Integration of BMRCL and BMTC

CENTER FOR STUDY OF SCIENCE, TECHNOLOGY & POLICY

Integration of BMRCL and BMTC

1. **Route Integration**
2. **Infrastructure Integration**
3. **Institutional Integration**

Final Report

Submitted by

Center for Study of Science, Technology and Policy

To

Bengaluru Metropolitan Transport Corporation, Government of Karnataka

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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%).

About BMRCL

Bangalore Metro Rail Corporation Limited provides metro rail mass transport services to the city of Bengaluru. Phase I of Metro operations covers the East-West corridor – 18.10 km, and the North-South corridor – 24.20 km. Commercial operations from MG Road to Baiyapanahalli began in October 2011, with additional stretches commencing operations subsequently. The complete Phase I commenced operations in June 2017. Daily ridership on Bangalore Metro regularly exceeds 4 lakh passengers with daily revenue of approximately INR 1.3 crores. Phase II of Bangalore Metro construction is currently underway and is expected to be completed by 2020-21.

While it is good that Bengaluru has two mass transport agencies, there is a need for integration between them. Integration between BMTC and BMRCL would lead to greater mode share for public transport, reduced congestion and lesser pollution levels. This study focuses on three aspects of integration – route, infrastructure and institutional between BMTC and BMRCL.

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.

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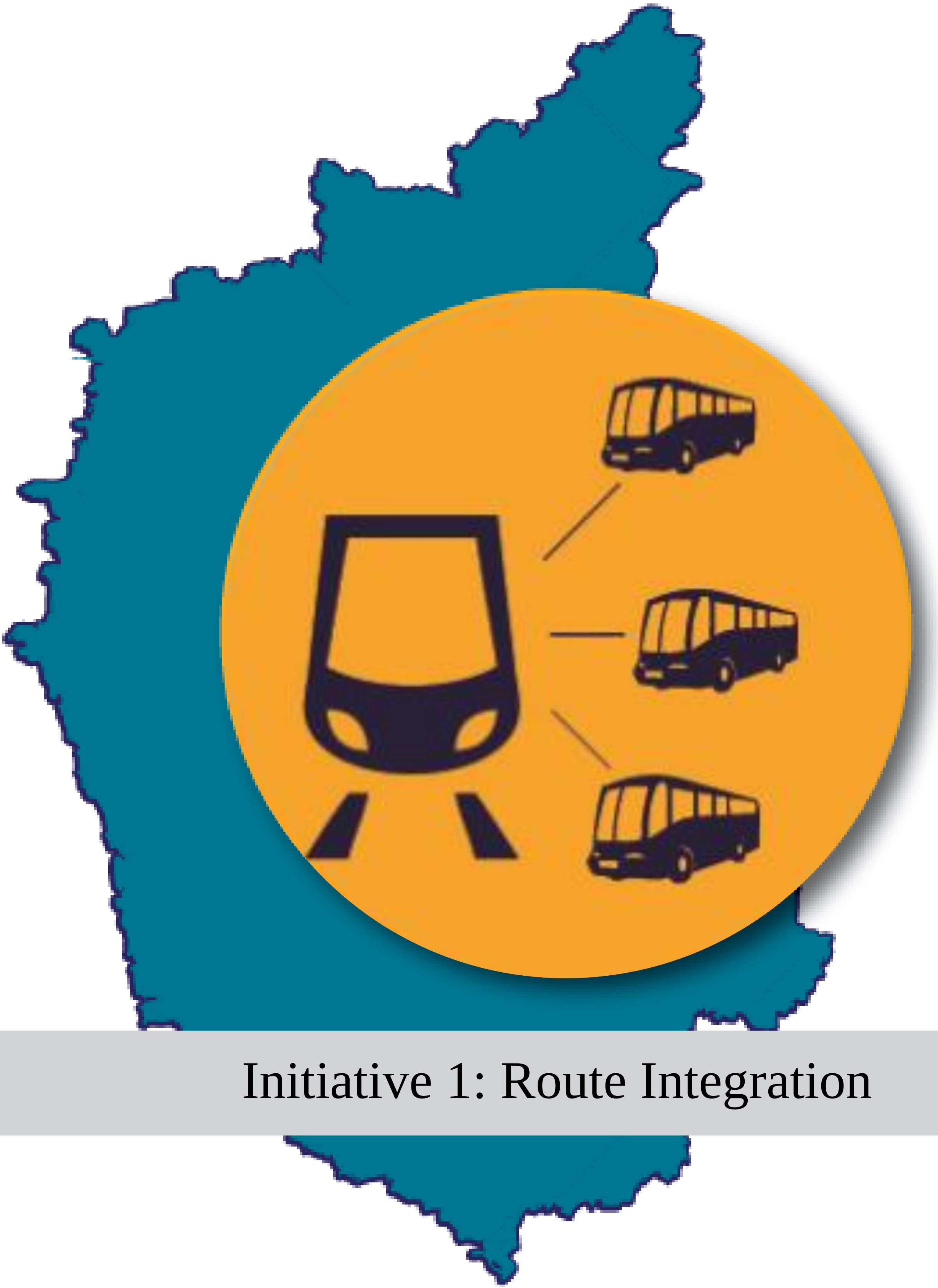

