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Review of First and Last Mile Connectivity for Bus Line

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Abstract: Demand for the public transport sector in Indian cities is increasing continuously. The Government of India has offered a number of transport systems such as Mass Rapid Transit System (MRTS), Bus Rapid Transit System (BRTS), and Light Rail Transit System (LRTS) in every transport city to mark these demands. However, the connectivity of the first and last mile point is not designed properly, so public transport riders lag behind. The purpose of this study is to identify the mode preference behaviour of passengers for first and last-mile travel for Ahmedabad BRTS users and to propose feeder transit for first and last-mile connectivity. The travel option model for first- and last-mile travel is determined using a multinomial logit model and a home interview survey. It also examines disparities in selection behaviour between youth and other age groups. The results of this study may enhance bus line ridership and improve the physical environment for first-to-last-mile connectivity through intermediate para transit (IPT) such as walking, auto-rickshaws, and e-rickshaws (battery operated). Intermediate Para Transit (IPT) is a part of a holistic transportation service provider for services to align transportation routes and regulations, and perfect for improving an enterprise infrastructure for safe and personal riding for pedestrians.

Keywords: first-last mile connectivity, multinomial logit model, BRTS, Intermediate para transit, feeder.

I. INTRODUCTION

The continuing urbanization of India is driven by urban sprawl transportation motorized vehicles and consistent growth in demand for travel, leading to congestion, high fuel consumption, and greater inequality in access to transport. The total number of registered automobiles increased from about 0.3 million in March 1951 to 253 million as on 31st March 2017 (MoRTH). Nowadays, Bus Rapid System (BRTS), Metros, Commuter Rail, even subway Lines are various types of public transportation systems that define cost, power, and technology, and several other aspects may include stop size, right-of-way reach, operating regimes, and guide procedures. In some cities such as Quito, Bogota, Jakarta and Beijing, the system has been successfully carried out. The past record of the BRT makes a convincing argument for other cities to make this another transportation priority if analyzed in relation to economic, social, and environmental benefits. That BRT system becomes highly desirable in several emerging countries in Asia pacific, like India. First and last-mile connectivity services are the backbone for public transport enabling passengers to easily use public transport or to get to the point of origin and destination. So many steps are taken by the government of India and different individual states of India (such as the National Urban Transport Policy (NUTP), the Jawaharlal Nehru National Urban Renewal Mission (JnNURM) bus project, etc.). In recent times, improving public transport (PT) patronage and the Intermediate Para-Transit (IPT) scenario in the aim of meeting growing demand, However, the position of last-mile connectivity (LMC) is crucial in order to reach the aims of attracting preferred riders to the main transit. Across many cases, due to the absence of suitable Last mile connectivity, the main transits are not really efficient.

Table - I BRTS Network in Indian Cities

Cities	Passengers per Day	Length km
Ahmedabad	130,000	82 km
Amritsar	60,000	31 km
Bhopal	77,289	24 km
Hubballi-Dharwad	90,000	22 km
Indore	45,500	11 km
Jaipur	6,622	7 km
Pune - Primpi-Chinchwad	67,000	29 km
Rajkot	7,500	11 km
Surat	13,500	10 km

