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Analysis of feeder connectivity for BRT station A case study of Indore BRT

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Abstract : Indore has a BRT system that extends for 11.4 kilometers along a major road. To get to the BRT system, one must take a variety of types of transportation, including walking. Personal automobiles, rented automobiles, city bus and so forth. The System as a whole promotes economic development in a region by allowing commuters to their destinations. The first/last mile transportation link to/from major transit lines enhances the chances for commuters from nearby communities to use the main public transport corridors. A zone in Indore city has been chosen for the current study. The first station of the Indore BRT the Rajiv Gandhi square is taken as hub and a circle of 2 km radius is taken as its boundary of the zone of influence. The E-Rickshaw is chosen as a Para transit feeder transport. In addition, based on community comments, a series of recommendations for improving e-rickshaw is provided. The fixed route transport is proposed to be designed to minimize the walking time for individuals with maximum coverage in a locality. The maximum walking time is restricted to 2 minutes. The stops are marked on the Google Earth Map and the measurement of distances and /or coverage is also carried out on the same map.

Index Terms **- feeder service, BRTS feeder, route analysis, e-rickshaw service**.

Introduction

In India, the proportion of urban residents to the overall population has risen at an average pace of 40% per decade over the last three decades, owning to urban economic growth providing expanded livelihood options and better employment opportunities in cities. The growth of cities has resulted in a greater demand for mobility. In the current situation, meeting current and future mobility requirement is a difficult task. Reducing the number of vehicles on the road and improving transportation infrastructure are two competing and conflicting options. However, reducing the number of vehicles particularly the private vehicles will be impossible until the public has access to economical, convenient, and high quality public transportation system with door -to-door connection. People's aspirations have risen as a result of improved affordability in connection with the comfort and safety. Unfortunately public transportation in most Indian cities has not been able to keep up with the city's growth and development needs. Due to a shortage of public transportation and an increasing need for connectedness and comfort, people have become more reliant on unsafe and most uncomfortable Para-transit options or go for private transportation getting on easily available credit facilities in the market. This is causing an environmental hazard and slowly transportation is becoming one of the key vehicles for global warming and climate change.

In recent years, the Indian government's urban development strategies have emphasized the provision and expansion of public transportation in all cities. The ten year old JNNURM projects, as well as the more recent AMRUT urban development initiative, have both invested heavily in public transit projects. Bus Rapid Transit systems were encouraged as part of the JNNURM initiative, and the city of Indore adopted an 11.4 km BRT system pilot project on an important road link. This link connects the city's business districts, residential neighborhoods, educational institutions, shopping malls, and transportation routes. A dedicated bus lane with central stop is the main feature of the system. The BRT system is a convenient and fast moving public transportation system. The main difficulty is the lack of a proper transportation link for BRT customers who live beyond the BRT

system's buffer zone. The people residing in 0.4 km radius around a bus station can walk up to the station easily. However, in a radius of 2 km the walking becomes difficult for many. Thus we need a feeder service to the BRT lane. The surrounding areas are densely inhabited and the road widths are insufficient to accommodate large buses of standard size. The other means include some kind of Para transit options which are either based on fossil fuel driven vehicles or electric vehicles. The former ones are causing pollution and green house gas emissions. In these circumstances e-rickshaw is one of the best solutions for the feeder systems up to a distance of 2 kms. Present study is focusing on the design of E-Rickshaw based feeder system based on Fixed Route Transit (FRT) facility with fixed stop locations. This will improve last mile connectivity and convenience to the people interested in public transport based mobility. The first station of the Indore BRT the Rajiv Gandhi square is taken as hub and a circle of 2 km radius is taken as its boundary of the zone of influence.

The E-Rickshaw is chosen as a Para transit feeder transport. In addition, based on community comments, a series of recommendations for improving e-rickshaw is provided. The fixed route transport is proposed to be designed to minimize the walking time for individuals with maximum coverage in a locality. The maximum walking time is restricted to 2 minutes. The stops are marked on the Google Earth Map and the measurement of distances and/or coverage is also carried out on the same map. The other details of the study are as follows.