Initiative 1: Route Integration

Initiative 1: Route Integration

Abbreviations and Acronyms

Abbreviations	Full Form
API	Application Programme Interface
BBMP	Bruhat Bengaluru Mahanagara Palike
BMRCL	Bangalore Metro Rail Corporation Limited
BMTC	Bengaluru Metropolitan Transport Corporation
BS	Bus Stand
CPKM	Cost Per Kilometre
DCM	Discrete Choice Model
EPKM	Earning Per Kilometre
ETM	Electronic Ticketing Machine
GIS	Geographical Information System
HH	Household
MS	Metro Station
O-D	Origin-Destination
ODK	Open Data Kit
OSM	Open Street Map
RMP	Revised Master Plan
RP	Revealed Preference
RTO	Regional Transport Office
SP	Stated Preference
SRS	Simple Random Sampling
TTMC	Traffic and Transit Management Centre

Executive Summary

Bengaluru Metropolitan Transport Corporation (BMTC) and Bangalore Metro Rail Corporation Limited (BMRCL) are the primary public transport service providers in Bengaluru, which aim to provide safe, reliable, clean and affordable transportation. To achieve this aim and to make public transport the preferred mode of transport in Bengaluru, it is important to integrate public transport services.

In this context, Government of Karnataka has engaged Center for Study of Science, Technology and Policy (CSTEP) as a technical research institution to suggest ways for the integration of BMRCL and BMTC. This study focuses on route integration, which involves estimating the willingness of Metro passengers to use the feeder bus service and identifying appropriate Metro feeder routes.

In this study, potential feeder routes were identified based on a Metro passenger opinion survey. Stratified Random Sampling technique was used to arrive at required sample size. This survey was conducted at 12 Metro stations and 2,431 respondents were interviewed. Discrete Choice Modelling technique was used to estimate the probability of shift to Metro feeder service.

The survey captured the current mode of transport and the preferred mode of transport using the revealed-preference and stated-preference survey techniques. The willingness to shift to Metro feeder service was captured for commuter trips from origin to the boarding Metro station (access trips) and also for trips from the alighting Metro station to the destination (egress trips). For the stations where there is a maximum probability of shift, potential feeder routes were identified considering the respondents' trip patterns, existing Metro feeders and major activity centres.

For access trips, the maximum willingness to shift to feeder services was observed at Goraguntepalya, S. V. Road, Mysore Road and Indiranagar Metro stations. Similarly, for egress trips, the maximum willingness to shift to feeder services was observed at Indiranagar and S. V. Road Metro stations. Based on the analysis the study proposes feasible feeder routes at four Metro stations. These routes cover areas which are not well served with BMTC services.