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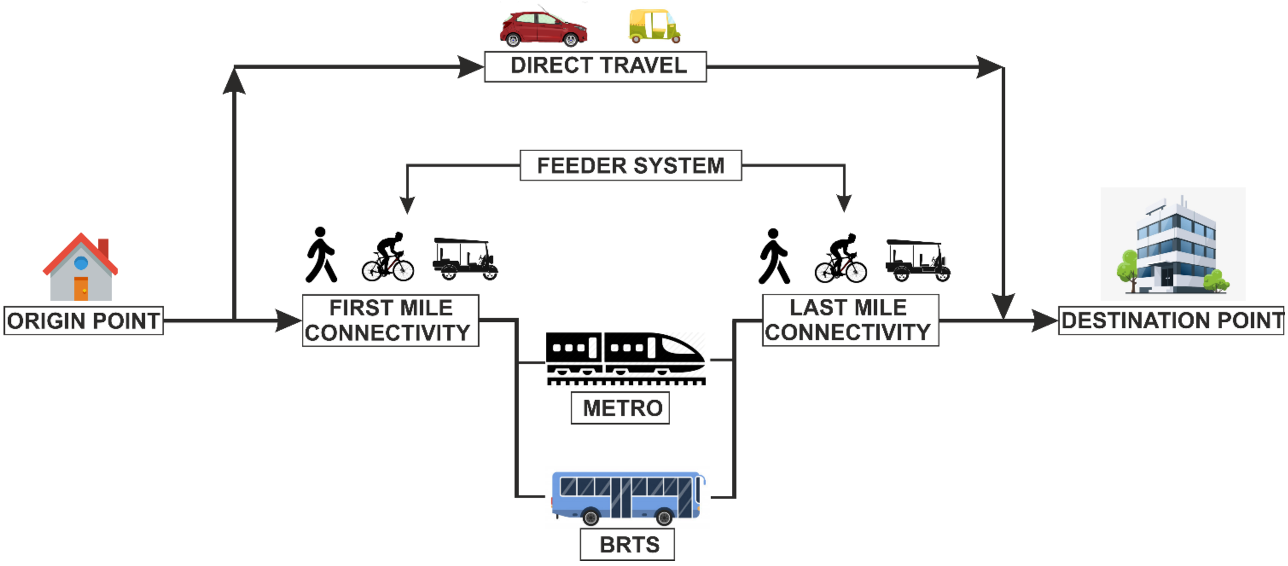

Figure - I First and Last Mile Connectivity with Feeder System

II. LITERATURE REVIEW

[9] The purpose of this study is to define the applicability of fixed routes (FR) and door-to-door services (DtD) as last-mile solutions in various scenarios for the assembly of automated vehicles. For this purpose, an empirical model is chosen for its usefulness in obtaining strategic guidance on the operation of transport networks. The criteria chosen to evaluate which method of service is the most competitive option in the overall cost of the system. The first step in the comparison is to decide the optimum solution that could be offered in a given situation by each alternative, i.e., the combination of values of the respective decision variables that provide the lowest total cost of the service. We minimize the objective function for this reason, which involves partial costs for the agency and users. The expense of the agency includes the distance and fleet size traveled per hour of service. There have been two expenses involved with the size of the fleet: the expense of purchasing vehicles and operating costs per hour. The expense of the user covers the duration of all stages of the passenger journey: access, waiting, traveling, and time per stop and during the process of boarding/lighting.

[8] The objective of this research is to examine the life-cycle effects of multimodal transit for first-last-mile trips using Los Angles as a case study. Life-cycle modeling of vehicle production and maintenance transportation systems in Los Angeles, Infrastructure building and maintenance impacts. Los Angeles Vehicle Operational and Propulsion Effects Life-cycle assessment Multimodal trip creation first-last mile auto use with transit has a substantial potential to increase impacts per trip, and in some cases may result in door-to-door trip impacts that are greater than competing auto travel. Ultimately, transportation policy and planning should be conscious of the significant potential for human and environmental impacts from long-term auto access and egress of transit. At the end of the day transport policy and planning should be mindful of the substantial potential for human and environmental effects of long-term access to and transportation.

[5] In this study, to understand the concept and importance of first and last-mile connectivity problems. Due to First and Last connectivity problem utilization of public transport falling off. World Resources Institute 70% people of Bangalore city not using metro service. Due to first and last-mile connection issues, the first and last-mile journey's unequal time and cost significance is an indicator of insignificant performance, corresponding to weak connectivity at the point of origin and destination, longer waiting time, and high transfer penalties. There is an indication that emerging transportation systems such as car-sharing, bike-sharing, micro-transit and intermediate para-transit have the ability to solve the public transportation gap for the last mile. The Station Access and Mobility Program (STAMP) was introduced to add gaps in first and last-mile connectivity mass transit system like metro rail and BRTS. The Bayappanahalli metro station was chosen due to its location and high traffic so that new feeders could test the potential demand by applying the service. This station has 7,000 peak hour footfalls, and 50 metro passengers leave the station every minute in search of last-mile connectivity to their final destinations; thus, considered to be the sufficient scale of passenger flows for testing limited-size pilot operations. There will be added conducted three pilot operations as com1, com2, and com3, at Baiyappanahalli metro station. Com1 offers short-distance scooter and motorbike rentals, intra-city

