

Evaluation of BMTC Initiatives on Modal Share



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- 1. Impact of Metro on Bus Ridership**
- 2. Feasibility of New Routes for High-end AC Buses**
- 3. Impact of Cab Aggregators on Vayu Vajra Services**
- 4. Improvement and Extension of Chartered Bus Services**
- 5. Exploring Potential of BMTC Land Resources**

Final Report

Submitted by: Center for Study of Science, Technology and Policy (CSTEP)

For: Bengaluru Metropolitan Transport Corporation,

Funded by: Planning Department, Government of Karnataka

September, 2018

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Designing and Editing by CSTEP

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September, 2018

Center for Study of Science, Technology and Policy

#18, 10th Cross, Mayura Street,

Papanna Layout, Nagashettyhalli, RMV II Stage,

Bangalore-560094 Karnataka, INDIA

Tel.: +91 (80) 6690-2500

Fax: +91 (80) 2351-4269

Email: cpe@cstep.in

Website: www.cstep.in

Background to the Study

About Bengaluru

Bengaluru, the capital of Karnataka, is one of the fastest growing metropolitan cities in India. It is home to major information technology companies, public sector undertakings and major educational and research institutions. The city of Bengaluru has an area of 741 sq. km. with a population of 8.52 million (Census of India 2011). In 2001, Bengaluru's area was 531 sq. km. and population was 5.10 million. Bengaluru has experienced rapid population and urban growth during the last decade (2001-2011).

With rapid urbanisation and population growth, there is a huge demand for improving urban infrastructure, of which public transport is critical. In Bengaluru, as per a study conducted by the Directorate of Urban Land Transport, 27% of all trips are by public transport, 31% of the trips are by two-wheelers and cars, 35% of the trips are by non-motorised transport (walk and bicycle) and 7% by intermediate public transport (autos and taxis) (DULT 2010).

About BMTC

Bengaluru Metropolitan Transport Corporation (BMTC) provides public transport bus services to Bengaluru metropolitan region. BMTC tries to keep pace with the changing urban mobility demand by operating various services such as chartered services, Vayu-Vajra services, Vajra services and ordinary services.

BMTC operates 6,383 buses and carries approximately 5.02 million passengers daily, generating a revenue of INR 5.76 crore per day (BMTC 2017). The gross revenue for BMTC in 2016-17 was INR 2,106 crore, of which traffic revenue contributed to INR 1,770 crore (~84%), while non-traffic contributed to INR 336 crore (16%).

In the recent past, BMTC has seen a reduction in ridership and revenue on account of competition from other modes. The introduction of the Metro Rail and cab aggregators has seen key BMTC corridors being financially affected. In order to assess the impact of other transport modes on BMTC ridership, this study focused on the impact of the Metro on BMTC operations, and the impact of cab aggregators on BMTC airport bus services.

BMTC also aims to increase its revenue through expansion of its AC bus services, monetisation of its land resources and increasing its presence for shared mobility (chartered/dedicated bus services). This study also analyses the feasibility of new AC bus services, suggests measures

to monetise land resources and proposes a financial model for increasing revenue from chartered/dedicated services.

In order to carry out the study, Government of Karnataka has engaged Center for Study of Science, Technology and Policy (CSTEP) as a technical research institution. Karnataka Evaluation Authority (KEA) has been appointed as the coordinating and nodal agency to ensure timely completion of this work.

Acknowledgement

Center for Study of Science, Technology and Policy expresses deep gratitude to Government of Karnataka for its support in conducting this study.

We would like to thank Bengaluru Metropolitan Transport Corporation (BMTC) officials Shri. V. Ponnuraj, MD, Shri. Biswajit Mishra Ex-IT Director, Shri. K. R. Vishwanath, CTM (O), Shri. Chandrasekhar M.S., DTO (O), Shri. Bailappa, DTO (C), Smt. Sabeena Begum, DTO (ITS) and other BMTC staff for sharing the required data and extending their support all through the project.

The authors are grateful to Bangalore Metro Rail Corporation Limited (BMRCL) officials Shri. Pradeep Singh Kharola, Ex-MD, and Shri. U. A. Vasanth Rao, GM, Finance (Taxation and Resource) for sharing the required data and granting permission to conduct survey at the Metro stations.

We would further like to thank Shri. Sanjay Chandra, Assistant Manager (Landside Traffic), Kempegowda international airport to grant permission to conduct the required survey at the airport and Commissioner of Police, Bengaluru city, to grant permission to conduct the required survey at different locations in the city.

We appreciate efforts of CSTEP colleagues Dr Gaurav Kapoor and Ms Shrimoyee Bhattacharya for the technical review and Ms Merlin, Mr Devaditya and Mr Abhinav for the editorial review and Ms Aswathy for graphical support.

We express gratitude to Dr Anshu Bharadwaj, Executive Director, CSTEP, Dr Jai Asundi, Research Coordinator, CSTEP and Mr Thirumalai N.C., Project Manager, CSTEP, for their constant encouragement and support throughout the project.



Initiative 1: Impact of Metro on Bus Ridership

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Abbreviations and Acronyms

Abbreviations	Full Form
BDA	Bengaluru Development Authority
BMRCL	Bangalore Metropolitan Rail Transport Corporation
BMTC	Bengaluru Metropolitan Transport Corporation
CSTEP	Center for Study of Science, Technology and Policy
ETM	Electronic Ticketing Machine
GIS	Geographical Information Systems
HB	High Boarding
IVTT	In Vehicle Travel Time
KBS	Kempegowda Bus Station
KEA	Karnataka Evaluation Authority
KSRTC	Karnataka State Road Transport Corporation
LB	Low Boarding
O-D	Origin Destination
ODK	Open Data Kit
RMC	Regulated Market Committee
RP	Revealed Preference
SP	Stated Preference
SRS	Simple Random Sampling

Executive Summary

Bengaluru Metropolitan Transport Corporation (BMTC), which started operations in 1997, was the only public transport service provider for urban, sub urban and rural areas of Bengaluru. It was one of the very few profit making state transport undertakings in India, until three years ago. More recently, with the completion of Phase I of Metro by Bangalore Metro Rail Corporation Limited (BMRCL), a new rapid mass transportation system is now available for Bengaluru.

The complete Phase I (East–West and North–South corridors) of Metro started operations in 2017. With the introduction of this new mode of public transport, commuters have shifted from BMTC bus to Metro. BMTC has taken up several initiatives to reduce the impact of this shift by re-routing the existing bus services, introducing new feeder routes, extending operations beyond Metro reach and reducing the number of schedules.

However, BMTC would like to understand the full impact of the Metro on its operations, through a scientific study, towards which the Center for Study of Science, Technology and Policy (CSTEP) has carried out a detailed research.

For assessing the impact of Metro on BMTC ridership, CSTEP conducted a Metro passenger opinion survey at 12 select Metro stations. The study identified the commuter's reasons for shift from bus to Metro and also identified impacted routes. For the impacted routes identified, revenue and ridership analysis was carried out to understand the most impacted stretch along the identified routes.

The study revealed that 38% of the respondents shifted from BMTC to Metro. The majority of these commuters are in close proximity (< 2km) to the Metro station. The results indicate that the major reason for shift from BMTC to Metro is due to reduction in travel time and to avoid traffic congestion.

With the completion of Metro Phase I, and with current Metro Phase II construction, it is important for BMTC to reduce the number of schedules running parallel to Metro corridors. These buses could be redeployed in corridors which witness heavy demand for BMTC services, in BMTC underserved areas and in Metro influence areas as feeder services

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1. Introduction

Till 2011, BMTC was the sole public transport provider for the city of Bengaluru. However the Metro rail operations started in 2011 and full operation of Phase I commenced in 2017. As of 2016-17, BMTC witnessed a decrease in service kilometres provided, from 12.21 lakh km per day in 2015-16 to 11.52 lakh km per day. A component of this reduction of ridership and revenue may be attributed to the introduction of new transport options in the city.

This study aims to understand the nature of this shift from BMTC services to Metro, the reasons for this shift and the impacted bus routes in terms of ridership.

2. Log Frame/Theory of Change/Programme Theory

Till 2011, BMTC was the primary public transport service provider for Bengaluru city. In 2011, the Bangalore Metro Rail Corporation Limited (BMRCL) commenced operations of Metro. Since Phase I Metro (Mysore Road to Baiyappanahalli and Nagasandra to Yelachenahalli) commencement in June 2017, the city has two major public transport service providers: BMTC and BMRCL.