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1. Introduction

BMRCL and BMTC are the two major public transport service providers for Bengaluru. Route integration is needed to increase the overall public transport mode share of the city.

One way by which this could be achieved is BMTC providing feeder service to Metro. For this, it is essential to understand the passenger demand for feeder and travel patterns of Metro passengers. This study estimates the willingness of Metro passengers to shift to the BMTC feeder bus service for first and last mile connectivity and identification of feasible feeder routes.

2. Log Frame / Theory of Change / Programme Theory

2.1. Logic of Route Integration

After the commencement of Bengaluru Metro Reach 1 (M. G. Road to Baiyappanahalli) in 2011, BMTC started a few feeder bus services. BMTC introduced additional feeder services with the completion of Phase I (Citizen Matters 2017). The current feeder services connect areas with nearby Metro stations as well as between Metro stations. These services are incurring losses due to low usage and high operational cost. There is a need to examine Metro users' travel patterns to propose new feeder routes. This study aims at identifying the feasible Metro feeder routes for Phase I Metro stations.

	Intervention Logic	Verifiable Indicators of Achievement	Sources and Means of Verification	Assumptions
Overall Objectives	*What are the overall broader objectives to which the activity will contribute?* To integrate the two public transport services of Bengaluru, bus and Metro, for better connectivity	*What are the key indicators related to the overall objectives?* Achieving first and last mile connectivity for Metro by BMTC service	*What are the sources of information for these indicators?* Metro passenger opinion survey	*NA*
Specific Objectives	*What specific objectives is the activity intended to achieve to contribute to the overall objectives?* • To estimate willingness of Metro users to shift to BMTC's Metro feeder service • To identify the feasible feeder routes for Phase I Metro corridor	*Which indicators clearly show that the objective of the activity has been achieved?* Implementation of suggested Metro feeder routes by the competent authority	*What are the sources of information that exist or can be collected? What are the methods required to get this information?* Secondary data collection: • Ridership details from BMRCL Primary data collection: • Metro passenger opinion survey	*Which factors and conditions outside the PI's responsibility are necessary to achieve that objective? (external conditions)* *Which risks should be taken into consideration?* • Permission of the competent authority to conduct the survey • Willingness of competent authority to implement the suggested Metro feeder routes
Expected results	*The results are the outputs envisaged to achieve the specific objective.* *What are the expected results? (enumerate them)* • Willingness of the Metro users to shift to the BMTC feeder service	*What are the indicators to measure whether and to what extent the activity achieves the expected results?*	*What are the sources of information for these indicators?* Site visits	*What external conditions must be met to obtain the expected results on schedule?* • Willingness of competent authority to implement the suggestions as per the report

	• Feasible Metro feeder routes for the select Metro station	Completion of Metro passenger survey at select Metro stations		• Schedule of survey and bus schedule as decided by competent authority
Activities	*What are the key activities to be carried out and in what sequence in order to produce the expected results?* *(group the activities by result)* 1. Secondary data collection for Metro ridership 2. Identifying Metro stations for primary survey 3. Preparation of questionnaire and arriving at sample size for primary survey 4. Conducting Metro passenger opinion survey 5. Formulating Origin-Destination (O-D) matrix 6. Identifying potential activity centres 7. Identifying of feasible Metro feeder routes 8. Secondary data collection of existing Metro feeder routes characteristics 9. Validation of feasible Metro feeder routes through site visits 10. Suggesting feasible feeder routes.	***Means:*** *What are the means required to implement these activities, e. g. personnel, training, studies, etc.* • Urban planning experts • Transport planning experts • Training for conducting primary survey	*What are the sources of information about action progress?* • Site visits • Interaction with competent authority	*What pre-conditions are required before the action starts?* • Acceptance by the authority for the suggested changes • Plan for actual implementation and timely completion

3. Progress Review

This section describes the existing feeder bus route characteristics.

