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An Assessment of Public Transport Accessibility Levels for Slums in Bhopal

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Abstract*: Good connectivity and accessibility ensure inclusivity of public transport system which is an indicator of a fair society. The modal shift of commuters towards public transit services depends majorly on its accessibility levels. To ensure that commuters have equal opportunities to access jobs, education, and other services, PTAL (public transit accessibility level) is often evaluated. Public transport accessibility levels are a detailed and an accurate measure of accessibility of a point to the public transport network which considers walk access time and service availability. Public transportation is often referred to as an affordable model for every section of society due to its cheap fare price. The major question lies in the inclusivity of public transit services for the economically weaker section of society whether or not public transportation is available and accessible for those who need it or those who cannot afford other mobility services. The present study intends to focus on affordable and inclusive transportation for economically weaker sections. The study is an attempt to assess the issues with public transport services in the city of Bhopal, India for economically backward areas like slums. The research will help in understanding the accessibility level of currently available public transit services by evaluating the PTAL (public transit accessibility level) for socially backward.

Keywords* : Transportation, Slums, Social inclusion, Public Transit Accessibility Levels (PTAL)

I. INTRODUCTION

Slum settlements have been one of the visible outcomes of urbanization. As estimated by UNDP, about one-sixth of the world's population lives in slums. According to the 2011 census of India, 65.5 million people live in slums which is around 17% of the urban population or one in every six people in urban areas. In case of fast urbanizing cities, most of these informal settlements are located in peri-urban areas due to poor land availability and lack of affordable housing. The peri-urban slums due to their location outside the city jurisdiction are not regulated by government authorities making it difficult to plan for their inclusivity i.e. providing them with an equal access to public facilities and services and welfare opportunities.

The public mobility services act as a major facilitator for the general public in order to provide access to and benefit from welfare services. The ease of reaching from a specific origin to a specific destination taking account of the delays due to spatial hindrances is referred to as accessibility (Adhvaryu,B 2019, 19-35). If due to economic or physical challenges, citizens are unable to access the public transport facilities then they are indirectly omitted from taking part in various social and economic activities. Good connectivity and accessibility ensure inclusivity of the public transport system which is an indicator of a fair society. One of the ultimate goals of any transport policy is to ensure accessibility. Transportation thus plays a vital role in promoting socio-economic development. Good accessibility towards public transport services helps in providing easy reach towards job, education, health, and other leisure facilities. However, due to the lack of mobility options like public transit for urban poor, they are forced to restrict their travel to essential trips.

Recent studies show that the ability to move and social inclusion reduces feeling of depression and also affect the mental wellbeing of an individual. Targeting poverty, social exclusion, and environmental vulnerability is a primary development objective, not only of national policies but also of urban and local development interventions including climate and natural disaster resilience action plans. Countries and cities which have been successful in drastically reducing poverty, social exclusion, and environmental vulnerability saw an equal reduction of poverty. They combined pro-poor economic growth, redistributive measures, and inclusive sectoral policies in order to tackle the multi-dimensional aspects of poverty, tackling not only economic aspects, but also those that are people-based such as social exclusion, place-based like upgrading and tenure regularization, and issue-based such as education, health, etc. In India, the contribution of the urban poor to the GDP is about 25%, but resources allocated to them are not even 2%.

In Indian, the larger is the city size, the higher is the percentage of urban trips served by public transport. As per Census 2011, in cities with a population between 1 to 2 million, 30 percent of urban trips are served by the public transport, whereas it's 42 percent for cities with population between 2 to 5 million, and 63 percent for cities with population over 5 million. According to United Nations, 40.76% of country's population is expected to reside in urban areas by 2030. As India continues to urbanise rapidly, a direct demand for the high quality of public transit services has been induced. With a drastic increase in population and demand for mobility, issues related to the current public transit system needs to be addressed in most million-plus cities.

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The study is thus an attempt to assess the issues associated to public transit services for selected slums locations in the city of Bhopal. It will provide an understanding of the inclusivity of the public transportation for the economically weaker sections by focusing on the accessibility levels of currently available public transit services.