2. Literature Review

The Para-transit option in India and other countries of the developing world are perhaps the most growing and convenient mode of public transport. The most important drawback is it is mostly unplanned, no governance coverage and no integration policy with the public transport system of the city. If the Para-transit systems are taken into main stream planning of mobility it will add to the quality of public transport system. Mostly the public transport systems follow main corridors of the cities that have sufficient right of way. But there are lots of areas that have a compact habitation and there exists a network of shrunk allies or roads providing less space for the movement of the vehicles. In such cases Para-transit systems throng which is mostly owned by private players and run in an uncontrolled manner. Bhat and Thingom (2011) presented a detailed study on Para-Transit system in Indore city in context of its overall mobility within the city. According to Jain and Khare (2014) the Para-Transit system in Indore constitutes nearly 60% of the travel demand fulfillment. They discover that Maruti vans and TATA magic are the major stakeholders of the Para-Transit transport. Nakamura and Okamura (2009) presented a report on the effects of Para transit as a feeder of mass transit system in developing countries based on commuter satisfaction. This study aims to examine the impact of commuter perceptions of Para transit service on attitudes toward mass transit connectivity and behavioral intentions in using mass transit and Para transit as a feeder, as well as the potential of Para transit as a feeder. They recommended that measures to increase Para transit service must be carefully crafted with the goal of improving mass transit performance. Thangphanaisankun et, at. (2010) discussed a case study of an integrated Para-transit system as a feeder in Bangkok in Thailand. In this study, they look into the consequences and interrelationships of commuters' attitudes and behaviors when it comes to the integration of Para-transit into urban transportation based on their preferences. Localities along Bangkok's rail transit lines were chosen as a case study. To acquire the estimates affects of commuters' attitudes on their choice consideration, descriptive statistics are used to explain differences in attitudinal and behavioral characteristics among choice groups. S. Chandra et al. (2013) examined the accessibility impacts of two typical feeder transit services- fixed route transit (FRT) and demand responsive transit (DRT) on first/last mile transportation connectivity to/from the major transit line. The major factor considered was the travel impedance factor 'Beta' (opposite of accessibility) which is supposed to have an impact on the number of stops in FRT type of feeder services. If the value of 'Beta' is equal to 1 then the number of stops is infinite and the 'Beta' value increases the number of stops will reduce. Thus there is a tradeoff between the number of stops and the travel impedance. Tabassum et al. (2016) studied a feeder system for the BRT system for the city of Lahore in Pakistan. The bus rapid transit system (BRTS) is a public transportation system in Lahore (BRT). A field interview survey were undertaken to better understand the travel pattern and characteristics. The poll was carried out over 296 samples surrounding offices, enterprises, and activity area and the major finding was that the BRT system is used by low income individuals. It also introduced a traditional method for generating optimum feeder routes. For feeder design, the number of stops is calculated using impedance. Zhu et al. (2016) examined the route design model of feeder bus service for Urban Rail Transit Stations, By extending feeder bus services and using a logit model for passenger flow distribution the study was performed. A route starting and terminating at urban rail transit stations was developed using a circular route model, and the route was then solved using a genetic algorithm. The Shanghai neighborhood of wei-fang was chosen as the test site. The feeder route length was conformed to a functional orientation of short-distance travel and the feeder service of a feeder bus, as per the model and algorithm; the route generally covered where conventional bus lines were less, as per the model and algorithm. Balya et al. (2018) focused on the network catchment analysis of an integrated feeder service to the bus along Ahmadabad city's BRT line. The revealed preferences and expressed preference survey are used to obtain data for spatial catchment analysis in SPSS and GIS. The results of the distance decay curve show that as the distance between home and transit bus stops increases, the percentage of trips decreases. For both BRT and non BRT users, the average outgoing catchment area was 940 m, whereas the projected catchment area was 1998 m, and this distance was spatially represented by GIS buffering approach. The improved methodology used can be used to plan integrated feeder service bus stops in similar sized metropolitan area.

