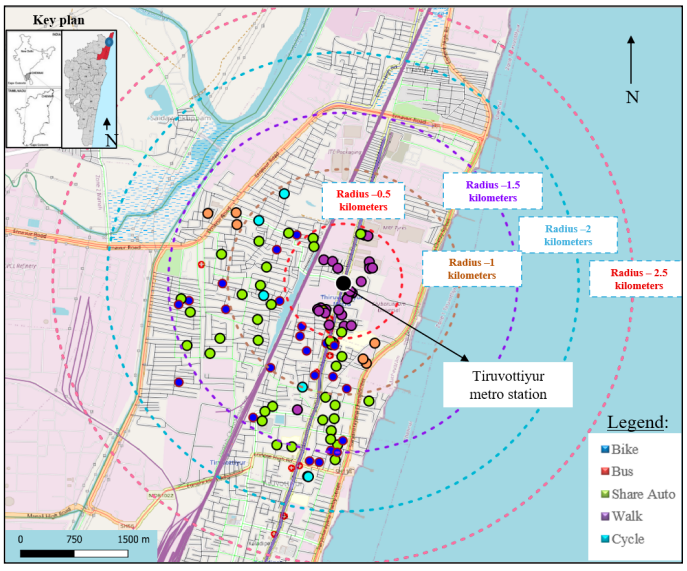

Fig 7 Influence zone of Tiruvottiyur metro station

5.7 Issue faced while moving away from the station

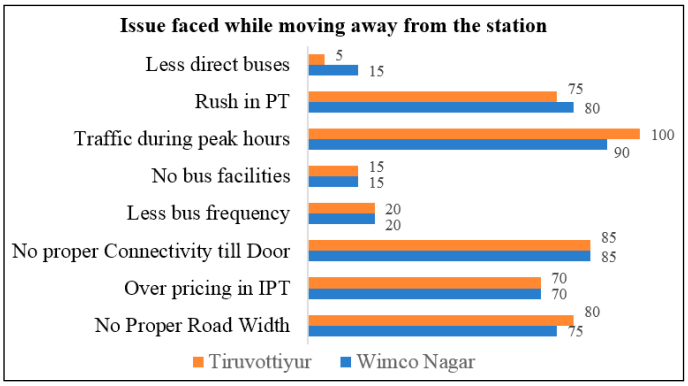

Fig 8 Issue faced while moving away from the station

The 8 eight major issues identified through survey are less direct buses, Rush in Public Transport, traffic during peak hours, No proper bus facilities, less bus frequency, no proper connectivity, over pricing in IPT and no proper road width. From Fig 8 it's evident that Peak hour traffic and no proper connectivity till door are major issues while comparing with others.

6. MODE CHOICE MODEL

The commuter's mode choice behaviour plays the important role in transportation planning. The commuters pick a mode for many reasons from the different available modes. The mode choice model is the travel demand analysis of the study area. This analysis comes after trip generation analysis as the third step of the four-step transportation planning process.

Statistical Package for Social Science (SPSS) is used for the analysis which is the standard computation tool. In MNL regression analysis, one category is chosen as the dependant variable and all other parameters are interpreted concerning it. The coefficients are estimated through an iterative maximum likelihood method. Odds ratios are determined for all independent variables for each category of the dependent variable except the reference category. The odds ratio represents the change in the odds of being in the dependent variable category versus the reference category associated with a one-unit change in the independent variable. **The mode of conveyance is chosen as the dependent variable**, to get the preference of bus relative to other modes, the bus is chosen as the reference category [Major public transport compared with personalized mode]. The **independent variables chosen are age group, gender, distance travelled to reach the metro, time per distance.**

6.1 Likelihood Ratio Tests

Likelihood ratio test shown in Table 2 is contribution of each variable to the model, all variables should have significance less than 0.05. Of these, travel time in Tiruvottiyur metro station, travel time and gender in Wimco nagar metro station found to be significant. Therefore, in the mode choice these factors are found significant.

6.2 Model Fitting Information

Model Fitting Information shown in Table 3 shows the **significance level of the test, which is less than 0.05,** it can be concluded that **the final model is outperforming the null in both cases.**

6.3 Pseudo R-Square

Pseudo R - Sq value shown in Table 4 indicates the proportion of variance of the response variable explained **by the predictors and its maximum value is 1**. Therefore, the **model can be considered statistically significant**

Likelihood Ratio Tests -Wimco nagar metro station				
Effect	-2 Log Likelihood of Reduced Model	Likelihood Ratio Tests		
		Chi-Square	Df	Sig.
Intercept	82.361	.000	0	0.00
Gender	85.997	3.636	4	.457
Age	**110.464**	**28.103**	**16**	**.031**
Distance	83.098	.737	4	.947
Travel Time	**82.361**	**.000**	**0**	**0.00**