1.1 Introduction to Site Area- Bhopal, India

Bhopal, the capital of Madhya Pradesh is the 16th largest city in India, and is also recognized as 'city of lakes' for its various natural and artificial lakes. The city is located on the Malwa plateau. According to the 2011 census of India, the city population is around 23, 68,145 on a total area of 2,772 square km which constitutes to a population density of 854 persons per square km. Bhopal is well connected with national and state highways, NH-12, SH-18, and SH-23.

During the 2000s, the emergence of the Kolar municipality area in the southern part of the city along with other residential regions such as near Shahpura, Piplani, Barkhera Patani, and Lalghati lead to increase in demand for public transport services. Transport demand in Bhopal also grew rapidly due to the emergence of commercial and industrial activities. Various educational institutes started to emerge on city peripheries around the same time. This resulted in need for a good road network connectivity of public transport services to provide accessibility towards the institutes.

1.1.1. Public Transit Services in Bhopal

The public transit system of Bhopal consists of intercity buses for intercity travel and BRTS and Mini bus (in some parts) which carries passengers for intra-city services. The bus system in Bhopal runs on the PPP (Public-Private Partnership) model. BCLL (Bhopal City Link Limited) manages the BRTS (Bus rapid transit system) in Bhopal.

Table 1 Detail of bus numbers and bus route in Bhopal

S.no.	Route	Type (No.)	Bus Stops	Route Length	Average distance between
1	Chirayu Hospital/ Bairagarh to Aakriti Eco City	Trunk route 1	50	24 km	480 m
2	Old Bus Stand to HEG Mandideep	Trunk route 2	34	23 km	676 m
3	Bairagarh/ Sehore Naka to HEG Mandideep or Bangrasiya	Trunk route 4	47	23 km	490 m
4	Bairagarh/ Sehore Naka to Bairagarh Chichi	Standard route 1	35	19 km	542 m
5	Nehru Nagar to Katara Hills	Standard route 2	45	15 km	333 m
6	Gandhi Nagar to Salaiyya/ Aakriti Eco City	Standard route 3	58	24 km	413 m
7	Karound Chauraha to Bairagarh Chichli	Standard route 4	50	25 km	500 m
8	Chirayu Hospital/ Bairagarh to Awadhpuri Khajuri Kalan	Standard route 5	50	25 km	500 m
9	City Depot Square to Ayodhya Nagar	Standard route 6	48	23 km	479 m
10	Gandhi Nagar to Patel Nagar Bypass	Standard route 7	46	20 km	434 m
11	Coach Factory to Bairagarh Chichi	Standard route 8	53	27 km	509 m

Source- Bhopal City Link Limited (BCLL)

BRTS Bhopal has 225 buses with a total route length of 186 km. According to table 1, three truck routes cater to 131 bus stops and eight standard routes which cater 432 bus stops. Standard Route 3 caters the most number of bus routes with 58 out of total 516 bus stops (11.2% of total bus stops) located here. Trunk Route 2 has least number of bus stops with 34. The highest route length is for Standard Route 8 which is about 27 km. Standard Route 8 runs from coach factory to Bairagarh Chichli, whereas Standard Route 2 runs for only 15 km and comprises 45 stops.

Bhopal Municipal Corporation is divided into 69 wards. According to the Primary Census Abstract 2011, the population of Bhopal Municipal Corporation residing in the slum was 4,79,699 which is about 26% of the total city population. In the city, there are 209 notified slums and 171 non- notified slums which together make up 380 Poverty pockets with a total of 1,28,170 households. Out of the total 1,28,170 households 49.8% are lie under Below Poverty Line (BPL) category (Municipal Corporation, 2006).

1.2. Slum Characteristics

The Census of India 2011 defines slum as a cluster of 60-70 households where dwellings are unfit for human habitation by reasons of dilapidation, overcrowding, faulty arrangements and design, narrowness of street, lack of ventilation, light, or sanitation facilities or any combination of that is detrimental to the safety and health (Census of India, 2011). It is an area with substandard housing and lack of basic amenities like poor sanitation and water supply, improper transit services, and high population density. The increase in income disparity, high land value, and increasing poverty rate along with increased population and demographic change are considered to be one of the major factors behind the formation of slums.

The typologies of slums can be classified based on their location within a city e.g. Inner-city slums, slums in scattered pockets, and slums in peri-urban areas. Slums in these locations are formed as a consequence of one of the three processes: deterioration of existing neighbourhoods, such as inner cities and public/ industrial housing, strategic squatting, or illegal subdivision of vacant sites. The location of a slum governs various aspects such as access to public transit services, types of livelihood, land values, housing conditions, and access towards other basic amenities to fulfill day to day livelihood needs.