3. Indore Bus Rapid Transit (BRT) System and the study Area

A BRT system often contains dedicated bus lanes and gives buses precedence at intersections where buses may interact with other traffic, as well as design features to eliminate delays caused by passengers boarding or exiting buses or purchasing fares. BRT aspires to combine the flexibility, lower cost and simplicity of a bus system with the capacity and speed of a metro. The BRT has

dedicated bus lane and operates along one of the city's busiest routes. BRT is Indore's rapid transit system, which began operations on May 1, 2013. It is built on the PPP model, which incorporates World Bank Investment. It is currently an 11.4 km bus corridor with 21 stops Indore's BRT system includes A/C Transport buses know as I-Bus, each with a seating capacity of 38 passengers. The NRT road width varies from 31.6 m in densely populated areas to 60 m in sparsely populated areas. The narrow width area has a higher traffic flow density than the width area. Recently, 50 buses have been put into service, with peak hours of service in the BRT lane ranging from 11 to 12 buses per hour per side.

Our study area is the BRTS Rajiv Gandhi stop. There is BRT station along the 2 km stretch both sides: Rajiv Gandhi stop. There are various colonies and village in the vicinity, as well as know places such as Choithram hospital and mandi, Garden, Institutional Academy, and so on. There are numerous proposed and completed infrastructure projects. The location has a lot of road for development. Despite the rapid development of the population in the area, public transport connection is weal and does not meet demand. The 2km Radius circle around the Rajiv Gandhi Bus Station is shown in Figure 3.1.

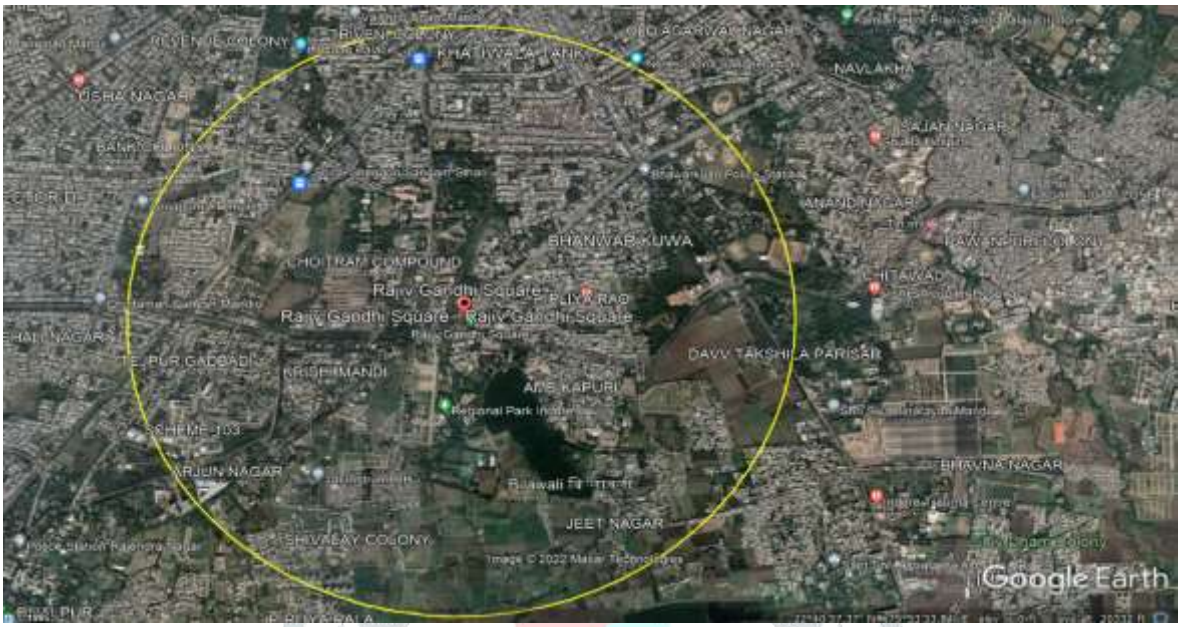


Figure3.1

(Figure3.1) Indicates a buffer zone created by a 2 km circle around Rajiv Gandhi Station of Indore BRT.

4. Methodology

The methodology used in the procedure is to finalize the routes that require less walking time for an individual from is origin or to the destination should be a minimum and the route should cover maximum area in a locality. For this purpose following steps are involved.