With the Metro operating on high density traffic corridors, BMTC witnessed a change in ridership. Hence this study aims at identifying the impacted routes and assessing the changes in ridership.

	Intervention Logic	Verifiable Indicators of Achievement	Sources and Means of Verification	Assumptions
Overall Objectives	<p><i>What are the overall broader objectives to which the activity will contribute?</i></p> <ul style="list-style-type: none"> Assessing the impact of Metro on BMTC's bus ridership 	<p><i>What are the key indicators related to the overall objectives?</i></p> <ul style="list-style-type: none"> Percentage change in ridership for the identified bus routes before and after commencement of Metro Phase I operations 	<p><i>What are the sources of information for these indicators?</i></p> <ul style="list-style-type: none"> Primary survey of Metro passengers Secondary data of affected routes 	
Specific Objectives	<p><i>What specific objective(s) is the activity intended to achieve to contribute to the overall objectives?</i></p> <ul style="list-style-type: none"> To identify percentage shift from BMTC bus to Metro To identify impacted BMTC bus routes 	<p><i>Which indicators clearly show that the objective of the activity has been achieved?</i></p> <ul style="list-style-type: none"> Percentage of previous bus-using respondents who now use the Metro BMTC routes experiencing maximum number of respondents shifting to Metro Percentage change in ridership of these routes post Metro 	<p><i>What are the sources of information that exist or can be collected? What are the methods required to get this information?</i></p> <ul style="list-style-type: none"> Primary survey (Metro passenger opinion survey at Metro stations) Secondary data (ridership and revenue data for the routes identified) 	<p><i>Which factors and conditions outside the PI's responsibility are necessary to achieve that objective? (external conditions)</i></p> <p><i>Which risks should be taken into consideration?</i></p> <ul style="list-style-type: none"> Willingness of competent authority to permit the survey Willingness of competent authority to share the required data

<p>Expected Results</p>	<p><i>The results are the outputs envisaged to achieve the specific objective.</i> <i>What are the expected results? (enumerate them)</i></p> <ul style="list-style-type: none"> • Percentage shift from BMTC bus to Metro • List of impacted BMTC bus routes due to this shift • Reasons for shift • Change in ridership for impacted routes 	<p><i>What are the indicators to measure whether and to what extent the activity achieves the expected results?</i></p> <ul style="list-style-type: none"> • Previous mode of travel • Previous bus users route no. • Revenue and ridership data for the impacted routes pre and post Metro 	<p><i>What are the sources of information for these indicators?</i></p> <ul style="list-style-type: none"> • Primary survey (Metro passenger opinion survey at Metro stations) • Secondary data (ridership and revenue data for the routes identified) 	<p><i>What external conditions must be met to obtain the expected results on schedule?</i></p> <ul style="list-style-type: none"> • Willingness of competent authority to share the data
<p>Activities</p>	<p><i>What are the key activities to be carried out, and in what sequence, in order to produce the expected results?</i> <i>(group the activities by result)</i></p> <ol style="list-style-type: none"> 1. Primary Survey – Metro passenger opinion survey at select Metro stations 2. Identifying the previous bus using passengers 3. Identifying impacted routes due to this shift 	<p><i>What are the means required to implement these activities, e. g. personnel, training, studies, etc.</i></p> <ul style="list-style-type: none"> • Survey experts • Transport planning experts 	<p><i>What are the sources of information about action progress?</i></p> <ul style="list-style-type: none"> • Date and time captured during the primary survey • CSTEP supervision during primary survey • Regular follow up with BMTC & BMRCL on secondary data 	<p><i>What pre-conditions are required before the action starts?</i></p> <ul style="list-style-type: none"> • Permission by competent authorities to conduct the survey • Willingness of competent authority to share the required data

3. Progress Review

For this section, the base data for comparison are the pre-Metro bus revenue and ridership details of the impacted routes. However, as the two corridors (East-West & North-South) of the Metro started operations over a period of time, the timeline has been divided into two timeframes (pre Metro operations and post Metro operations).

4. Problem Statement

To understand the impact of Metro Phase I operations on BMTC's bus ridership.

As stated above, until Metro was operational, BMTC was the sole public transport service provider in Bengaluru. It is expected that after commencement of Phase 1 Metro operations, there could be some impact on BMTC ridership. This study aims to estimate and understand Metro's impact on BMTC's ridership in order to enable BMTC to plan future operations.

5. Objectives and Issues for Evaluation

Objectives:

- To assess the potential impact of Metro operations on BMTC bus ridership
- To identify the impacted routes due to shift from bus to Metro

Scope:

- Geographical coverage - East West and North South Phase I Metro corridors
- Target population - The target population for this study are the Metro passengers.

6. Evaluation Design

6.1. Information Sources

For this evaluation, both primary as well as secondary data collection methods are considered.

The information sources for secondary data were:

- BMTC – Ridership and revenue data for the impacted routes
- BMRCL – Boarding and alighting data for the Metro stations
- Bengaluru Development Authority (BDA) Revised Master Plan, 2015

A gap analysis between the data requirements for the study and the data available from the secondary sources was carried out to derive the type and quantum of surveys to be undertaken. Based on the same, the following primary survey was planned:

- Metro passenger opinion survey

This survey was conducted at selected 12 Metro stations along both East-West and North-South corridor to assess the impact of Metro on BMTC operations. Details of the survey are given in Table 1.

Table 1: Primary survey details

Type of Survey	No. of Locations and Sample Size	Mode of Data Collection	Date of Survey
Metro passenger opinion survey	12 Locations 2,312 Samples	Open Data Kit (ODK) App based survey	20 th February - 28 th February 2018

6.2. Evaluation Criteria or Indicators

The evaluation criteria for impact assessment of Metro on bus ridership are:

- Percentage of passengers shifting from BMTC bus to Metro (estimated from the Metro passenger opinion survey)
- Changes in the ridership and revenue of impacted routes (from ridership and revenue data from BMTC).