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trips, pick-up and drop-off at several city-wide touchpoints, and prices based on distance and time for the Com1 service. Com2 provides an intra-city carpooling platform that Empty seats in private vehicles match with current travel demand in one direction, depending on the distance and the price set by the ride giver, varying between INR 0-5/km, with a four-wheeler average of INR 3.5/km. Com3 is a parking cluster and, the fare for the com3 operation has been set by Metro. Data were collected for 12 weeks, with each pilot operation having different operation data. Feeder services were determined to have an average travel length of 9 km and 12 km, and 1000 parking spots were set in Com3. com1 service has a large number of trip destinations in the Whitefield area east of the city. Three clear destination zones are defined in the com2 service, the average journey was longer for com2 carpool service. The utilization rate of Com1 service is continuously increasing. For Com2 service, the demand for multiple rides and the number of ride supplies has steadily increased; The overall growth rate of demand is 15% while supply growth is 22% while the growth rate of complete transactions is 8%. STAMP technology was the first attempt to provide proper service to public and private mobility, which could be improved the utilization of public transport, and to fill the gap at the first and last-mile segments in the city.

[3] The aim of this paper discusses about the need of directions for the consistent operation and incorporation of the E-rickshaws as the important mode of Intermediate Public Transport (IPT) and Last Mile Connectivity (LMC**)** option for Delhi. LMC modes make people reach to public transportation of a city. Non-motorized transport (NMT) as LMC has been adopted as a sustainable mode since it reduces emission excessively. There is a variety of modes like cycle rickshaw, auto rickshaws, E-rickshaws etc. are found as the LMC options, besides walkability and cycling. The mix and diversity of such variety in LMC and NMT options pose a serious challenge to policy and plan makers in many countries in the global south, and India is no exception. The manifold population and culture in India are consider also in transport modes and needs continuous boost of practice and research in transport planning and engineering. E-rickshaw is one of such serious discussion, which has appeared as new mode for LMC in recent years and needs the recognition of scholars and experts urgently. The MRTS system could bring faster commuting between various zones and sub cities like Gurugram, Noida, Greater Noida, Dwarka etc. Still there are few difficulties in retrieving MRTS for common person and lack of systematic planning for feeder services and LMC to accolade with MRTS network. In the last few decades, the first- last mile connectivity was serving by the ordinary mode of transport like cycle rickshaws, feeder buses and other intermediate public transport (IPT). India has a share of three-quarters of the world's auto-rickshaws, three motor vehicle that hired to move both people and goods. Additionally, in last few years, battery operated rickshaws known as E- rickshaws are plying on the road for serving as the last mile and first mile for the travel. E-rickshaws is a 3-wheeler vehicle with a differential mechanism at rear wheels for seating of passengers. These vehicles have a mild steel tubular chassis. It is equipped with brush-less DC motor capacity of 650W to a maximum of 1400W, which are driven by lead-acid batteries**.** E- rickshaws are manufactured locally with components from India and China. The electrical system used in Indian version is 48VDC can run 90-100 km/full charge, top speed 25 km/hour the battery takes 8–10 hrs. to become fully charged. Drivers usually get it charged during nighttime. E-rickshaw has a seating capacity of 5 people including the driver with an additional luggage capacity of 40 kg which is allowed by the government. The weight of E-rickshaw is in between 200-250 kilograms and the government of India to be less than 2800 mm length, 1000 mm width, and 1800 mm height, mandates the size of the E- rickshaw. E-rickshaws are vehicle with low noise, zero air pollution. E-rickshaw has gained popularity for its zero emission and emerged as more sustainable mode of transport. E-rickshaws comes with a cost of INR 120000 to 150000 ($1720-$2150). The running cost and maintenance cost is much lesser compared to other similar modes. If we compare it to another similar mode like auto rickshaws and cycle rickshaws running, cost is very much less and profit is high for the operator of E-rickshaws.