DATA PROCURMENT AND PRILIMINARY ANALYSIS

Questionnaire design and survey

Separate questionnaire were used for the interview based survey. The questionnaire is divided in to two parts. The socioeconomic data for BRT users was acquired in the first section, which included information about one's income class, vehicle ownership, frequency of using BRTS, and trip purpose, among other things. The second segment discussed the existing mode e-rickshaw and mass transit mode in terms of service quality perception. The quality of these modes was evaluated using 13 performance parameters and one overall performance question. A five-point Liker's scale was used to record the attributes: very good, good, fair, bad, and very bad. On chosen routes, the Type-second Questionnaire survey was conducted.

It included questions about the service qualities that are used to determine impedance factors.The following are some of the servic e characteristics:

1) Service/route reliability 2) Time spent travelling

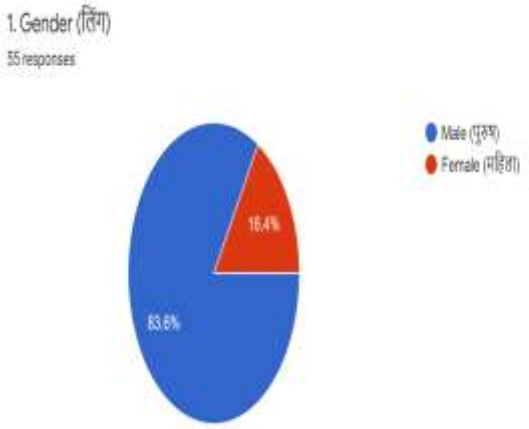
3) The expense of travel/fare 4) Convenience

5) Security and safety.

Their weight is determined by the passenger's ratings on a scale of 1 to 5, with 1 being the least important and 5 being the most critical element as impedance.

The BRTS users were interviewed, and a total of 55 people participated in the Survey.

Socio-economical characteristics of BRT users



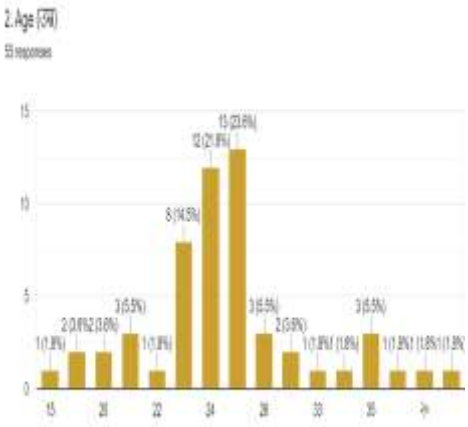


Figure 4.1 (a) Gender **Figure 4.1(b) Age Group**

The survey included 55 people who used the BRT system, with 46 of them being male and 9 of them being female (Figure 4.1 (a)).

According to the overall survey results of BRT users, 42 people were between the ages of 15 and 25, and 13 people were between the ages of 25 and 40 (Figure 4.1(b)).

Educational Qualifications

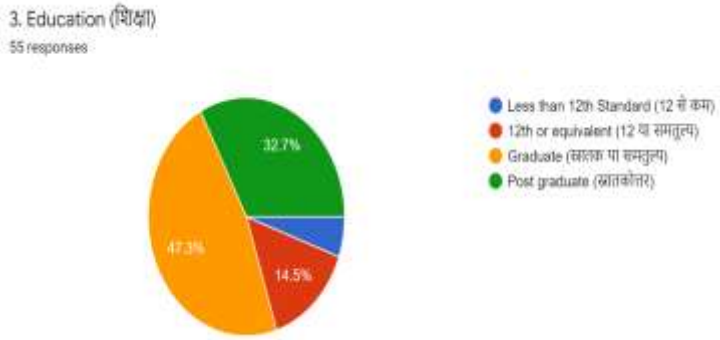


Figure4.2 Educational Qualifications

The BRT users are mostly young people and maximum of them are students. This is mirrored in the educational qualifications of the respondents, who include 3 respondents who have not passed the 12th standard examination, 8 passengers who have passed the 12th standard examination, 26 graduates, and 18 postgraduates (Figure 4.2).