7. Evaluation Methodology

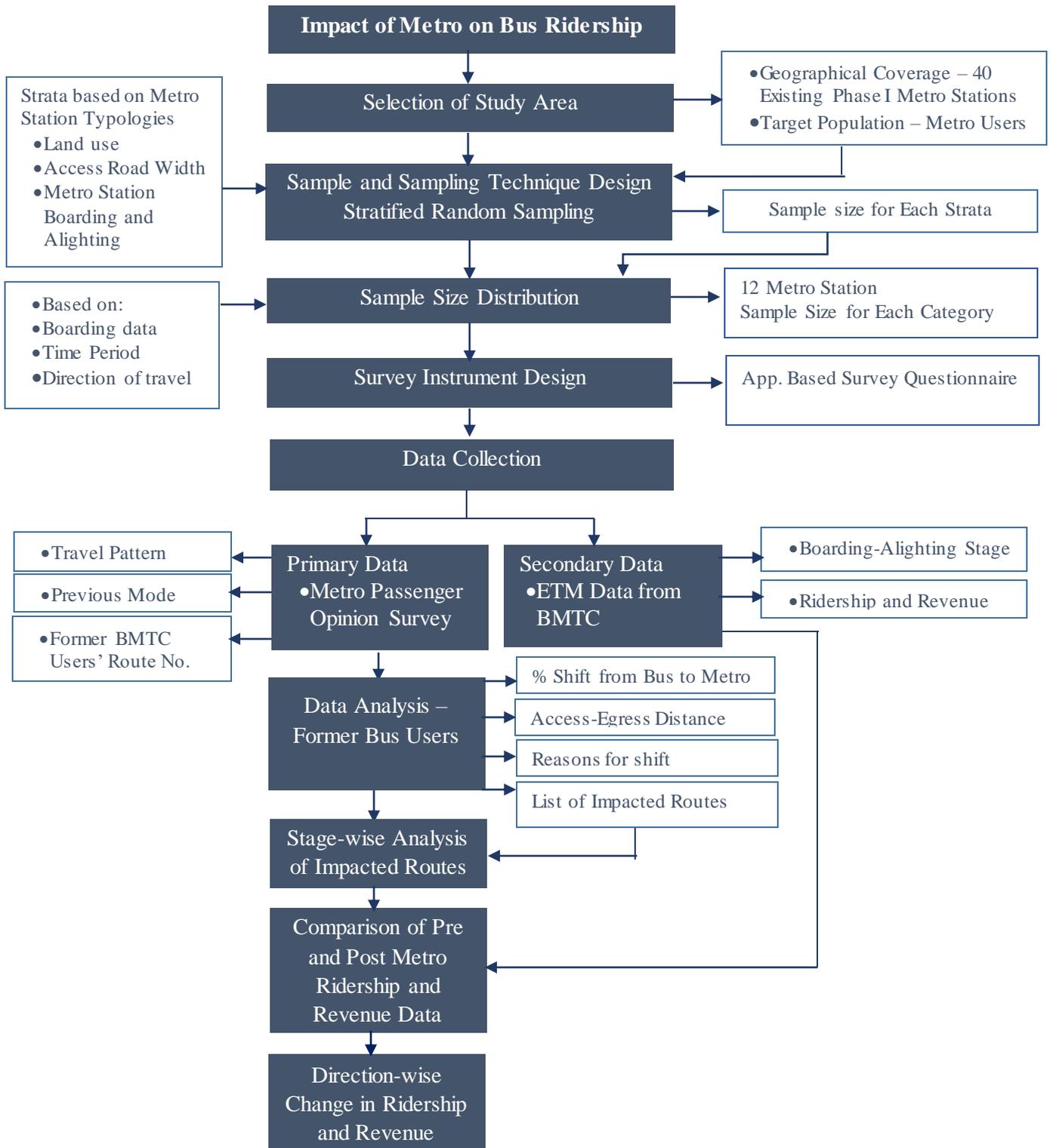


Figure 1: Methodology for assessment of impact of Metro on BMTC bus ridership

7.1. Sample and Sampling Design

7.1.1. Stratified Random Sampling

A stratified random sampling technique was used to arrive at an appropriate sample size at each Metro station. The existing 40 Metro stations were stratified based on the parameters given below:

1. Land-use in 500m radius of the Metro station
2. Access road width
3. Boarding type (high and low boarding).

The six station typologies are described below:

Type 1 – Transport hubs which are connected with other public transport modes in the vicinity

Type 2 – Metro stations which are located in predominantly residential areas, with high boarding and access road width in the range of 30 to 80 metres

Type 3 – Metro stations which are located in predominantly non-residential areas, with high boarding and access road width of 30–50 metres

Type 4 – Metro stations which are located in predominantly residential areas, with high boarding and access road width of 12–30 metres

Type 5A – Metro stations which are located in predominantly residential areas, with low boarding and access road width of 30–80 metres

Type 5B - Metro stations which are located in areas of mixed-land use, with low boarding and access road width of 30–80 metres

Type 6 – Metro stations which are located in predominantly residential areas, with low boarding and access road width of 12–30 metres.

Metro station typologies are given in the Table 2 below:

Table 2: Metro station typologies

Station Name	Predominant Land Use					Access Road Width			Boarding Data		Type
	Residential	Commercial/ Public-Semi- Public	Industrial	Transport	50 m – 80 m	30 m – 50 m	12 m – 30 m	HB	LB		
Majestic	Yellow	Blue		Grey			Light Blue	Orange		1	Transport Hubs
Yeshwanthpur	Yellow	Blue	Purple	Grey	Dark Blue			Orange			
Baiyappanahalli	Yellow		Purple	Grey	Dark Blue			Orange			
City Railway Station	Yellow	Blue		Grey			Light Blue		Light Orange		
Nagasandra	Yellow		Purple		Dark Blue			Orange		2	High Residential, 30-80 m Road, HB
Dasarahalli	Yellow		Purple		Dark Blue			Orange			
Yelachenahalli	Yellow		Purple			Blue		Orange			
Rajajinagar	Yellow					Blue		Orange			
Banashankari	Yellow	Red				Blue		Orange			
J. P. Nagar	Yellow	Red				Blue		Orange			
Vijayanagar	Yellow					Blue		Orange			
Trinity	Yellow	Blue				Blue		Orange		3	Non-Residential, 30-50 m Road, HB
Sandal Soap Factory	Yellow	Red	Purple			Blue		Orange			
M.G.Road	Yellow	Blue with 'ii'				Blue		Orange			
Mysore Road	Yellow	Red				Blue		Orange		4	Residential, 12-30 m Road, HB
National College	Yellow	Red					Light Blue	Orange			
Southend Circle	Yellow						Light Blue	Orange			
R.V. Road	Yellow						Light Blue	Orange			
Indiranagar	Yellow						Light Blue	Orange			
Sampige Road	Yellow	Blue					Light Blue	Orange			
Vidhana Soudha	Yellow	Red with 'ii'					Light Blue	Orange			
Sir M. Visveshwaraya	Yellow	Red with 'ii'					Light Blue	Orange			

Station Name	Predominant Land Use				Access Road Width			Boarding Data		Type	
	Residential	Commercial/ Public-Semi- Public	Industrial	Transport	50 m – 80 m	30 m – 50 m	12 m – 30 m	HB	LB		
Hosahalli	Residential					30-50 m			Low Boarding (LB)	5 A & 5 B	Residential, 30-80 m Road, LB
Deepanjali Nagar	Residential		Industrial			30-50 m			Low Boarding (LB)		
Mahalakshmi	Residential	Commercial/ Public-Semi- Public				30-50 m			Low Boarding (LB)		
Halasuru	Residential					30-50 m			Low Boarding (LB)		
Attiguppe	Residential					30-50 m			Low Boarding (LB)		
Jalahalli	Residential		Industrial		50-80 m				Low Boarding (LB)	6	Mixed Land Use, 30-80 m Road, LB
Peenya Industry	Residential		Industrial		50-80 m				Low Boarding (LB)		
Peenya	Residential		Industrial		50-80 m				Low Boarding (LB)		
Goraguntepalya	Residential		Industrial		50-80 m				Low Boarding (LB)		
Cubbon Park	Residential	Commercial				30-50 m			Low Boarding (LB)		
S.V. Road	Residential		Industrial		50-80 m				Low Boarding (LB)	6	Residential, 12-30 m Road, LB
Chickpet	Residential	Commercial					12-30 m		Low Boarding (LB)		
K. R. Market	Residential	Commercial					12-30 m		Low Boarding (LB)		
Kuvempu Road	Residential						12-30 m		Low Boarding (LB)		
Srirampura	Residential	Commercial/ Public-Semi- Public					12-30 m		Low Boarding (LB)		
Jayanagar	Residential						12-30 m		Low Boarding (LB)		
Lalbagh	Residential	Green					12-30 m		Low Boarding (LB)		
Magadi Road	Residential						12-30 m		Low Boarding (LB)		

Legend:

	Residential
	Public/Semi Public
	Commercial
	Green
	Industrial
	Transport
	50-80 m Wide Road
	30-50 m Wide Road
	12-30 m Wide Road
	High Boarding (HB)
	Low Boarding (LB)
	Other Additional Land Use (Defined by Colour)

Twelve representative Metro stations from each strata were selected for further study, as shown in Table 3. For each of the strata, the total population was the sum of the boarding passengers' at all Metro stations falling under it.

Simple Random Sampling (SRS) technique was used to estimate the statistically relevant sample size for each strata, using the formula given below:

$$n_1 = \frac{Z^2 \times p(1 - p)}{e^2}$$

$$n'_1 = \frac{n_1 \times N_1}{n_1 + N_1}$$

$$n = n_1 + n_2 + n_3 + \dots + n_h$$

Where,

n_1 = Sample size for each stratum

n'_1 = Finite population correction for stratum

N_1 = Population for stratum

n = Total sample size

Z = Z – Score (Z-Table value for 95% confidence interval is 1.96)

e = Margin of Error (5%)

p = Prior judgment of the correct value (probability), which is 0.5 here

Table 3 shows the Metro stations selected for survey.