[6] The primary purpose of this study includes adopting a last-mile transport system in a high-density residential neighborhood and assess the effect of the last-mile solution on the efficiency of the system. The study area is the city of Sejong, a newly developed city considered as the administrative capital of Korea since 2012. For high-density land use, Sejong was originally intended for transit-oriented construction. The share of Bus rapid transit (BRT) and local bus is just 5%. The slightly longer distance from home or office to bus stations is one of the reasons for this low usage of public transport, taking a little less than a mile to walk depending on user expectations. A simulation methodology was used, consisting of a simulation that was used to estimate the changes resulting from the implementation of a minibus-based transport system. The minibus operation was selected as the target service and the simulator software was chosen as MATSim. MATSim has been developed as an open-source implemented in Java, so it is easier to use for various research purposes than other simulation tools. The MATSim simulation process consists of five modules: initial demand (Module 1), simulation (Module 2), scoring (Module 3), analysis (Module 4), and replanning (Module 5), which are optimized through repeated computations. MATSim assumes that walking speed is 3 kilometers per hour. The simulations were repeated 1000 times to determine if the values reached a stable value and here, the mode share of public transport (PT) included BRT and minibus mode share It is important to design neighborhoods that have high connectivity between land use and transportation in areas with high densities such as Korean cities. In this research, by

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introducing a minibus service across a high-density housing complex where it would be hard for large buses to reach, we studied the impact of a last-mile solution. The study revealed that the BRT system and minibus service improved connectivity to and from high-density clusters effectively. Unlike previous research in which minibus need was set, his study compared the level of customer service between commuters (e.g., car, walking, and minibus). The findings showed that trunk traffic wasn't really replaced by minibuses. These findings indicated that the minibus service can also be used for trunk traffic as an auxiliary. It was evaluated that the minibus service raised the public transport modal shift by 3-5 percent as per the scenario presented by the minibus.

[1] This paper includes a literature review of the problem of the first and last mile, integrated network architecture and approaches, bicycle-sharing features, the effect of bicycle-sharing systems on the behaviors of travelers' preference, and advantages of incorporation of cycling-transit over the last few decades, car ownership of China has improved exponentially. Consequently, issues with road congestion and traffic emissions have arisen. Regulations limiting the purchasing and use of cars have been implemented and enforced in some of China's cities in response to these problems. Bicycles have been advocated as a sustainable mode of transport. In this situation, bicycle-sharing services have been introduced, including public and private bicycle-sharing schemes. Before and after the introduction of shared bicycles, we developed a questionnaire to collect traveler mode choices for first/last mile trips. The modeling questionnaire has four parts: individual and sociodemographic characteristics, travel characteristics, distances relative to the built environment, and first/last-mile trip mode choices. More than 95 percent of the participants ride less than 2 km to public transit stops before introducing bicycle-sharing programs. Bicycling or walking is more appropriate than a 2 km trip by car. More than 85 percent of young public transport travelers take shared bicycles or walk as the feeder mode since the introduction of bicycle-sharing systems. In order to better understand the traveler's choice behaviors for first/last mile trips after bicycle-sharing systems are implemented, this study considers the effect of individual features, travel characteristics, and the built environment on travel mode choices for such trips. The multinomial logit model is used to model preference behavior and travel choice models for first/last mile trips prior to and after the launch of bicycle-sharing networks. The mode share of shared bicycles for first/last mile journeys hits 45.9 percent after the implementation of bicycle-sharing systems. The first choice is shared bikes, followed by cycling, individual bicycles, and cars.

[4] The study carried out extensive research on the impact of the built environment with four features of "D" along with density, diversity, design and transit distance. Three types of variables were collected for research to understand the behavior of the first and last-mile journey. This choice behavior is based on the evaluation of all possible options and maximization of utility as defined by the train. Walking, bus, and LRT are options in this study. In addition to the BE variable, modal preference is often considered to be influenced by individual and household level factors. Gender, age, household size, income, purpose of travel, etc. were selected in the model variables to understand its effect. Specific variables of model travel such as travel time and travel costs etc. were also taken into consideration. The choice of first and last mile modal was determined by the factors of origin, destination and non-MRT station area of the respondents.

