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Service Area Analysis for Determining the Accessibility to Bus Stops - A Case of Daund, Indapur and Baramati of Pune District

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Abstract: ***Public transportation plays a vital role in the daily lives of millions of people in India, providing an affordable and convenient mode of travel. However, the accessibility of bus stops, the crucial starting point for public bus journeys, remains a significant concern. Accessibility is one of the most important outcomes of the transportation system. Public transport accessibility has gained vital importance in designing and evaluating the transit system in terms of mobility, and sustainability and has gained a considerable impact on life satisfaction in the form of perceived accessibility. Moreover, researchers have revealed several impacts and correlations of the provision of public transport accessibility to the environment and daily life. Therefore, the purpose of the study is to determine the service areas of bus stops in three taluks of the Pune district namely the Daund, Indapur and Baramati with specified impedance i.e., travel time using the ArcGIS Network Analyst tool. Through this study, the non-served areas can be identified and considered as critical zone that can be superimposed with various parameters to find an optimum location of additional facilities that would improve the public transportation system in the study region.***
Keywords: Service Area, Public Transportation, Spatial Analysis, Accessibility, Bus Service Efficiency, Travel Time.

I. INTRODUCTION

Public bus transport is the predominant mode of motorized local travel in some of the cities in India. As it reduces traffic congestion, public transportation is a crucial part of a sustainable transportation system. A city's health can be strongly predicted by its urban transportation system as public transportation can carry more passengers per hour than any other form of transportation and it offers long-term resource consumption sustainability. Meeting demand throughout an area is a very effective way to move big crowds of people. All community members, wealthy and poor alike, should consider a public transportation system as a highly desirable form of transportation rather than as a "second choice" mode of transportation. In all respects, the public transportation system can be viewed as a substitute for private motorized traffic as a means of transportation.

Public buses offer an economical means of travel compared to private vehicles or other modes of transport like taxis and auto rickshaws. Buses typically have lower fares, making them more affordable for a wide range of people, including students and lower-income groups. In terms of connectivity, public buses provide connectivity, both within cities and across different regions of India facilitating travel between cities and towns and supporting intercity and interstate mobility. They serve as an important mode of transportation for daily commuters, connecting residential areas with commercial centres, educational institutions, healthcare facilities, and other essential services. Buses also therefore, providing a public transportation system that only serves those with restricted opportunities is neither fair nor viable. In addition to being crucial for satisfying the mobility needs of this fast-expanding economy, a greater use of buses would also cut energy consumption and local and global pollution. In Indian cities, buses make up more than 90% of the public transportation system and are a practical and affordable method of transportation for all social strata.

II. SERVICE AREA ANALYSIS

Service area analysis refers to the assessment of the geographical coverage and reach of a particular service, in this case, bus stops. The general factors considered for performing service area analysis are: the distance passengers are willing to travel to reach a bus stop, availability of connecting routes and transportation modes from the bus stop, surrounding land uses that determines the demand for transportation services and demographic characteristic and specific needs. Performing service area analysis would facilitate in identifying gaps in bus stop coverage, especially in underserved or remote areas, determining the percentage of the population within a specific radius of a bus stop, analysing the accessibility of bus stops to key destinations, and assessing the availability and efficiency of connecting routes and transportation modes.

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III. FORMULATION OF OBJECTIVES, SCOPE, AND LIMITATIONS

A. Objectives

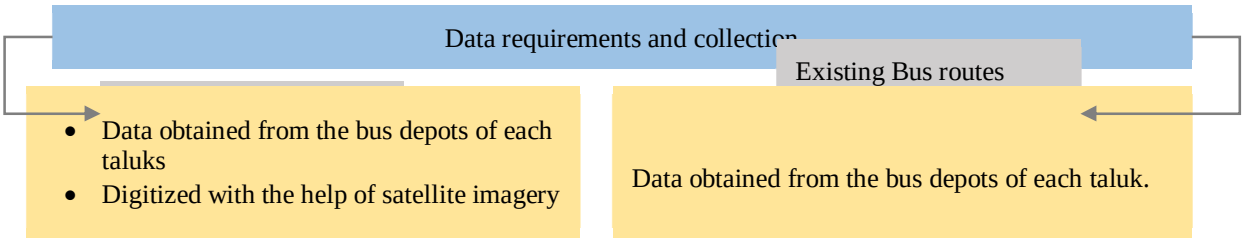
1) To identify the underserved areas which can target their resources to improve service in those areas.
2) To reduce travel time and increase the reliability of public transportation through Route Optimization
3) Increasing ridership by improving the coverage of public transportation system

B. Scope

The scope is limited only to the three taluks of Pune district i.e., Daund, Indhapur & Baramati .