Profession

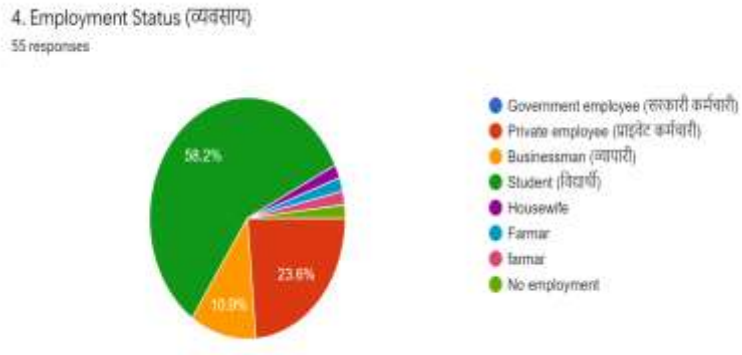


Figure4.3 Profession

Students and private employees make up the majority of BRT users, accounting for 58.2% and 23.6% respondents, respectively, followed by 10.9% businessmen and 1.8%-1.8% daily wage workers and housewives. Following the trend, educational and work/job purpose excursions are the most popular among BRT users, accounting for 1.8% percent and 1.8% percent of respondents, respectively (Figure 4.3).

Frequency of using BRTS

The total number of travellers questioned was 41.8%, divided into two categories: daily users and users who go twice or three times each month. While 12.7% respondents said they take BRT more than twice a week, 7.3% said they take it less than or equal to twice a week. 38.2% people said they just use it once in a while. Figure (4.4)

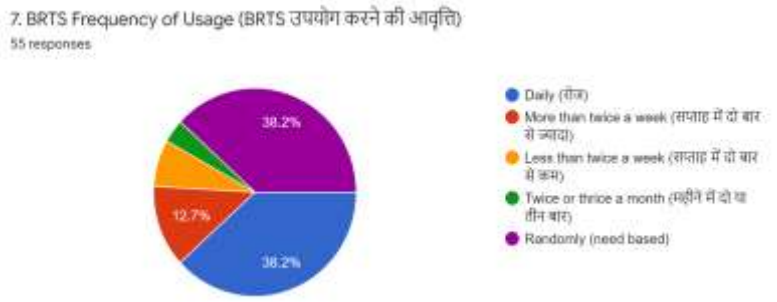


Figure4.4 Frequency of using BRTS

Income Group

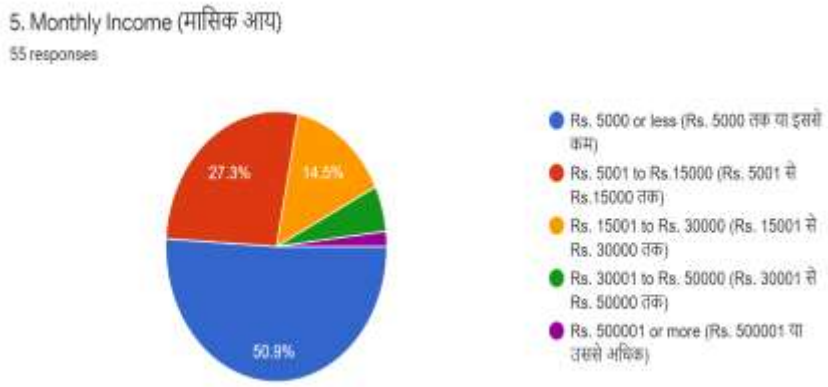


Figure 4.5 Income Group

The number of travellers who responded regarding their monthly income was 50.9% (less than or equal to Rs. 5000), 27.3% (Rs. 5001 to 15000), 14.5% (Rs. 15001 to 30000) and 5.3 %(Rs. 30001 to 50000) and 2% (above 50000) (Figure 4.5).