Table 3: Metro passenger opinion survey locations and sample size

Sr. No.	Metro Station	Total Sample Size
1	Majestic	173
2	Baiyappanahalli	209
3	Nagasandra	160
4	Banashankari	222
5	Mysore Road	172
6	M.G.Road	210
7	Indiranagar	251
8	Vidhana Soudha	153
9	S.V. Road	200
10	Attiguppe	181
11	Kuvempu Road	171
12	Goraguntepalya	210
Total		2,312

After arriving at an appropriate sample size, the sample to be collected at each Metro station was distributed temporally as well as directionally. The temporal distribution was done for three time periods in a day, morning peak (8 AM to 11 AM), evening peak (5 PM to 8 PM) and off peak (2 PM to 4 PM). The directional distribution was based on the location and type of the Metro station. A detailed sample distribution is shown in the Annexure I.

7.2. Type of Data Collected from Various Sources

7.2.1. Secondary Sources

1. Station-wise boarding and alighting Metro passenger data
2. Electronic Ticketing Machine (ETM) data for revenue and ridership
3. Land use data for Bengaluru

7.2.2. Primary Surveys

Metro Passengers Opinion Survey for Assessment of Impact of Metro on BMTC Operations

- Travel pattern of Metro passengers (origin-destination, mode of travel used for first and last mile connectivity, etc.)
- Reasons for shifting to Metro
- BMTC route no. from previous bus users

7.3. Instruments for Data Collection

7.3.1. Secondary Sources

For collecting data from secondary sources, a data requirement template was prepared and shared with the concerned agencies (Annexure II).

7.3.2. Primary Surveys

For primary data collection, a structured closed-end survey questionnaire was used to capture the data required for the current study. The questionnaire for this survey is given in Annexure III.

Metro passenger opinion survey questionnaire comprised of three sections:

1. Passenger information
2. Travel information
3. Information about their current mode choices and stated preferences about mode choice under changed conditions (scenarios considering existing fare and frequency and decreased fare and increased frequency).

All project related data was then compiled and reviewed thoroughly till a firm database was evolved for the fruitful outcome of the study.

7.4. Protocols for Data Collection and Ethics Followed

Secondary data for the current study was collected from BMTC and BMRCL. For the primary field survey, permission letters from BMRCL and BMTC were taken for conducting surveys within the Metro stations. Care was taken by the survey team to ensure that regular movement of passengers and duties of the workers were not hampered.

8. Data Collection and Analysis

8.1. Data Collection and Cleaning

8.1.1. Primary Data

The survey sample details for the primary survey are given in Table 4 below. Effort was also made to ensure that equal number of men and women responded to the survey.

Table 4: Metro passenger opinion survey sample details

Heading	Required	Collected
Survey Sample Size	2,312	2,430
Bus Users	-	915 (37.6%)

The survey was carried for a time period of 12 hours (8:00 AM-8:00 PM) at all the select Metro locations covering morning peak, off peak and evening peak on a normal working day. The survey locations are given in Table 3. The locations were duly identified based on Metro station typology. The survey was carried out using Open Data Kit (ODK) suite, an android based mobile app that replaces paper-based forms. Specially trained field investigators and trained enumerators, under the close guidance of supervisory staff were utilised for this purpose. The compiled data was subjected to a thorough verification and analysis.

The data from the primary survey was extracted in Excel spreadsheet. This data was then checked for complete and incomplete responses, invalid samples and data entry errors. After all these filters, a clean data set was prepared for analysis.

8.1.2. Secondary data

For the selected impacted routes, daily revenue and ridership data for one week, stage-wise, was collected for the following period:

- Before commencement of Metro (pre Metro operations) – May 2017
- After commencement of Metro (post Metro operations) – July 2017

8.2. Data Analysis

The primary data analysis was done with the following objectives:

- To understand the Metro passenger's access and egress distance to the Metro station
- To estimate the percentage shift from bus to Metro
- To understand the reasons for this shift
- To identify the impacted BMTC routes.

The secondary data analysis was done with the following objectives:

- To classify Metro stations with respect to each strata
- To analyse the stage-wise revenue and ridership change.

8.3. Data Analysis Techniques

For analysing the primary as well as secondary data set, Excel and Geographical Information Systems (GIS) were used. Excel was used to create the analysis template, graphs and charts and GIS was used to locate the origin-destinations of the respondents and analyse the stretch-wise impact on BMTC routes.

8.4. Preliminary Analysis

8.4.1. Profile of Metro Passengers Shifted from Bus

The socio-economic profile of the Metro passengers who have shifted to Metro from BMTC bus is shown in Annexure IV. Out of the total former bus users interviewed 54% were men and 46% were women. The current study reveals that maximum shift from bus to Metro was seen in the age group of 31-50 years (46%) and 19 - 30 years (44%). The surveys showed that only 14% respondents used their private vehicles to reach the Metro station and 28% of them parked their vehicle at the Metro station. For egress trip only 9% used their private vehicle and only 14% of them parked their vehicle at the Metro station.

The survey also revealed that 68% of the previous bus users were daily metro commuters. 64% previous bus users were coming to the Metro station from a distance of less than 2km and ~70% were travelling a distance of less than 2km to reach their destination from the Metro station.

Table 5: Access distance of previous bus users

Access Distance	No. of Respondents	Percentage
<0.5km	222	25%
0.5-2km	365	40%
2-5km	229	25%
>5km	95	10%

Table 6: Egress distance of previous bus users

Egress Distance	No. of Respondents	Percentage
<0.5km	309	34%
0.5-2km	327	36%
2-5km	198	21%
>5km	79	9%

It was observed that maximum shift with respect to monthly household income range is INR 20,000 – 50,000. Income group INR 10,000 – 20,000 comes next with 21% shift. 63% respondents were from working class and for 64% respondents the purpose of trip was work, followed by education trips (14%).

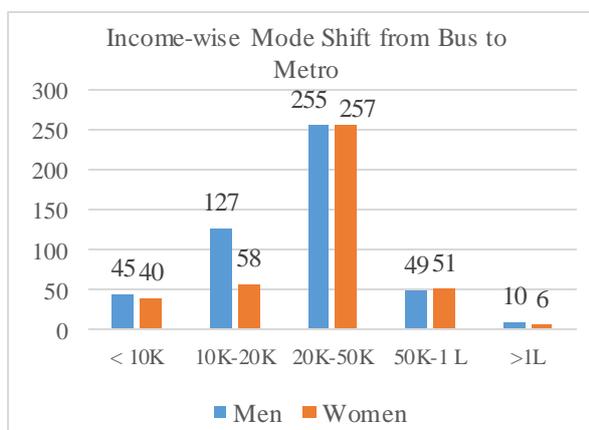


Figure 2: Income-wise mode shift from bus to Metro

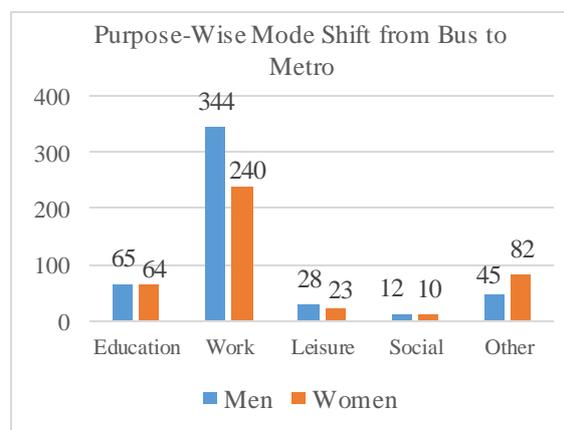


Figure 3: Purpose-wise mode shift from bus to Metro

Previous Mode of Travel

The details of the previous mode of travel of Metro Passengers are presented in Table 5. Out of 2,431 respondents interviewed, about 38% of the commuters were bus users who have now shifted to Metro.

Table 7: Previous mode of travel

Previous Mode of Travel	Count	Percentage
Cycle	6	0.2%
Two wheeler	744	31%
Auto	89	4%
Bus	915	38%
Private Car	285	12%
Taxi	165	7%
Others	227	9%
TOTAL	2,431	100%

9. Findings and Discussions

9.1. Shift from Bus to Metro

The station-wise shift from bus to Metro are presented in Figure 4. The maximum percentage shift is seen at Kuvempu Road (67%). The other locations experiencing a higher shift from bus to Metro are Banashankari Metro station, M. G. Road and Mysore Road.