The scattered slum pockets are those settlements which are accommodated mostly by urban poor's in developing cities. Most low-income households illegally occupy vacant land close to their workplace without the consent of the owner or the local authorities (UNHSP, 2003).

1.3. Accessibility to Public Transit and Social Inclusion

Accessibility in many kinds of literature has been mentioned as the ease of travelers to reach any activity places using a particular transportation system (Tahmasbia, B., 2019). It is the measure of access to the public transport system potentially available at various spatially segregated locations (Adhvaryu, B., Chopdeb, A. & Dashorac, L., 2019). Accessibility is not only referred to as physical access to opportunities and services, but also considers affordability, reality, and safety. It is the potential of opportunities for interaction. Good connectivity and accessibility of public transit services for basic amenities as well as leisure, not only promotes sustainability but also promotes a better quality of life (Saif, A., 2018). Public transport is not only about accessibility towards services but it also provides a platform for social interaction and establishes social connections. Access to public transportation is important from the spatial equity perspective (Singha, A.P, 2012).

Good connectivity and mobility, especially for lower income groups makes them better participate in the labour market, eventually fostering economic growth and social equity (Adhvaryu, B., Chopdeb, A. & Dashorac, L., 2019). The promotion of accessibility for any transportation policy is paramount, however, if the public transit services are not optimally available, it may create social exclusion. There could be two scenarios in public transport that lead to social exclusion. First is when the accessibility of public transport system is poor, that is, it does not cover the locations where the urban poor live and work. The other situation is when the system is accessible, but is unaffordable in terms of monetary cost like fuel or fare, parking, and operations and maintenance and value of time. Public transport accessibility areas translate to higher accessibility to desired work destinations of the urban poor (Adhvaryu, B., 2019). An inclusivity study conducted in Ahmedabad depicts that living in high PTAL areas may not result in a high accessibility level for urban poor residing in the same zone (Chopde, A., 2016).

The performance of a city in terms of its economic and environmental aspects can be enhanced by providing a better and more efficient public transit system. Internationally, over the last decade, there has been unequal distribution of transport mobility benefits between different social groups and/or different areas, particularly as this relates to people without private car access in communities that have become increasingly car-dependent. The Social Exclusion Unit (SEU) popularized this recent awareness of the social value of transport, exploring accessibility barriers that make it difficult or impossible for people to participate fully in society. Using the accessibility planning approaches, the mobility services available to society have always played a crucial role in facilitating urban development employing promoting social capital and community strengthening (Stanley, J., 2017). The diversity of public transit services makes mode choice flexible varying with travel purpose, distance, and time. The improvement in urban public transport services for urban poor's residing majorly in informal settlements enhances their access, not only towards basic amenities but also for better educational facilities and job opportunities (Onyango, G.M., 2018).

The lack of availability and affordability towards healthcare and educational services negatively impact the quality of life as they are identified as its major determinants. Unlike wealthy countries, this is observation is more relevant in low-income developing countries as the services are located at a greater distance which impedances its availability. On the other hand, investing time and money for constructing flyovers and better quality of the road is not going to solve this issue, eventually makes it futile and worse as this directly encourages the use of private mode to travel and discourages the use public transport because anyways the urban poor's can seldom afford private mode for commuting (D. Harshanee, J., 2015).

1.4. Calculating Accessibility levels

The modal shift of commuters towards public transit services depends highly on its accessibility levels. The accessibility to public transport can be evaluated using different methods like LUPTAI (Land use public transport accessibility index), PTAL (public transport accessibility level), and TTSAT (Time based transit service area tool). To ensure that commuters have equal opportunities to access jobs, education, and other services, PTAL (public transit accessibility level) is often evaluated. Public Transport Accessibility Levels (PTAL) measures accessibility of a point of interest, in terms of availability of public transport service at nearest point (e.g., bus stop) within a given maximum access time (irrespective of destination) (Transport for London, 2010). PTAL maps are useful in several ways like guiding future public transport investments, enhancing the urban plan-making process by integrating transport and land use, informing the parking policy, improving residential location choice, optimising supply locations of affordable and low-cost housing, and better understanding the mobility needs of the urban poor (Adhvaryu, B., Chopdeb, A. & Dashorac, L., 2019).