Vehicle Ownership

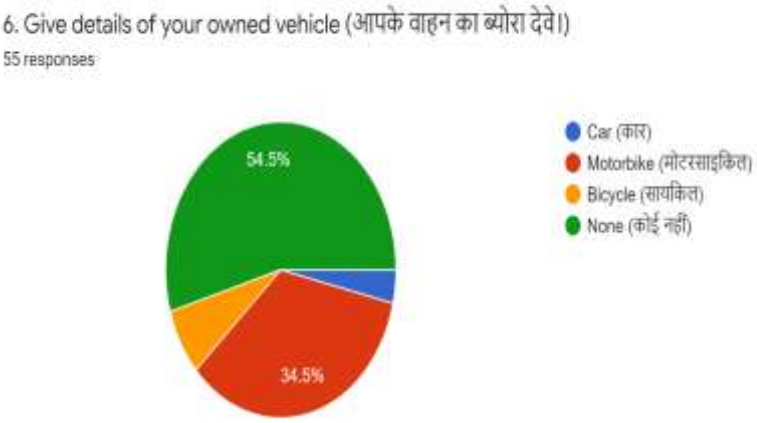


Figure4.6 Vehicle Ownership

This demonstrates that people in lower and moderate income groups utilise BRT more frequently. A striking trend emerges when it comes to vehicle ownership and BRT ridership. The greatest number of respondents who owned a two-wheeler was 34.5, followed by 54.5 who did not possess a vehicle, 7.5% who had a bicycle, and 3.5% who owned a four-wheeler (Figure 4.6).

Trip Purpose

Entertainment and shopping are the other prominent trip purpose i.e. 0% and 1.8%% respondents. 40% Studying purpose, and 41.8% is working purpose and 16.4% respondent have other trip purposes to travel in BRT like meeting relatives and friends, outside travelers from drop points of Inter-City buses etc (Figure 4.7).

BRT customers mostly use the service to travel to educational institutions, workplaces, and leisure facilities. BRT is also used more by the low-income class and students than by any other category. The higher-income segment is less interested in BRT. In addition, those who do not possess a private automobile use the BRT system more frequently than those who own a private vehicle.

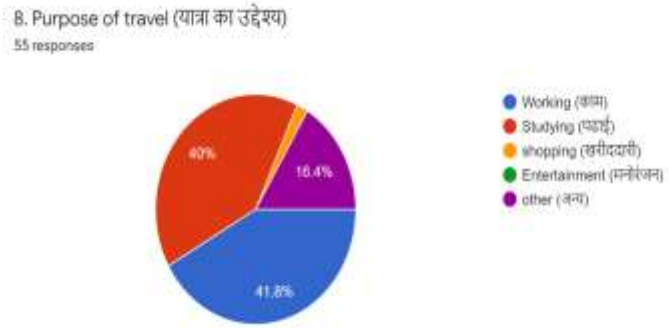


Figure4.7 Trip Purpose

Access and Egress for BRTS

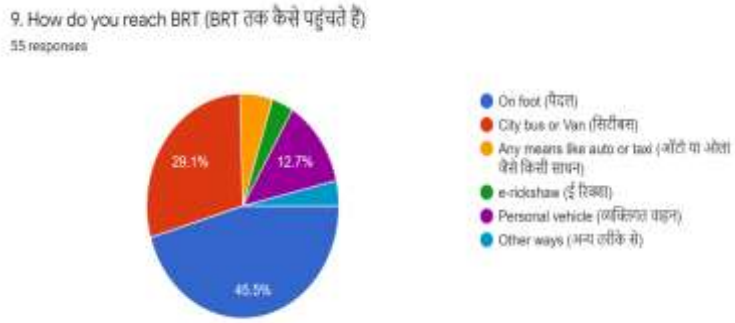


Figure 4.8(a) Percentage Distribution of mode for access to BRTS

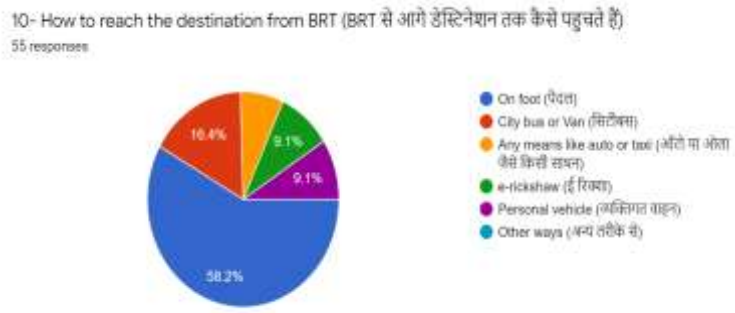


Figure4.8(b) Percentage Distribution of mode for Egress from BRTS

The data on BRT users' access and egress shows a nearly identical pattern for all modes. The majority of the time is spent walking (45.5 percent and 58.2 percent of surveyed persons for access for egress respectively use walk mode). The city-bus (29.1 percent), E-rickshaw (7.5 percent), taxi and auto-rickshaw (6.9 percent), and usage of personal vehicles (10.9 percent) in the form of personal driving of a two-wheeler or hitchhiking are all popular ways to get to and from BRT stops near major intersections. (Figure 4.8 (a) and (4.8 (b)).