C. Limitations

1) Assumes that people will travel to the closest facility offering a service & the service being analysed is the only provider in the area.
2) Focuses only on the geography of the service area.
3) Applicability is limited only for analysing services that have a fixed physical location i.e., bus stops



IV. INTRODUCTION TO STUDY AREA

The study area is in the three sub-regions or taluks i.e., Baramati, Indapur, and Daund of Pune district in Maharashtra state with a population of 1193279 according to the 2011 census. It has an area of 4325 sq. km with a population density of 277 people per sq.km. It has 3 municipal councils and 329 villages. The major national highway NH 65 passes through the study area, connecting the region with other states and cities and providing internal connectivity to municipalities and MIDCs. Major district roads and other district roads provide taluka-level connectivity, and the village roads and internal roads connect the villages. However, the region will need more effective transportation networks to support the movement of people and commodities with a reduction in travel time and cost, resulting in increased regional competitiveness.



Fig. 1 Study Area

V. PUBLIC TRANSPORTATION SYSTEM IN THE STUDY AREA

At the district level, public transport in PMR consists of bus and rail-based nodes of transport for mobility. The city bus service provided by PMPML serves the city centre and suburbs up to 20 km from PMC and PCMC boundaries. The annual ridership for PMPML services has declined from around 420 million passengers in 2013 to about 390 million passengers in 2016. The decreased ridership can be attributed to the shift to private vehicles. Long-distance PMPML bus routes operate at a lower than 2-hour frequency due to less ridership.

MSRTC popularly known as ST (State Transport), from its three main bus stations in Shivajinagar, Pune Station and Swargate provides intercity bus services for passengers travelling outside Pune. Public transport coverage is primarily concentrated in PMC and PCMC jurisdictions. From the latest statistics, an average of 0.3 million passengers travelled on MSRTC services with a fleet of over 18,000 buses.

At the regional level, the tentative passenger in and out per day is 15,000 with an average fleet utilisation of 96%. Public transport coverage is limited to only national highways and some major roads. Lack of demand for buses due to high dependency on private vehicles, company buses for daily commute to and between home and office adds to congestion. Thus, to improve the public transport coverage in the region, the major focus needs to be on developing residential and employment centres around the rail and road-based infrastructure provisions ((PMRDA, 2021).