Public transport accessibility levels are a detailed and accurate measure of the accessibility of a point to the public transport network which considers walk access time and service availability. The evaluation of PTAL (Public transport accessibility level) becomes important for improving the process of urban planning through using approaches such as integrated land use planning, more effective parking policies, locations for affordable housings, etc. The sustainability of the urban setting is governed by the quality of public transit services.

The methods to quantitatively measure the accessibility level involves counting opportunities such as jobs and shopping destinations within reach and assessing the degree of travel impedance.

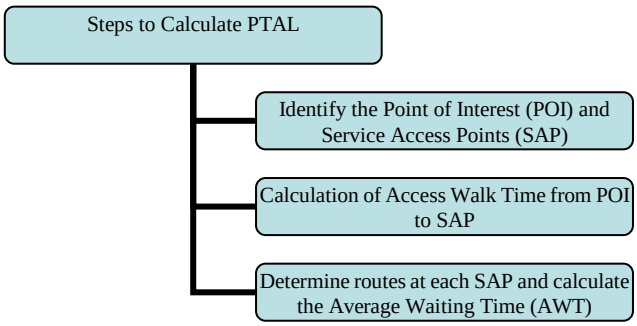
Travel time impedance is the most common way of estimating the accessibility by considering access, egress, and the transfer time from origin to destination (Tahmasbia, B., 2019).

The necessity to conduct a baseline study followed by its detailed assessment is of paramount importance for authorities and policymakers to make better decisions about investments in public transit system (Kim, J., 2019).

II. METHODOLOGY

The present study intends to assess the availability and accessibility of public transport services in Bhopal. In an attempt to assess the Public Transit Accessibility Level in existing slum locations primary survey was conducted in selected slum locations through a structured questionnaire. The slums were selected such that they were spatially distributed in the city. The questionnaire aimed to understand the issues and challenges faced by slum dwellers regarding the accessibility of current public transit in Bhopal.

The current slum locations were marked using Google Earth to set basis for calculation of PTAL. PTAL was also evaluated for posh neighborhood areas to assess whether the public transit services are equally accessible or not. IDW (Inverse distance weighted Interpolation) tool in Arc GIS was used to extend the spatial extents of calculated PTAL for Identified locations, and hence represents PTAL levels spatially.



Methodology (author)

Public Transport Accessibility Level (PTAL) is a tool to measure accessibility at various location in a city and spatially visualise it. Steps to Calculate PTAL include:

1. **Identify the Point of Interest (POI) and Service Access Points (SAP):** POI is defined as a point for which the accessibility level is to be measured with reference to a public transport stop (such as bus stop, metro station, etc), referred to as SAP.
2. **Calculation of Access Walk Time from POI to SAP**: The actual road network distance from POI to SAP is measured via a primary survey. The average walking speed is considered as 3.2 km/hr.
3. **Determine routes at each SAP and calculate the Average Waiting Time (AWT):** AWT is defined as the period when a passenger arrives at an SAP until the arrival of the desired service. All services on all routes are taken into consideration during peak hours.

   AWT = 0.5*(60/f) +K

   (f = Hourly frequency, K= Reliability factor)

   Calculate Total Access Time (TAT) for each valid route at each SAP:

   TAT = WT+AWT

   (WT = Waiting time, AWT= Average Waiting time)

   Convert TAT into Equivalent Doorstep Frequency ***(EDF): = 0.5*(60/TAT) or 30/TAT***

The reason for dividing 30 by TAT is to re-apply half the headway rule because the values have a different meaning. In the third step, frequency is converted in AWT, and in step 5, TAT is converted back into a frequency (EDF). The above calculation includes three elements: walk time+ average waiting time (assumed to be half the headway) + reliability factor. TAT is now converted into a number that is comparable to service frequency that considers the additional walk time taken to reach the stop along with the reliability of the service (Abhay Chopde, 2016).

Calculating Accessibility Index (AI) for each POI:

Route with the highest frequency is assigned a weighting factor of 1 and for all the other routes, a weighting factor of 0.5 is assigned.