Likelihood Ratio Tests – Tiruvottiyur metro station				
Effect	-2 Log Likelihood of Reduced Model	Likelihood Ratio Tests		
		Chi-Square	Df	Sig.
Intercept	55.074	.000	0	0.00
Gender	58.456	3.382	4	.496
Age	75.055	19.981	16	.221
Distance	57.906	2.832	4	.586
Travel Time	**212.503**	**157.429**	**8**	**.000**

Table 2: Likelihood ratio test

Model Fitting Information – Wimco Nagar				
Model	Model-fitting criteria	Likelihood Ratio Tests		
	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	201.953			
Final	**82.361**	**119.592**	**36**	**.000**

Model Fitting Information - Tiruvottiyur metro station				
Model	Model-fitting criteria	Likelihood Ratio Tests		
	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	249.149			
Final	**55.074**	**194.075**	**32**	**.000**

Table 3: Model Fitting Information

Pseudo R-Square		
	Wimco nagar	**Tiruvottiyur metro station**
Cox and Snell	0.698	0.856
Nagelkerke	0.739	0.914
McFadden	0.415	0.702

Table 4: Pseudo R-Square

6.4 Predicted value

The predicted response category is chosen by selecting the category with the highest model-predicted probability. Cells on the diagonal are correct predictions, which is highlighted. Cells off the diagonal are incorrect predictions

In Wimco nagar: Table 5 shows the predicted valve with accurate percent of 62% and comparing with existing and predicted shown in Fig 9 it's clear that the preference towards using the **bike is decreased, share auto and Walking is increased.**

In Tiruvottiyur metro station: Table 5 shows the predicted valve with accurate percent of 82% and comparing with existing mode split and predicted shown in Fig 10 its clear that preference towards using **the bus is decreased, share auto and bike is increased.**

Predicted value of Wimco nagar						
Observed	Bike	Bus	Share Auto	Train	Walk	Percent Correct
Bike	2	2	7	0	7	11.1%
Bus	0	14	5	0	0	73.7%
Share Auto	0	1	32	0	8	78.0%
Train	0	0	0	5	0	100.0%
Walk	2	0	6	0	9	52.9%
Overall Percentage	4.0%	17.0%	50.0%	5.0%	24.0%	62.0%

Predicted value of Tiruvottiyur metro station						
Observed	Bike	Bus	Cycle	Share auto	Walk	Percent Correct
Bike	18	0	1	6	0	72.0%
Bus	5	0	1	0	0	0.0%
Cycle	2	0	3	0	0	60.0%
Share auto	2	0	0	36	0	94.7%
Walk	1	0	0	0	25	96.2%
Overall Percentage	28.0%	0.0%	5.0%	42.0%	25.0%	82.0%

Table 5:Predicted value of two metro station

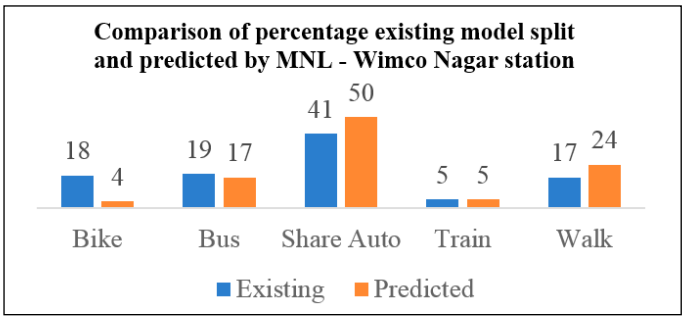

Fig 9 Comparison of percentage existing model split and predicted of Wimco nagar metro station

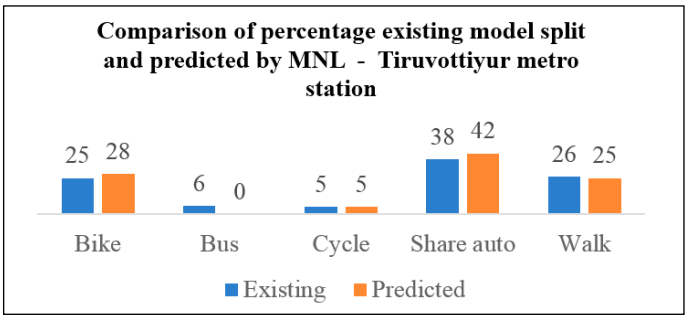

Fig 10 Comparison of percentage existing model split and predicted of Tiruvottiyur metro station.