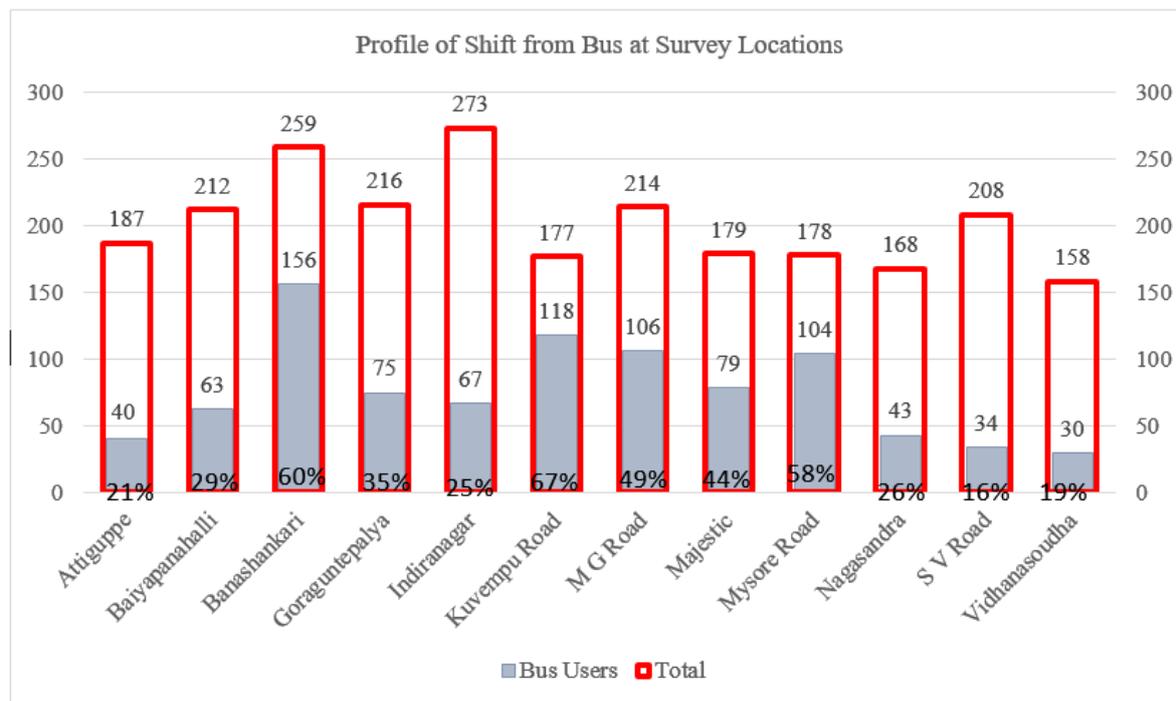


Figure 4: Profile of bus to Metro shift at survey locations

9.2. Reasons for Shift from Bus to Metro

Out of the 915 previous bus users interviewed, 910 responded to survey questions regarding reasons for the shift to Metro. The respondents had a choice to select multiple reasons for their mode shift. The reasons in the questionnaire include: reduction in travel time, comfort, low bus frequency, reasonable metro fare and avoiding traffic jams and pollution. 95% of the respondents cited reduction in travel time as the reason for their shift and 60% responded saying they wanted to avoid traffic jams. Table 6 shows that travel time, avoiding traffic jams and comfort were the major three reasons for the mode shift and that more weightage was given to time related factors than expense (reasonable Metro fare).

Table 8: Reasons to shift from bus to Metro

Reason to Shift	Count	Percentage
Travel Time	869	95%
Avoid Traffic Jam	543	60%
Comfort	412	45%
Low Bus Frequency	89	10%
Reasonable Metro Fare	62	7%

9.3. Impacted Routes

This study also aims at identifying the BMTC routes impacted due to Metro operations. The routes were identified using two methods:

1. Direct response of the former bus using respondents
2. Origin-destination of the former bus using respondents (whose route numbers were not known).

The top impacted routes are given in the Table 7 below.

Table 9: List of impacted routes

Route No.	Origin	Destination	Parallel Metro Corridor
258	Nelamangala	KR Market	N-S
215	Amruth Nagara	KR Market	N-S
317	Hosakote	KR Market	E-W
335	Sai baba hospital	KR Market	E-W
315	KBS	KR Puram	E-W
210	Uttarahalli	KR Market	N-S
252	KBS	Peenya 2nd stage	N-S
61A	KBS	Chandra Layout	E-W
138	Jeevan Bhimanagara Bus stand	KBS	E-W
304	Arehalli	KR Market	E-W
225	Channasandra	KR Market	E-W
314	Shivajinagar Bus Station	CGHS Nagavar Palya	E-W
250	Chikkabanawara Railway Gate	KR Market	N-S
253	Krishnarajendra Market	Hesaraghatta Indo Danish Farm	N-S
401K	Yelahanka	Kengeri	E-W
201	Domulur TTMC	Srinagara	E-S

9.4. Stretch-wise Impacted Route Analysis

After identifying the impacted routes from Metro passengers' response, a four months stage-wise ridership data for select two routes was considered for analysis. This data was collected for Jan - Feb 2017 for pre-Metro and Aug - Sept 2017 that is two months after commencement of full Phase I Metro corridor.

9.4.1. Stretch-wise Impact Analysis of Route No. 258

258-UP (KR Market to Nelamanagala)

The route 258 UP runs from KR Market to Nelamanagala and has a route length of 30 Km. Of this, around 16 Km (~50%) runs parallel to the Metro North-South corridor (from Nagasandra to KR market). Table 10 shows the change in ridership of the BMTC route 258 after commencement of Metro Phase I. Analysis has been done considering peak and off-peak time frame. Time based analysis of the ridership variation for route shows that, peak hour (8:00 am to 11.00 am, morning peak and 4:00 pm – 08:00 pm, evening peak) impact is similar to overall average impact pattern. During off-peak period (11:00 am – 4:00 pm) change in ridership is not that significant. It may imply that impact of Metro is more affected during peak period.

Table 10: Stage-wise change in ridership (Route no. 258UP)

Sl.No	Stage Names	Pre-Metro Ridership	Post-Metro Ridership	% difference in boarding ridership (UP)	Peak	Off-peak
1	KR Market	1792	570	-68%	-57%	-84%
2	Kempgowda Bus Station	1663	1084	-35%	-6%	-46%
3	Corporation	161	51	-68%	-63%	-70%
4	Central	532	452	-15%	12%	32%
5	11 th Cross Malleswaram	469	236	-50%	-45%	-34%
6	Yeshwanthpur TTMC	1540	804	-48%	-42%	0%
7	RMC Yard	1102	862	-22%	-26%	66%
8	SRS Peenya	342	298	-13%	-29%	38%
9	Jalahalli Cross	2847	2081	-27%	-42%	34%
10	Marison Factory	323	231	-28%	-53%	8%
11	Anchepalya	343	324	-6%	-31%	43%
12	Madanayakanahalli	233	175	-25%	-61%	29%

13	Makali	215	71	-67%	-92%	-53%
14	Adakimaranahalli	11	0	-100%	-98%	-33%
15	Dasanapura	83	29	-65%	-96%	-22%
16	Arishinakunte	146	75	-49%	0%	-29%
17	Binnamangala	425	179	-58%	-39%	3%

The route seems to have an overall loss of about 44% in its ridership after commencement of Phase I Metro (overall monthly ridership in January 2017 was 1,22,212, this reduced to 7,517 in September 2017). The stage-wise analysis observed a significant reduction in ridership at KR Market (68%). Overall ridership at KR Market reduced to 570 in September from 1,790 in January. Also inter-stage trips shows that there is an average drop of 60% in ridership for the trips from KR Market to Yeshwanthpur TTMC and Dasanapura. Since KR Market bus station is in close proximity to the Metro station there is a high possibility of passengers opting for Metro.