Opinion about E-Rickshaw

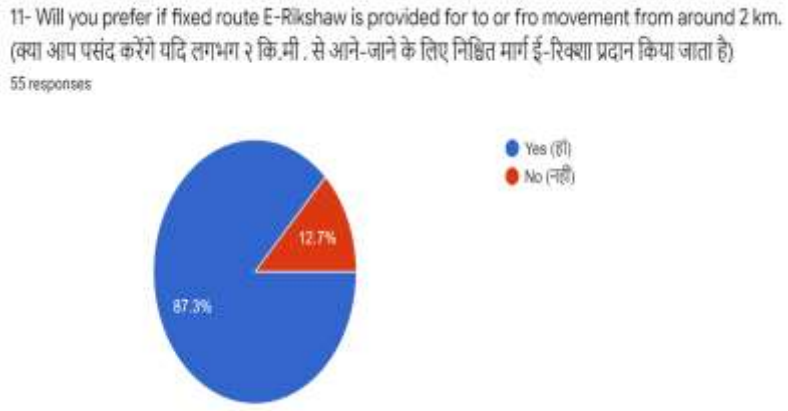


Figure 4.10 Opinion about E-rickshaw System

The opinion of users about use of E-Rickshaw around 87.3% respondents says that they would appreciate if E-Rickshaw service vehicle will run in the city while 12.7% say that they won't like to use that service. The maximum responds are favour with the e-rickshaw.

Formulation

The formula for E [Twk] is used for the average walking time to the nearest stop:

$$E[T_{wk}] = \frac{1}{V_{wk}}\left(\frac{W}{4} + \frac{d}{4}\right)$$ ……Eq.1

Where Vwk is the passenger's average walking speed.

The distance d between two fixed stops and service area width W is measured from generated routes in Google earth, allowing passenger to walk the maximum distance to a stop (Guerra et al., 2012; Ei-Geneidy et al., 2006; O'Sullivan and Morrall, 2012).

Assumption includes a walking speed Vwk of 4.3 km per hour. Passengers will find walking to transit stop inconvenient, especially if the paths leading to these stops are not suitable for walking. Walking is also inconvenient owing to safety concerns surrounding a half and in inclement weather.

It is also that living within coverage area zone is .14 km radius circle of the main service can walk to it, thus they are not included further. The feeder stops might be regarded origin, whereas the main system BRT stop is the destination. (Shailesh et al, 2013)

5. Results

Following discussions with residents in our research area, an updated proposal has been plan. The main features of the proposed p lans are shown below.

Route Plan 1

Figure 5.1

The above figure (5.1) shows the route and this route length 1.96 km and the each feeder stop coverage the area is .14 km. The total number of stops for this route is 6 stops covered the total residential colonies as Amitesh Nagar and other all area.