Table 4 PTAL grading standards

PTAL	Range of Index	Description
1a	0.01-2.50	Very poor
1b	2.51-5.0	Very poor
2	5.1-10.0	poor
3	10.01-15.0	moderate
4	15.01-20.0	Good
5	20.01-25.0	Very good
6a	25.01-40.0	Excellent
6b	40.01+	Excellent

Source- Transport for London (2010)

III. CASE STUDY

3.1. Public Transport inclusivity in Ahmedabad, India

The largest city in Gujarat and the state's capital, the city of Ahmedabad has city has two major bus public transport systems: the Ahmedabad Municipal Transport Service (AMTS) and the bus rapid transit system (BRTS) that runs on a dedicated right-of-way. The modal share in the city is 17% public transport (all buses) and 54% non-motorised transport (GIDB, 2001) implying that public transport remains unaffordable to a very high proportion of the population. As per 2011 census, 40% of Ahmedabad's population lives in informal settlements. The percentage of Ahmedabad housing categorised as slums stood at 26% in 1991 (UN-Habitat, 2003).

The city has most of its urban poor living in areas with high public transport accessibility (PTAL) yet 27% of the urban poor do not use public transport due to lack of first/ last mile connectivity; locations of bus stop is beyond comfortable walking distance from the origin/ destination.

This is important for urban poor who have variable job destinations, and are employed as construction workers, casual labourers, street vendors, etc.

They rely on non-motorised modes of transit. Thus, living in a higher PTAL area does not ensure higher connectivity to the desired destinations.

Though, the city has better public transport services than any other city, the public transport system in Ahmedabad can be made more inclusive, by improving the quality of infrastructure to enhance first/last mile connectivity, and introducing more high-frequency direct routes (Adhvaryu, B.,2019).

3.2. Mapping Public transport accessibility level (PTAL) in Surat, India

Improving accessibility with respect to population distribution is one of the ways to enhance a public transport system. PTAL methodology that helps correlate population spread can be easily applied to develop public transport accessibility mapping. Surat and London are examples where a well-developed PTAL methodology has been applied to create PTAL maps that provide a strong visual tool to assess the accessibility levels offered by existing transport systems (Transport for London, 2010). A PTAL map helps correlate accessibility levels with spatial distribution of population and serve as a guide in making strategic city-level decisions allowing planners to prioritise investments in public transport and supporting non-motorised transport (NMT) facilities. As NMT is key to the first and last mile connectivity, improvements made into it translate into better walk times, increasing the Accessibility Index (AI).

The city of Surat has a huge migrant population, most of which are dependent on public transport. The maps can help captive public transit users like urban poor to make more informed residential location choice. PTAL maps can help real-estate developers for locating affordable housing projects. Lastly, and most importantly, PTAL maps can be used by government agencies to prioritise sites having government-supplied low-income housing and hence address the agenda of social inclusion. The assessment can help inform urban and transport planning policy decisions in developing countries (Adhvaryu, B., Chopdeb, A. & Dashorac, L., 2019).

IV. RESULTS

The Public transport accessibility level (PTAL) for slum areas in Bhopal city is less than 5 in many of the areas, which corresponds to the 'poor' category. Although, PTAL for the posh neighborhood areas is also not appreciable but comparatively better. The highest PTAL for slums and a formal settlement was evaluated as 7.9 and 10 respectively, both lie in the core area of the city near CBD. In the peri-urban areas.

The table below shows PTAL calculations for the selected locations in Bhopal city. A and B denote the reference SAP locations. The PTAL level for both, the posh neighborhood areas and slums were found to be very low with poor connectivity and accessibility to public transit. The average waiting time for public transit services was estimated at around 6 minutes during peak hours with a frequency of 10 buses per hour. The majority of the slums are spatially in proximity to bus stops but the travel impedance affects their accessibility due to lack of pedestrian infrastructure, whereas for most of the posh neighborhood areas, the accessibility level was comparatively higher. The PTAL for posh neighborhoods and slums in Bhopal is mapped in the maps (1,2) shown below.