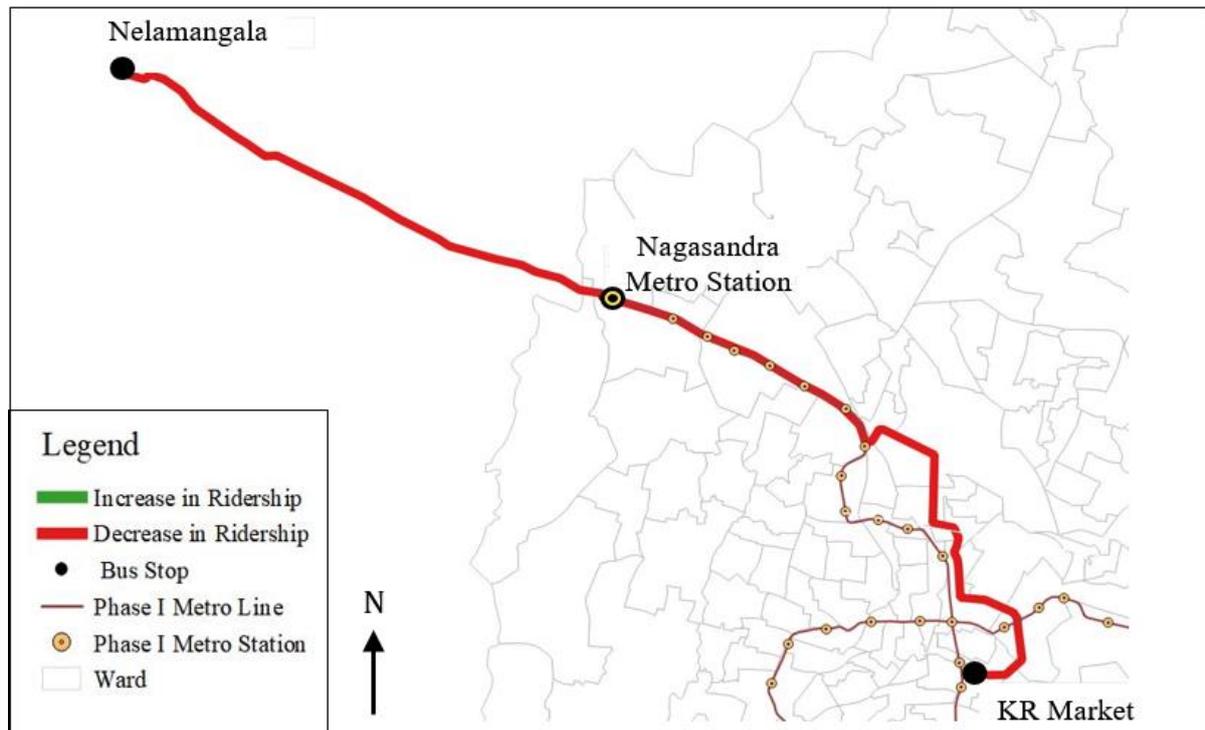


Figure 5: Stage-wise impact on BMTC route no. 258-UP

258- DN (Nelamangala to KR Market)

For the down journey (from Nelamangala to KR Market), a reduction of 27% was observed from Arishanakunte to Maharanis College. The ridership seems to go up by approximately 20% on the initial stretch (from Nelamanagala to Arishanakunte). It also showed that the commuters were using this route for a shorter trips from Nelamangala and Binnamangala. A slight increase in ridership from Nelamangala to Marison Factory (26 in January to 52 in September), indicated that passengers could be using this as feeder for their first mile connectivity.

Table 11: Stage-wise change in ridership (Route no. 258 DN)

Sl. No.	Stage	Pre- Metro Ridership	Post-Metro Ridership	% difference in boarding ridership (DN)
1	Nelamangala	1645	1875	14%
2	Binnamangala	71	86	21%
3	Arishinakunte	193	119	-38%
4	Dasanapura	296	261	-12%
5	Adakimaranahalli	67	16	-76%
6	Makali	814	674	-17%
7	Madanayakanahalli	1743	1391	-20%
8	Anchepalya	960	836	-13%
9	Marison Factory	2401	2006	-16%
10	Jalahalli Cross	773	672	-13%
11	SRS Peenya	742	562	-24%
12	RMC Yard	706	541	-23%
13	Yeshwanthpur TTMC	1157	941	-19%
14	8th Cross Malleswaram	693	518	-25%
15	Swastik Sheshadripuram College	212	108	-49%
16	Ananda Rao Circle	97	47	-52%
17	Maharanis College	62	90	45%
18	Corporation	192	181	-6%

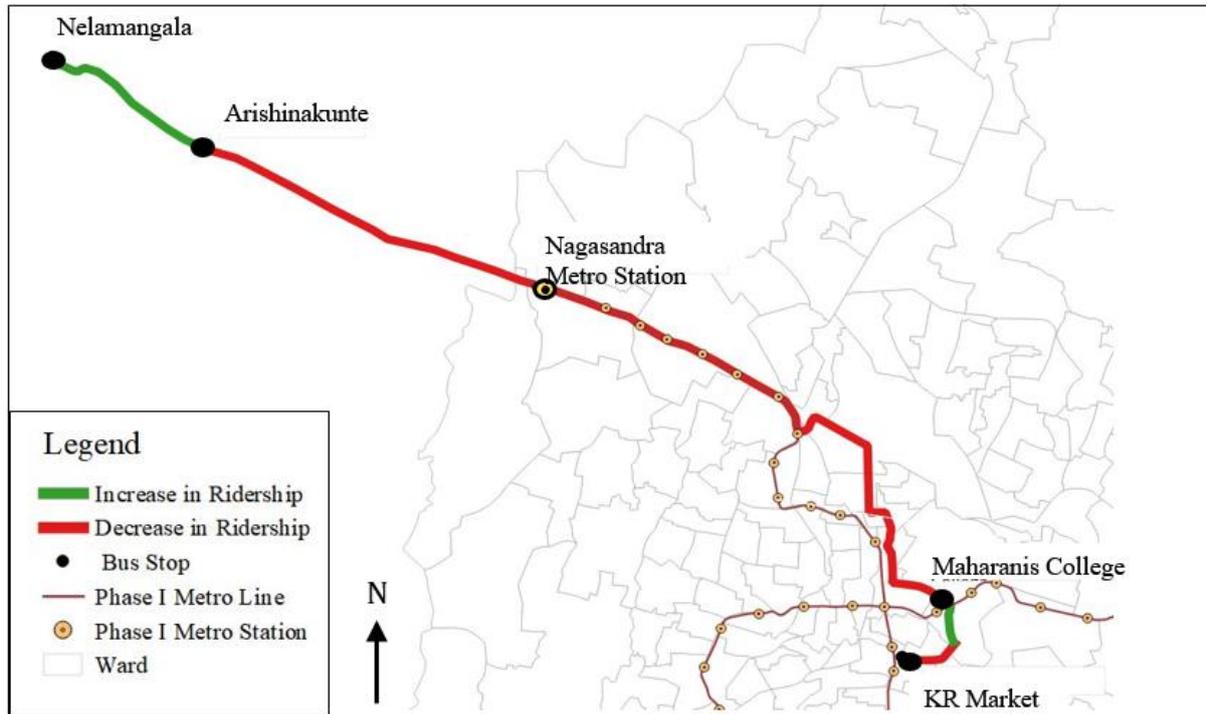


Figure 6: Stage-wise impact on BMTC route no. 258-DN

9.4.2. Stretch-wise Impacted Route Analysis – 401 K

The route 401-K UP runs from Kengeri TTMC to Yelahanka Old Town and has a route length of 37 Km. This route runs radial to Metro corridor. About 10km stretch of this route (from Mallatahalli Cross to Yeshwanthpur TTMC) runs parallel to Metro. Table 12 below shows the change in ridership of the BMTC route 401-K after commencement of Metro Phase I. For route no 401-K, change in ridership pattern follows a similar trend throughout the day irrespective of peak and off-peak period

Table 12: Stage-wise change in ridership (Route no. 401-K UP)

S.No	Stage Names	Pre-Metro Ridership	Post-Metro Ridership	% difference in boarding ridership (UP)	Peak	Off Peak
1	Kengeri TTMC	5834	3922	-33%	-34%	-29%
2	Jn of Kommaghatta	3786	2773	-27%	-13%	-22%
3	Shirke KHB Quarters	2410	1822	-24%	6%	-14%
4	Mariyappanapalya	2802	1966	-30%	-22%	-24%

5	Mallathahalli Cross	2517	1974	-22%	-17%	-19%
6	Nagarabhavi Circle	2280	1643	-28%	-22%	-24%
7	Moodalapalya	3734	2759	-26%	-21%	-28%
8	Vijayanagara	2874	1984	-31%	-28%	-23%
9	Industrial Area Rajajinagara	947	736	-22%	-12%	6%
10	ESI Hospital Rajajinagara	2541	1598	-37%	-32%	-34%
11	1st Block Rajajinagara	1668	1327	-20%	-4%	-21%
12	Govt Soap Factory	1056	914	-13%	10%	2%
13	Yeshwanthapura TTMC	4329	4458	3%	-21%	9%
14	Mattikere	2279	1628	-29%	-48%	-29%
15	BEL Circle	2008	2065	3%	-36%	16%
16	Nagaland Circle	1243	1015	-18%	-51%	-16%
17	Nanjappa Circle	1732	1522	-12%	-8%	-14%
18	Vidyaranyapura Bus Station	900	688	-24%	-25%	-37%
19	Chikka Bettahalli	789	692	-12%	-36%	13%
20	Atturu Layout	1016	872	-14%	-32%	-30%
21	Yelahanka Satellite Town	1204	1249	4%	-20%	-6%
22	NES Office	531	434	-18%	-30%	-35%

The survey showed that respondents using Metro service from Yeshwanthpur Metro station (going till Vijayanagar /Mysore road Metro station) were using 401-K route before Phase I Metro was operational. These trips were majorly starting from Global Tech village/ Kengeri and ending at Mathikere or Yeshwanthpur.