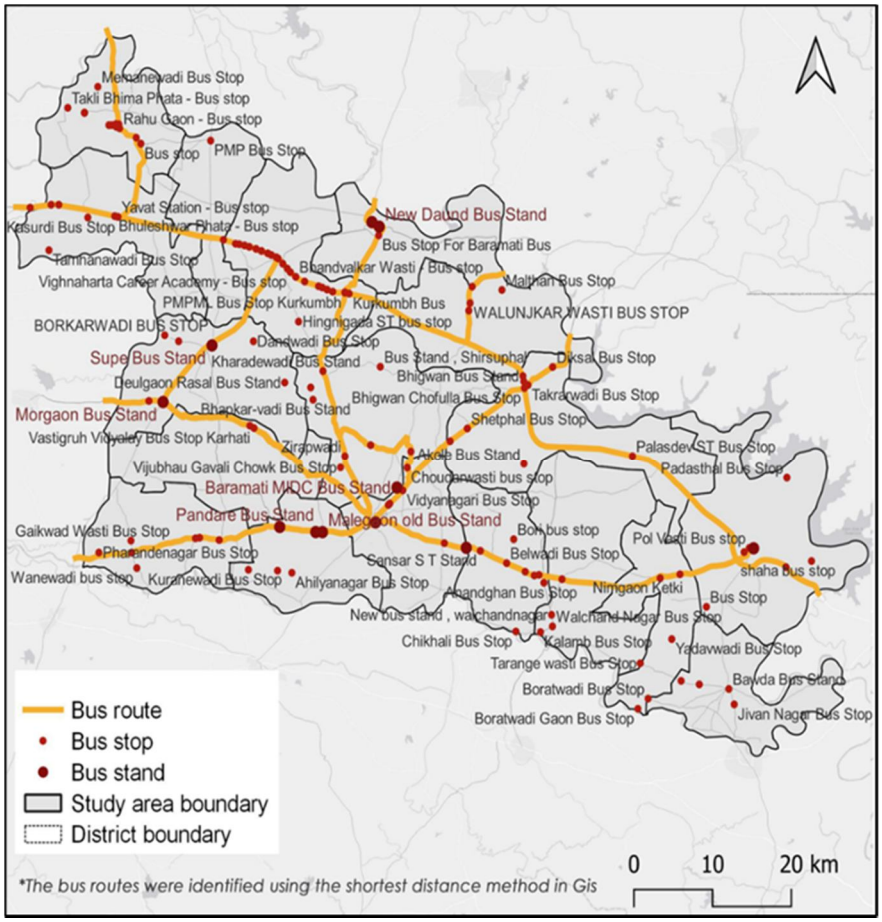


Fig. 1: Bus Stops And Bus Routes in Baramati,Daund and Indapur
Source: Authors

VI. NETWORK SERVICE AREA ANALYSIS

Service Area Analysis

1. Input Data- Point Feature The input data here is the bus standpoint feature layer, for which the influence area has to be identified

2. Mode, Direction & Cut-off, Distance/ Time Cut-off- mention the benchmark time or distance to be generated Layer Properties window > Analysis (travel time zones i.e., within 1, 2, 3, 4, ...10,15 minutes were defined)

3. Identification of critical zone the area that does not fall under the services area- Critical zone
the extend of coverage of each facility in terms of accessibility is identified

A. Analysis Tools and Methodology

The data for this study were gathered from a variety of sources. The road network used in the study was captured from satellite images (Google Earth) and geo-referenced with corresponding SOI toposheets. The bus stop coordinates were collected using satellite imagery and fed into a GIS environment. Following the creation of layers for bus station location and road network, the service area dataset for each station was created in ArcGIS using the Network Analyst tool. Finally, inferences are drawn to determine the best locations for new bus stations.

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VII. FINDINGS AND DISCUSSION