Table 5 Typical Accessibility Index Calculation sample: 1 (Kolar slum)

Mode	SAP	Distance (m) of SAP from POI	Frequency (per hour)	Reliability factor (k)	AWT (km/hr)	WT (min)	AWT (min)	TAT (min)	Weight	EDF (per hour)	AI
BRTS	A	700	10	3	4.8	8.8	6.00	14.8	1	2.0	2.0
	B	900	10	3	4.8	11.3	6.00	17.3	0.5	1.7	0.9
											2.9

Source- Primary survey

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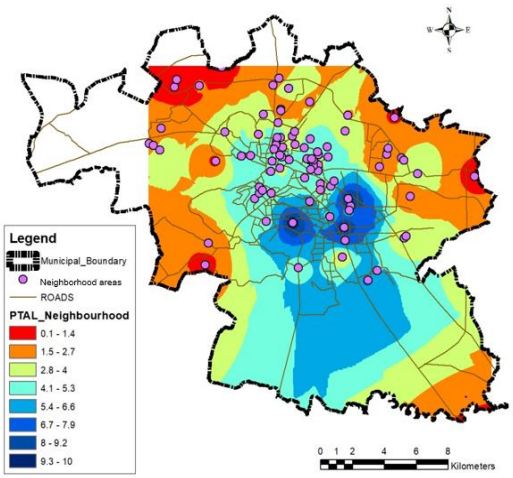
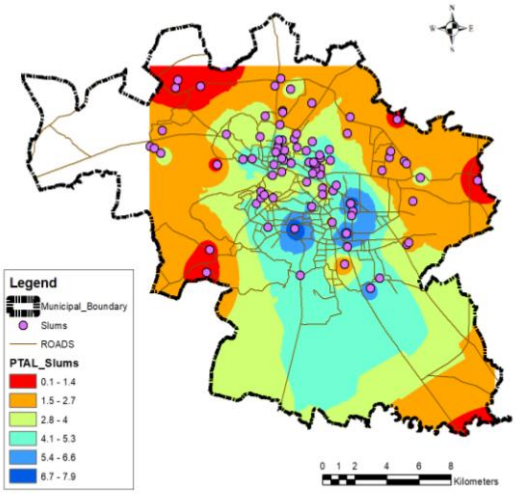


Map 1 PTAL for posh neighborhood areas in Bhopal



Map 2 PTAL for slums in Bhopal

Source- Primary survey

V. DISCUSSION ABOUT UNDERSTANDING THE MOBILITY NEEDS OF THE SLUM DWELLERS IN BHOPAL

As per the qualitative study conducted during the primary data collection, it was assessed that slum dwellers were unhappy with the reliability and location of transit stops from their residence. Some of the slum dwellers owned 2-wheelers and use it for daily commute as they were not satisfied with the Public transport services, even though this increase their cost of traveling directly, which affects the cost of living. Slum-dwellers were even ready to pay a hiked fare price if the current services improve and were ready to shift towards public transit against their prevailing private mode of travel. Most of the slums are located near expensive residential areas but the setting of the bus stop was near to residential colonies. The major issues for slum dwellers were the frequency, scheduling, and service quality of public transit.

Scheduling of route, Timing, frequency of bus services, and service quality which relates to maintaining ace of bus services is also an important aspect for them. Even if the paying capacity of a different class of people differs, their expectation for good services still plays a vital role when selecting a mode to travel.

VI. CONCLUSION

The present study concludes that GIS mapping can be used to assess and represent the availability of public transit spatially. PTAL maps does not only help assess PTAL but may be of aid to real-estate developers for locating affordable housing projects and to government agencies for prioritizing sites with government-supplied low-income housing. The assessment can also help urban and transport policy decision makers to make evidence based policies in developing countries. The obtained PTAL map showed that for the city of Bhopal, PTAL is quite low for the identified residential areas in Bhopal. The map highlighted that most of the slums have low PTAL compared to posh locations which experience comparatively better accessibility levels. Discussions with slum dwellers further reveal that a lack of pedestrian infrastructure leads to an increased walking time and travel impedance for them. The frequency of buses, scheduling, routing and service quality are other major issues which affect their mode choice. In order to improve accessibility levels of public transport, there is a need to work around the identified causes to encourage inclusivity.

The maintenance system of buses is another major lacuna that require intervention by the authorities to ensure a more efficient and comfortable ride. The case of Ahmedabad city shows similar scenario highlighting that existing public transport services can be made more inclusive by investing in the quality of infrastructure and introducing more high-frequency direct routes. There is a need for route rationalization plan to be modified to minimize the travel time for slum dwellers by keeping their purpose, trip length, and place of attraction into account.

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