The route (401-K UP) experienced an overall reduction in ridership of 32%, and the stretch which is running parallel to Metro corridor has observed an average reduction of 30%. Figure 7 shows that there is a slight increase in ridership at Yeshwanthpur TTMC, which is in close

proximity to the Metro station. This could be due to Metro commuters using the bus service for their last mile connectivity.

The inter-stage trips data show a significant reduction in ridership for the trips from Kengeri to Govt. Soap Factory, Yeshwanthpur and Mathikere. One of the reasons for this reduction can be a commuter shift from bus to Metro.

Likewise, on the downward journey (401K-DN), it was observed that there was a constant decrease in ridership from Yelahanka Old Town to Moodalapalya (from 47335 in January to 40533 in September), and it slightly increased at Moodalapalya, which is in close proximity to Vijayanagar Metro station. Even though the ridership seems to increase on the last few stages, the route observed an overall reduction of 21%, and for the stretch parallel to Metro, it was around 18%.

The inter-stage trips show a reduction of 23% in ridership from Yelahanka to Vijayanagar, Moodalapalaya and Nagarbavi Circle. It is also observed that ridership has increased for shorter trips from Vidyaranyapura and Nanjappa Circle to Govt. Soap Factory indicating that passengers might be using this stretch for their first mile connectivity.

Table 13: Stage-wise change in ridership (Route no. 401-K DN)

S.No	Stage Names	% difference in boarding ridership (DN)	Pre-Metro Ridership	Post-Metro Ridership
1	Yelahanka Old Town	-2%	5427	5326
2	NES Office	-20%	4443	3556
3	Yelahanka Satellite Town	-27%	2669	1957
4	Atturu Layout	-10%	1638	1470
5	Chikka Bettahalli	-24%	1433	1089
6	Vidyaranyapura Bus Station	-14%	3273	2821
7	Nanjappa Circle	-8%	3689	3407
8	Nagaland Circle	-23%	570	441
9	BEL Circle (Towards Mathikere)	-21%	1863	1478
10	Mattikere	-11%	3692	3282
11	Yeshawanthapura TTMC	-13%	2051	1789
12	Govt Soap Factory	-36%	1730	1100
13	1st Block Rajajinagara	-22%	3549	2759
14	ESI Hospital Rajajinagara	-18%	2061	1689
15	Industrial Area Rajajinagara	-13%	1619	1416
16	Vijayanagara	-20%	4719	3793
17	Moodalapalya	9%	2909	3160

18	Nagarabhavi Circle	4%	2193	2281
19	Mallathahalli Cross	-8%	898	829
20	Bengaluru University Quarters	-6%	1027	967
21	Mariyappanapalya	2%	1271	1295
22	Shirke KHB Quarters	-2%	283	277
23	Jn of Kommaghatta	133%	6	14
24	Police Station Kengeri	-2%	5427	5326