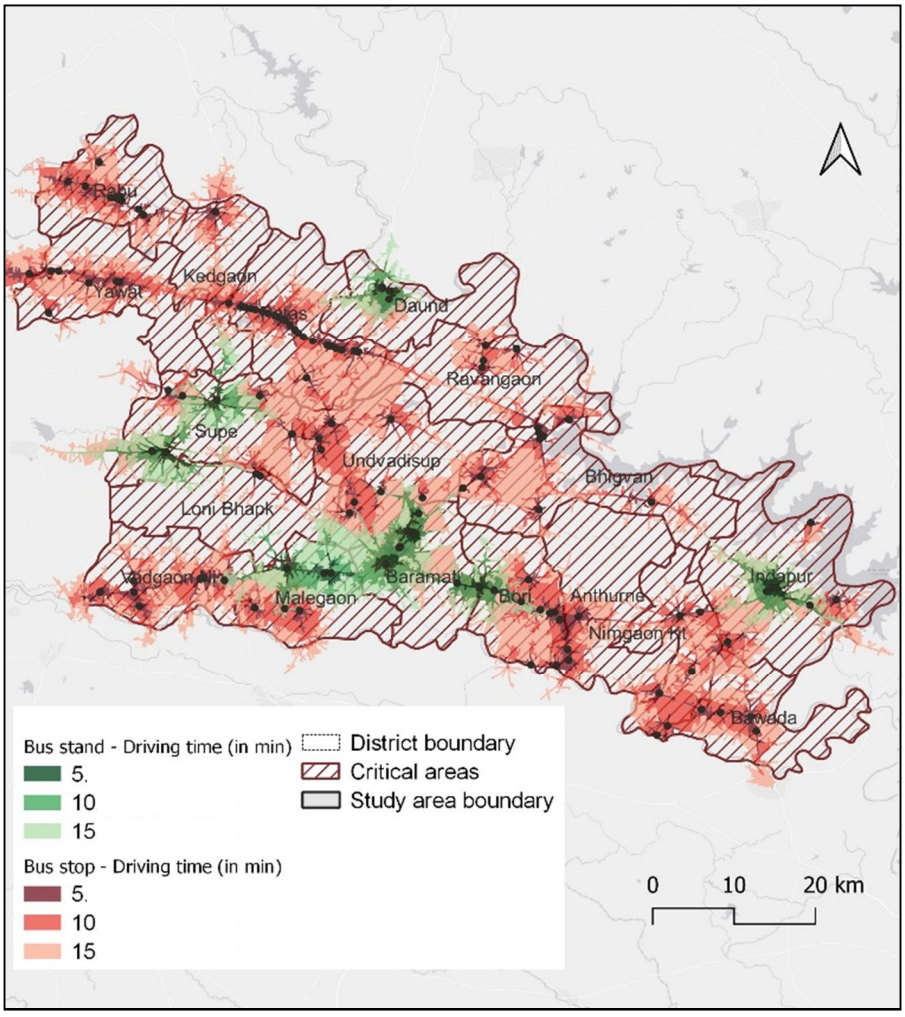


Fig. 3 : Service Area Network Map
Source: Authors, 2022

A network service area is a regional area that includes all accessible streets (that is, streets that are within specified impedance). These service areas allow us to assess accessibility from the bus station in various directions. Travel time zones, i.e., within 5,10,15 minutes, were defined to identify the bus station's service area by using assumed drive time as impedance. Drive time was calculated for the current study using the assumption of 60 km/h for highways and 30 km/h for other street roads.