[2] This study aims to identify the factors that affected the option of whether to walk or take the rickshaw mode access/egress. Characteristics of variables that are usually used in the option for mode analysis. The first one is Individual characteristics like socioeconomic and demographic, Quality/characteristics of mode-specific operation, psychological attributes like attitudes. Trip characteristics, Attributes of the built environment, and Transport Demand Management. Based on the following criteria, survey locations were determined. Areas that show high demand and availability for rickshaws. Areas that draw heavy pedestrian foot traffic; areas with a change can occur of land use which includes many major travel attractors, such as malls, universities, and government agencies. Surveys were undertaken between 7 a.m. and 12 p.m. during weekdays to capture journey-to-work and journey-to-school trips. The survey was administered among individuals within the selected 10 station catchments. Based on a systematic sampling design, potential respondents were selected based on a random start. At intercept points, they were initially approached and invited to engage in the survey. If they agree, the respondent was surveyed by surveyors. Upon completion of the interview, the next pedestrian walking past the intercept point was then asked if he/she was ready to be questioned. 488 (69.8 percent) of the 700 respondents participating were pedestrians and 212 (30.2 percent) were pedicab users. The variables considered for developing the Utility model are the mode-specific variables included time of travel (TIME), cost of travel (COST), and waiting time (WAIT) for pedicabs while route-specific variables include distance over safety (DISAFE), safety rating (SAFETY), accessibility rating (ACCESS), and walking environment rating (ENVIRO). An additional combination variable was also developed such as the cost over travel time (COSTIM) variable. The generic variables include being male or female (GENDER), age (AGE), with child companion (WCHILD), working-age (WRKAGE), and with baggage (WBAG). Factors that influenced the decision of a person to walk or take the pedicab as their preferred choice for the first and last mile trip.

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[7] The purpose of this study is to prioritize "walking" through a range of factors related to users' socioeconomic status, travel characteristics, and station background and substitute it for the last mile. Transit commuter surveys provided direct questionnaire interviews with first/last mile users of these seven case stations covering a total of 850 samples. Surveys were conducted on weekdays since the main focus of the study was on the everyday types of trips. The second part of the survey concerns the evaluation of the pedestrian facilities and the environment around these case stations. The Chi-square test is used to analyze the relationship between walking as a mode used for FM & LM against many socio-economic characteristics of commuters. The pedestrian environment in this study relates to the availability and efficiency of walking facilities to/from stations to/from origins/destinations within walking distance. This paper concludes that the overall walkability environment provided to transit commuters is critical to the share of FM/LM journeys.

[10] The feeder network design aspect is defined and understood in this research paper. The research suggests feeder design techniques using a gravity model. A GIS-based spatial analysis for the service areas of existing public transport was performed to check the consensus that new public transport (buses) operates as feeders. They conduct a Questionnaire survey to design a new feeder system for the first and Last mile option. Information about an individual's income class, vehicle ownership, frequency of use of BRTS and purpose of travel was given in the first section, While the next part is about the perception of the quality of operation of the feeder mode. Feeder mode service characteristics were performed using a five-point based scale like, very good, good, fair, poor and very bad.
These service attributes include:

1. Reliability of Route
2. Travel duration
3. Cost of travel
4. Convenience
5. Safety & Security.

III. CONCLUSION

Various aspects for first and last-mile connectivity of students from different colleges located in different countries have been studied. Some focus on the role of active travel activity in public transport – walking, cycling, and e-rickshaw, due to first and last-mile connectivity, BRTS riding is lagging behind, while others focus on traffic congestion due to rising non-motorized vehicles. Although some highlight the importance of first and last-mile connectivity in transport planning. Thus, the first and last-mile connectivity was given due importance in all the publications.

The surveys were performed by the Home Interview Survey, which proved to be very successful. The questionnaire was designed to include key factors influencing the choice of mode categorized into various groups like Socio-demographic characteristics, vehicle ownership, Trip specific variable, Built environment attribute, psychological attributes, and Transport Demand Management (TDM). All these, are found to have a huge influence on the mode-choice behavior of the first and last-mile connectivity.

STAMP invention, chi-square test, model utility function, multinomial logit model, bivariate and multivariate analysis were used to analyze travel patterns. Each of these models could be used appropriately to research for first and last-mile connectivity while keeping the above points into consideration

It is stated that individuals who are away from public transport within 2 km to 2.5 km do not use public transport. Therefore, walking, bicycles and e-rickshaws are the essential mode of transport to fill this gap. In addition, first and last-mile connectivity is critical for public transport due to the fact that motorized users have increased daily. It causes traffic congestion and also creates carbon dioxide emissions.

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