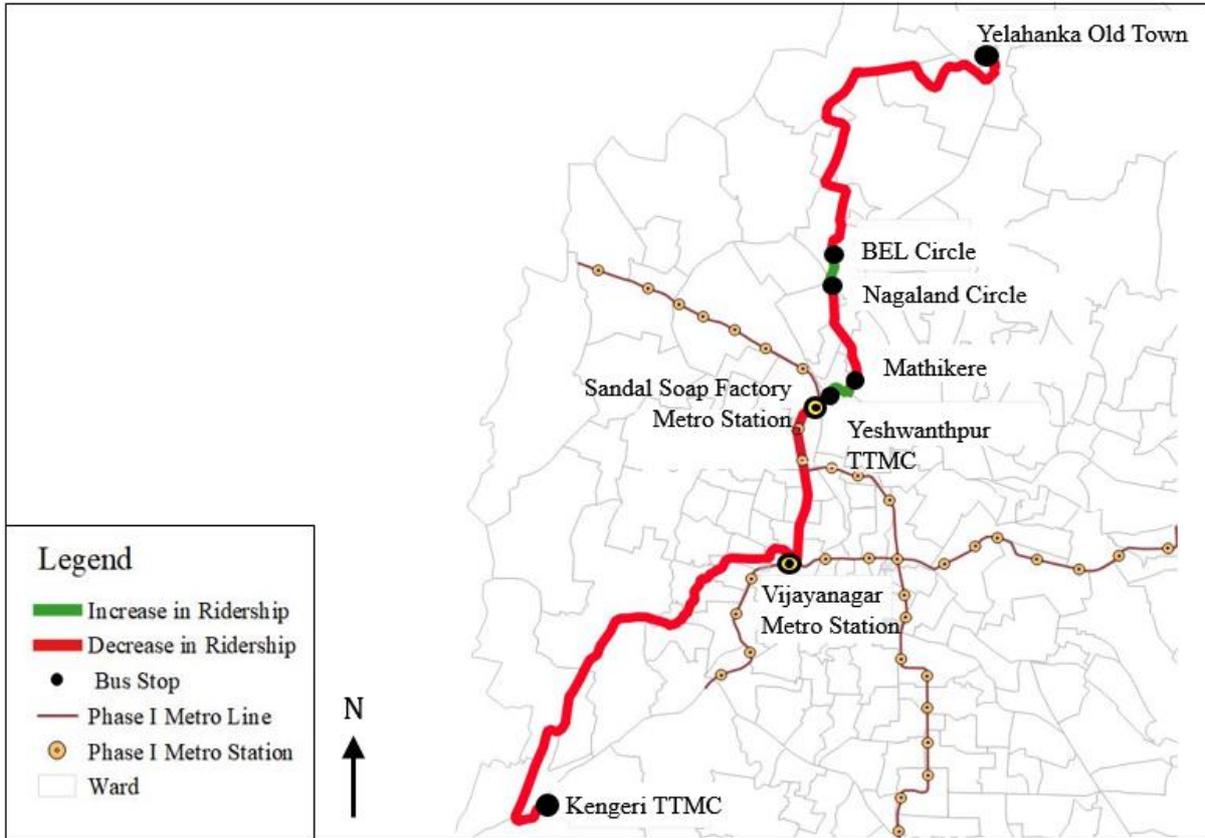


Figure 7: Stage-wise impact on BMTC route no. 401-K UP

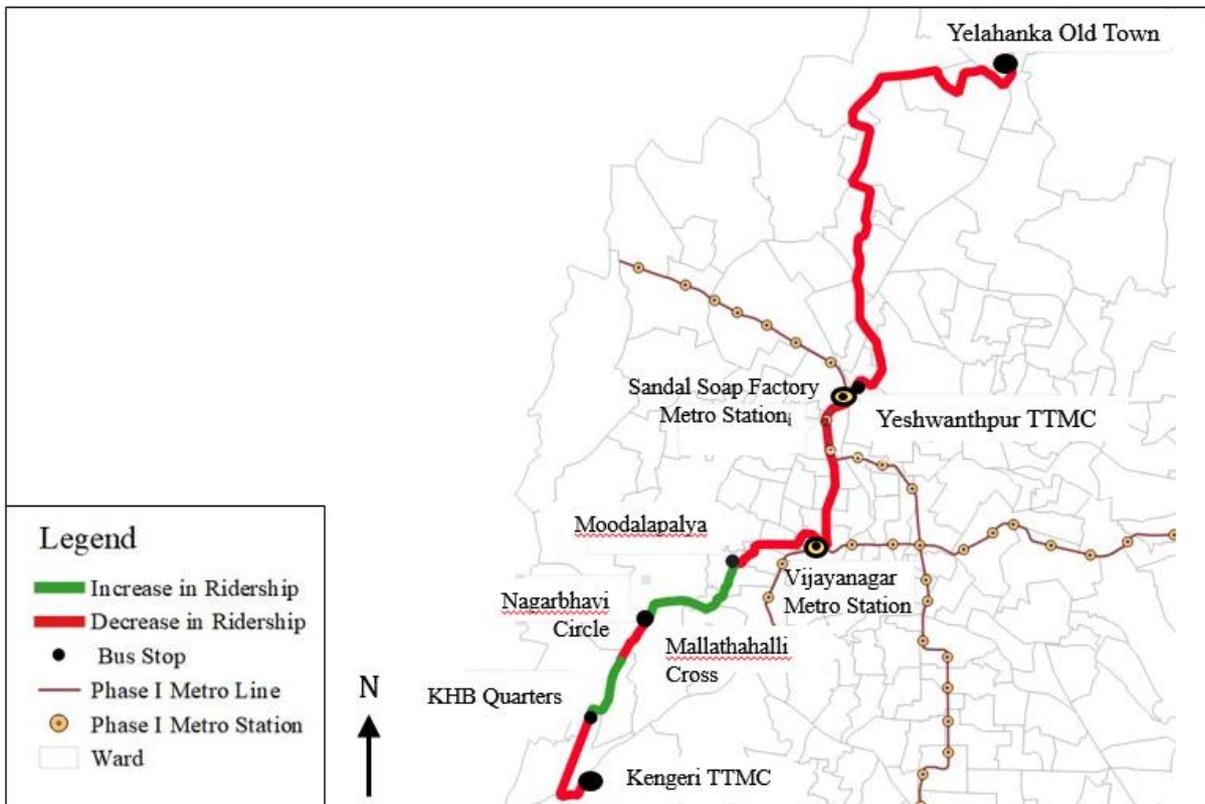


Figure 8: Stage-wise impact on BMTC route no. 401-K DN

10. Conclusion and Recommendations

Conclusions

Through this study, socio-economic and trip characteristics of former BMTC bus-users was captured through a Metro passenger opinion survey. Metro station-wise, percentage of shift from bus to Metro was estimated. The survey was also able to reveal the underlying reasons for this shift and identified the impacted bus routes. For the impacted routes, a stretch-wise assessment was carried out to identify the bus ridership variation.

According to the findings of the study, there is a shift from bus to Metro. The primary reason identified for this shift is reduction in travel time. From the impacted route analysis, it was also evident that due to this shift, there is a variation in bus ridership.

Recommendations

With the completion of Metro Phase I, and with current Metro Phase II construction, it is important for BMTC to reduce the number of schedules running parallel to Metro corridors. These buses could be redeployed in:

- Corridors which witness heavy demand for BMTC services
- Areas which are underserved by BMTC operations
- Influence area of Metro as feeder services

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Annexure I

Sample Size Distribution

SL No	Metro Station	Time Period			Total Sample Size	Direction			
		T1	T2	T3		N	S	E	W
1	Majestic	80	34	59	173	58	44	40	31
2	Baiyappanahalli	42	137	30	209	0	0	0	209
3	Nagasandra	36	91	33	160	0	160	0	0
4	Banashankari	63	99	60	222	222	0	0	0
5	Mysore Road	94	41	37	172	0	0	172	0
6	M.G.Road	60	100	50	210	0	0	105	105
7	Indiranagar	77	131	43	251	0	0	126	125
8	Vidhana Soudha	35	88	30	153	0	0	76	77
9	S.V.Road	79	86	35	200	0	0	0	200
10	Attiguppe	86	55	40	181	0	0	91	90
11	Kuvempu Road	53	80	38	171	85	86	0	0
12	Goraguntepalya	88	82	40	210	105	105	0	0
Total					2,312				

T1 – Morning Peak (8:00am – 11:00am)

T2 – Evening Peak (5:00pm – 8:00pm)

T3 – Off Peak (12:00noon – 4:00pm)

Annexure II

Data Requirement Template for Impacted Route Stage-wise Data from BMTC

Route No.	Schedule No.	Date	Time	Boarding Stage	Alighting Stage	Ridership	Revenue

Annexure III

Metro Passenger Opinion Survey Questionnaire

(At Metro Stations)

Purpose: To identify feasible Metro feeder routes and also to assess the impact of Metro on BMTC services

Survey Location:

Date & Time:

Gender

Male	Female
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Age group

Less than 18	19 – 30	31 - 50	51 - 60	Above 60
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1. Employment Type:

- a) Working
- b) Unemployed
- c) Retired
- d) Student
- e) Homemaker
- f) Others

2. Monthly Household income

Less than 10,000	Rs. 10,000–20,000	Rs. 20,000–50,000	Rs. 50,000 – 1,00,000	More than 1,00,000
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3.

Origin (Land mark, Nearest Bus stop & Pin code)	Destination (Land mark, Nearest Bus stop & Pin code)
Boarding Metro Station	De-boarding Metro Station

4. Purpose of travel

Education	Work	Leisure	Social	Other
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5. How often do you make this trip?

Daily	Weekly	Monthly
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6. How long have you been using metro?	Less than 3 months	3 to 6 months	6 to 9 months	More than 9 months
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7. What was your previous mode of travel?	Cycle	Two wheeler	Auto	Bus Route no.	Private car	Taxi/cab	Commuter rail
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8. If the answer is BMTC, What prompted you to shift to metro?

Sr. No.	Reasons	Response
1	Travel Time	
2	Comfort	
3	Low bus frequency / High waiting time for BMTC	
4	Reasonable Metro fare	
5	Avoid traffic jams and pollution	

9. How did you reach the Metro station?	Walking	Car	Two wheeler	Auto	Bus Route no. _____	Cab/ taxi	Share taxi
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10. Home to Metro station distance?	Less than ½ Km	½ - 2Km	2 - 5 Km	More than 5 Km
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11. Travel Time to reach Metro station? _____ Min

12. Do you use the same mode for returning to your origin? Yes/No

13. How will you reach your destination from the Metro station?	Walking	Car	Two wheeler	Auto	Bus Route no. _____	Cab/ taxi	Share taxi
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14. Metro station to final destination distance?	Less than ½ Km	½ - 2Km	2 - 5 Km	More than 5 Km
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15. Travel Time to reach your destination from the Metro station? _____ Min

16. Do you use the same mode to reach Metro station from destination? Yes / No

17. Do you park your Vehicle at Metro station? Yes / No

18. Do you pay for your parking? Yes / No

19. Scenarios & ranking (would you shift to Metro feeder if..)

Scenario	Travel Cost Current Mode	Travel Time Current Mode	Travel Cost with Metro feeder	Travel Time with Metro feeder (Min)	Comfort	Your Response	
						Current Mode	Metro Feeder
1				IVTT ¹ +30	AC		
2				IVTT+24	AC		
3				IVTT+30	AC		
4				IVTT+24	AC		
5				IVTT+30	Non AC		
6				IVTT+24	Non AC		

20. Any other suggestions for improvement?

¹ IVTT – In Vehicle Travel Time

Annexure IV

Profile of Former Bus Users Currently Using Metro

Socio – economic Characteristics of Respondents	Category Range	Respondents	
		Count	Percentage
Gender	Men	494	54%
	Women	419	46%
Total		913	100%
Age	Less than 18	25	3%
	19-30	405	44%
	31-50	421	46%
	51-60	46	5%
	Above 60	18	2%
Total		915	100%
Employment Type	Working	572	63%
	Unemployed	78	9%
	Retired	23	3%
	Student	140	15%
	Homemaker	89	10%
	Others	13	1%
Total		915	100%
Monthly Household Income	Less than 10,000	85	9%
	INR 10,000-20,000	185	21%
	INR 20,000-50,000	514	57%
	INR 50,000-1,00,000	100	11%
	More than 1,00,000	16	2%
Total		900	100%