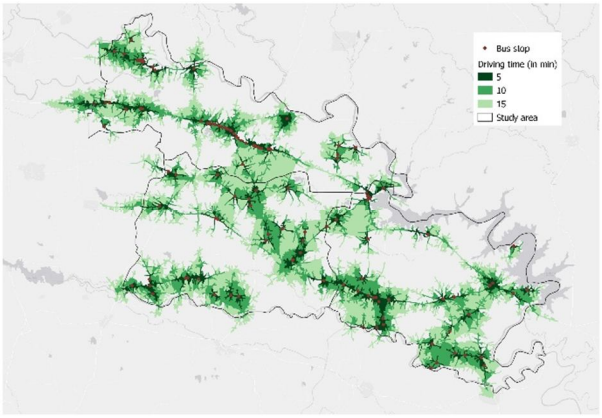


Fig. 3. Service Area Network Map for Bus Stops
Source: Authors, 2022

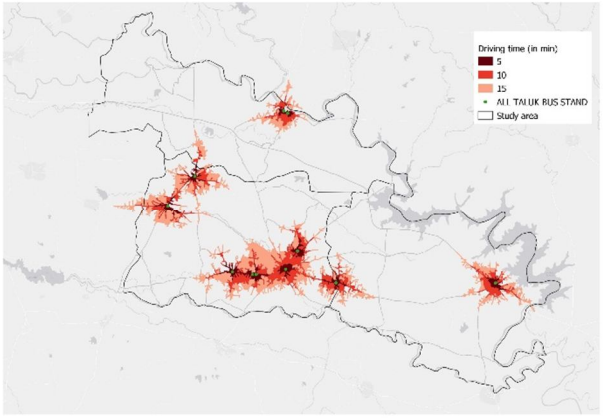


Fig. 4. Service Area Network Map for Bus Stands
Source: Authors, 2022

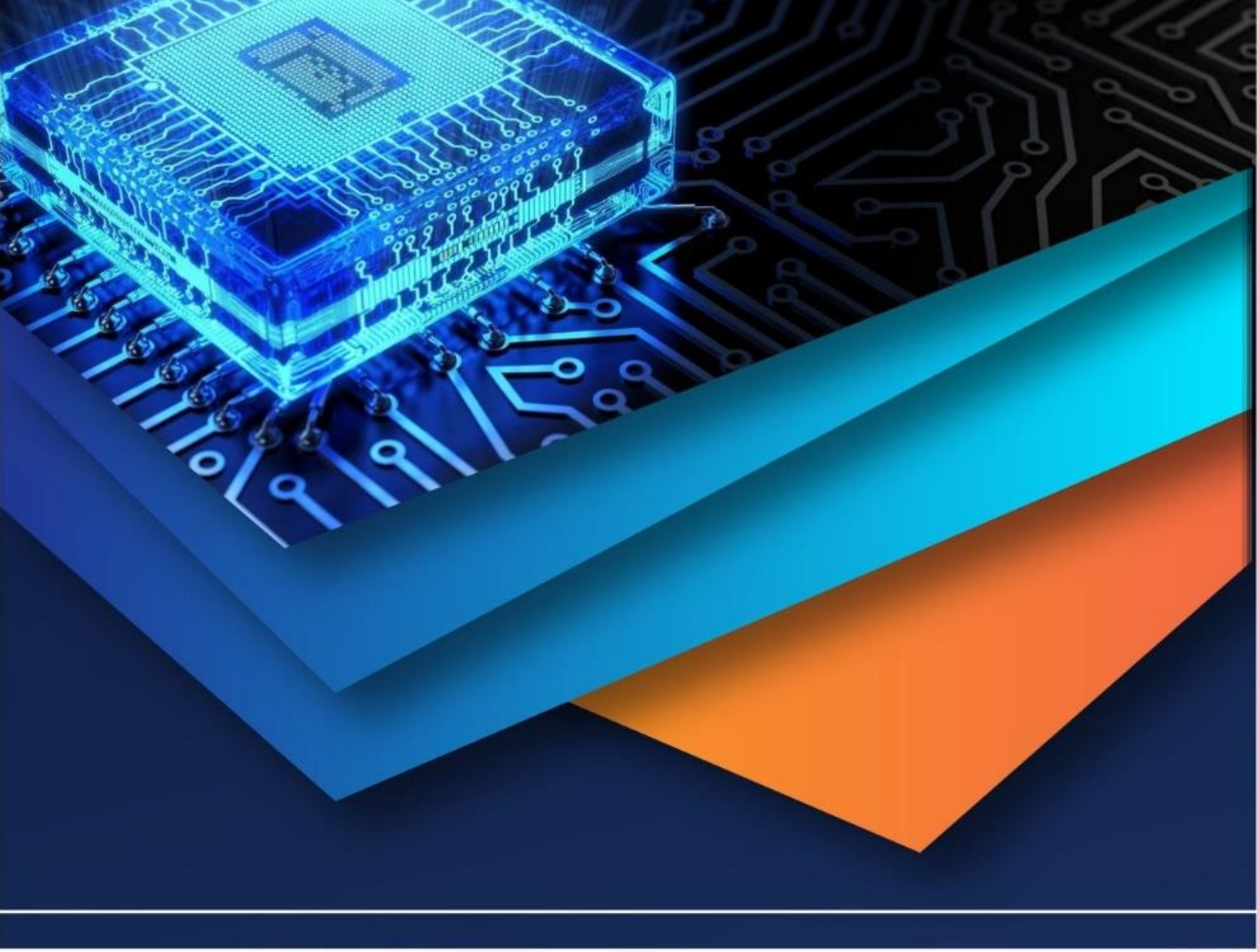
For example, a station's 5-minute service area includes all streets that can be reached in five minutes from that bus station. These are typically generated as a polygon layer overlaid on the network, indicating travel time bands constructed around station locations. Each zone was distinguished by colour schemes, and areas that did not fall within these zones were designated as critical areas where station service was inefficient. Travel time zones were defined to identify the station's service area by using assumed drive time as impedance. From the analysis, it can be inferred that the coverage of bus stops and bus stands in 5–15-minute drive time is relatively lesser and around 75% of the area falls under the “critical area” (refer to fig.3) category, where the bus stops service is inefficient and inaccessible by 5–15-minute drive. Lengthy drive times can discourage individuals from using public transportation which may result in making the citizens opt for the convenience of using their private vehicles instead. This can lead to decreased ridership on public transportation systems, potentially undermining efforts to promote sustainable transportation. This may also make public transportation less accessible, particularly for individuals who do not own private vehicles or those who are unable to drive, such as younger individuals, seniors, or people with disabilities. Limited access to public transportation can lead to social exclusion, reduced mobility, and difficulties in accessing essential services and opportunities. Addressing the impacts of increased drive time to public transportation stops requires a comprehensive approach, including strategies such as improving the efficiency and coverage of public transportation networks.

VIII. CONCLUSION

From this study, the area that is under non served were identified and it shows that the regions of Indapur are highly critical when compared to the other two taluks, i.e., Daund and Baramati, this would be helpful in locating new bus stops to mitigate the insufficiency of facilities. This study uses GIS to analyse, assess, and plan for service accessibility problems in a more efficient manner than was previously possible. The main advantage of using GIS is its ability to analyse spatially distributed data, which other database management systems cannot do. The result of the study is also useful to measure how many minutes are needed to access any point in the study area from any one of the bus stations. The database generated in the study could also be used for identifying the shortest path between existing bus stops and the new bus stops that can be proposed or identified in the critical zones. This will enable the traveller to find out the destination through optimal routing. There are additional opportunities to optimise the decision-making process by taking demographic and other causal factors into account in conjunction with network-based service area analysis.

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