7. RECOMMENDATION

Comparing both metro stations, it is observed the in both stations' male are the major commuters, 21-30, 31-45 and 46-55 are major age group traveling and work is the major purpose of traveling, their travel frequency is daily and also many commuters have a smart card for their travel. The distance travelled by the commuters in Wimco nagar metro station is 62% within 1km and 12 % within 1-2 km, and many commuters travel for above 5 km, whereas in Tiruvottiyur metro station influence lies within 1km is 64% and 38 % 1-2 km. The major maximum travel time of each station is 15.-20 min because of the less frequency of bus, and unavailability of IPT in inner residential areas. The major waiting time of the commuters in Wimco nagar metro station is 5-15min were as in Tiruvottiyur metro station it is 10-15 min because Wimco nagar metro station has an influence zone of more than 2.5 km radius since it is the last station in the corridor. Both the station has good visibility, accessibility and proper street light in station premises, but both the station lack in the proper drop off zone, since it is located in Tiruvottiyur high road which is a major road in that zone in Greater Chennai Corporation (GCC). Wimco nagar metro station is well connected with commercial space but Tiruvottiyur metro station is not well connected to commercial spaces, due to the availability of industries on the east side of the road. Peak hour traffic and no proper connectivity till destination are the major issues comparing others in both metro stations because of the lesser existing road width, encroachment in walkways, and crosswalks, and also the presence of truck movement and illegal parking. 65% of commuters in Wimco nagar metro station and 75% of commuters in Tiruvottiyur metro station said that the station needs to be well connected with other transport facilities.

From the mode choice model done using the SPSS software in Wimco nagar metro station comparing the existing mode split and predicted, its clear preference towards using bike is decreased, share auto and walking is increased. Similarly, in Tiruvottiyur metro station it's clear that preference towards using the bus decreased, share auto and bike is increased. Solving these issue at early stage will help in improving the economic development of the region, increase in the patronage of public transport, which ultimately results in better quality of life.

These are the 12 recommendation given to solve 7 problems to enhance the last mile connectivity till destination by involving a pure participatory approach. The problem and proposal given to solve the issue is given below in Table 6.

8. CONCLUSION

The study clearly shows more than 80% of the commuters mentioned problems like a Lack of infrastructure quality, less pedestrian-friendly, high peak hour traffic, no last mile connectivity, less frequency of share auto in the inner residential area.

The predicted model split of Wimco nagar metro station shows the usage of private transport got reduced and increase in preference share auto and walking. But were as,

S.No	Problems/ Issues in stations	Recommendations arrived in participatory approach
1	Insufficient parking facilities in station premises	• Multi storey parking in both stations
2	To achieve last mile connectivity till door	• Feeder bus service • Smart bike • Increasing number of auto stands within radius of 2.5 km of study area in both stations.
3	To reduce the traffic	• Proposing a separate truck lane in Manali high road, • Avoiding encroachment of shops in Tiruvottiyur high road.
4	To enhance NMT	• Proposing of separate Cycle Lane and walkway in Manali high road, Tiruvottiyur high road and Ennore express road. • Proposing a cycle repair shop in both station premises
5	To Enhancing Hawker space in Tiruvottiyur metro station premises	• Proposing the mixed residential area in west of Tiruvottiyur high road (250m stretch in north-south, 150m, stretches in east-west within station premises)
6	To achieve pedestrian friendly road	• Proposing a pedestrian walkway in Manali high road, Tiruvottiyur high road and Ennore express road.
7	To achieve better quality infrastructure for commuters	• Proposing proper waiting area (bus stops) within delineated study area. • Enhancing existing crosswalks - Restricting no parking and no hawker in crosswalk area under the metro route in Tiruvottiyur high road.

Table 6: Recommendations arrived in participatory approach

the predicted mode split of Tiruvottiyur metro station shows a large decrease in public transport and an increase in usage of private transport and hence ways to increase the usage of public transport was one of the key focus.

In this method of participatory approach, each commuter is given the importance to make their plan according to their needs. So that quality of life improves. The role of the planner is well defined till finding the issues of research, which helps in achieving the pure participatory approach.

The research aims to achieve the last mile connectivity of metro stations using a participatory approach and the main objectives of the research are (1) To analysis the existing last-mile option on basis of different parameters. (2) To evaluate the influence zone of existing last-mile options. (3) To prepare a model to predict the modal share and the effect of certain parameters. (4). To prepare the mobility plan to strengthen last mile connectivity using a participatory approach. This research focuses on engaging the citizen in design, were from "for the citizen to by the citizen" and hence it helps in improving their quality of life.

This method of participatory approach satisfies the 73rd and 74th constitution amendment act of Government of India, and this method of participatory approach is called ***"People plan", where resident take advantage of legislation to prepare their plans.***

CONFLICT OF INTEREST

The author has no conflict of interest.

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