Route Plan 2

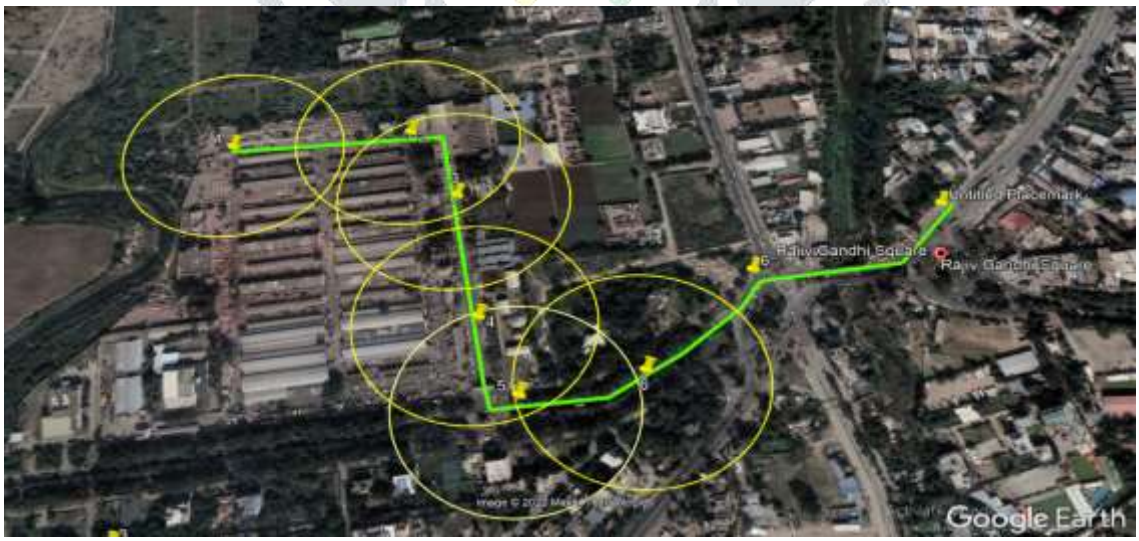


Figure 5.2

This route length is 1.32 km and the each feeder stops coverage area is .14 km and gives the better facilities. The total 6 number of stops are covered the Choithram Krishi Upaj Mandi area in figure (5.2).

Route Plan 3

Figure 5.3

This route length is 2.54 km and the each feeder stops coverage area is .14 km and gives the better facilities. The total 10 number of stops are covered all residential area as Pawan Putra Nagar, Regional Park and so on in figure (5.3)

Final Route Plan

Fig.5.4 Final Route Plan

In the table 5.1, the total route length, number of stops and journey time are listed.

Table 5.1 Final Route Length, No. of stops and walking Time

Lane no.	Length of Lane	Total no. of Stops	Walking time
1	2.54 km	10	2 min
2	1.96 km	6	1.5 min
3	1.32 km	6	1.3 min

The no. of stops on route 1 which having 1.96 km route length is 6 and walking time estimated as 1.5 min. The no. of stops on route 2 which having 1.32 km route length is 6 stops and walking time estimated as 1.5 min. and The no. of stops on route 3 which having 2.54 km route length is 10 stops and walking time estimated as 2 min. Minimum walking time is the acceptable limit for a feeder stops to be adopted. Longer walking time are not only unattractive for commuters but difficult for maintaining schedule. The average distance between two stops to be 0.23 km. (Figure 5.4)

6. Conclusion

The current study investigates the role of informal E-Rickshaw service as feeders for the Indore BRT system. Passengers must be transported from the origin to the BRT system for onward transit, and vice versa. A questionnaire survey, a physical site survey, and the design of E-rickshaw service based feeder route system for the BRT in Indore were all part of the project. The study's findings suggest that such a system might be implemented. The data on BRT users' access and egress shows a nearly identical pattern for all modes. The lion's portion belongs to walking (45.5% and 58.2% of surveys persons for access for egress respectively use walk mode) because they work stay in close vicinity of BRT lane. The city bus 29.1%, E-rickshaw 7.5%, taxi and auto-rickshaw 6.9%, and usage of personal vehicle 10.9% in the form of personal driving of a two-wheeler are all popular ways to get to and from BRT stops near major intersections. Because there is no feeder infrastructure for BRT, there is limited

connectivity to BRT from their trip origin point. The current study concentrated on these disparate places where the prospect of establishing the e-rickshaw based feeder system was suggested. Many walkers will be benefitted in time and comfort if the E-Rickshaw based feeder system is provided from unrepresented areas in the ambit of public transport system. People in the research area are more concerned about the vehicle's environmental impact, safety, and comfort than they are about trip time and cost.

However, many respondents of the survey about E-Rickshaw show a reluctance to use the current e-rickshaw owing to poor connectivity, unpleasant seats, overcrowding, and a difficult travel and some of the driver's misbehavior. Before employing an e-rickshaw, improvement measure should be implemented, including the vehicle's existing design, which should be assessed by professionals in order to make it safer, more comfortable, and quieter. The study recommends a frequent e-rickshaw based feeder service, which would provide good coverage of the study region as well as greater connectivity with the BRT.

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