3.1. Scope of Existing Feeder Bus Service

BMTC initiated the Metro feeder service after the launch of the first reach of Metro from MG Road to Baiyappanahalli in 2011. BMTC operated about 24 feeder routes with 60 buses deployed at six Metro stations (Sastry 2011). As BMRCL started operating the entire Phase I Metro corridor, BMTC made arrangements to introduce more services based on the feedback from the public through its website, social media and other sources. Thus, BMTC started operating 29 Metro feeder bus routes with 205 schedules from June 2017 (Kumar 2017). As on February 2018, BMTC runs 793 schedules for 23 feeder routes. The list of operational feeder routes is given in Annexure 1.

3.2. Performance of Existing Feeder Services Based on Baseline Data

The existing Metro feeder routes are running with an average route length of 15 km and frequency of about 10-20 minutes. As of June 2017, 1,918 feeder trips (out of 3,142) are running for the North-South Metro corridor. There are seven routes running from S. V. Road Metro station to different parts of the city including Whitefield, Marathahalli, Hoodi, Ramamurthynagara, Koramanagala etc.(Citizen Matters 2017). The spending per kilometre for all BMTC feeder services for the East-West Metro corridor from October 2016 to March 2017 was INR 13,129 and the earning was INR 7,464 per km (Madhavan 2017).

4. Problem Statement

To understand the willingness of Metro users to shift to feeder services and also to propose new feeder routes to improve connectivity.

4.1. Gaps/Weaknesses in Existing Feeder Service

As mentioned in the previous section, BMTC is unable to meet the operational expenses of the feeder services. On the other hand, even if the Metro ridership is observed approaching 3.5 lakhs per day (The Hindu 2017), the first and last mile connectivity seems to be a matter of concern for the metro users; for instance, the auto fare and parking fee increase the expense of the total travel cost by Metro (Bandyopadhyay 2017).

A few studies suggest Metro feeder routes should serve a short distance (4 to 6 km), with a high frequency of 5 to 10 minutes or a maximum of 15 minutes (WRI 2014), (NCR Transport Department 2014), (Urban Mass Transit Company Limited 2014). However, the average route length of BMTC Metro feeder routes is 13.2 km with a maximum route length of 28 km and a minimum of 4.5 km. As per the discussion with BMTC officials, the shorter trip lengths increase the CPKM. Hence preference is given to longer trip lengths, that is, above 15 km. This contradiction poses a challenge to arrive at an optimal feeder route length.

The other challenges faced for Metro–bus route integration are stated below:

- Lack of potential ridership for feeder on account of limited Metro ridership
- Lack of information on passenger demand for feeder services
- Lack of coordination between the two agencies (in terms of frequency and time)

Evaluation Question

What are the feasible BMTC feeder routes for Phase I Metro corridor?

This study identifies potential feeder routes based on trip-generating and trip-attracting areas. This will be further refined/modified according to the on-ground scenario (such as road width along the route, activity centres along the route etc.) in consultation with stakeholders.

5. Objective and Issues of Evaluation

Objective

To propose feeder routes for Phase I Metro corridor

Scope

Target population: The target population for this study are the Metro users.

Geographical coverage: Influence area based on origin and destination of Metro users

6. Evaluation Design

6.1. Information Sources:

The required data and information need to be gathered by primary as well as secondary sources. The secondary data was collected from the following agencies:

1. Bengaluru Metropolitan Transport Corporation (BMTC) – List and details of existing feeder routes
2. Bangalore Metro Rail Corporation Limited (BMRCL) – Station-wise Metro ridership data
3. Census 2011 – Ward-wise population and population density
4. RMP 2015 – Land use along the Phase I Metro corridor

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

Metro Passenger Opinion Survey: This survey was conducted along Phase I Metro stations, to gather information regarding socio–economic and travel characteristics of Metro users. This survey also captured Metro users’ willingness to shift to the BMTC Metro feeder service.

7. Evaluation Methodology

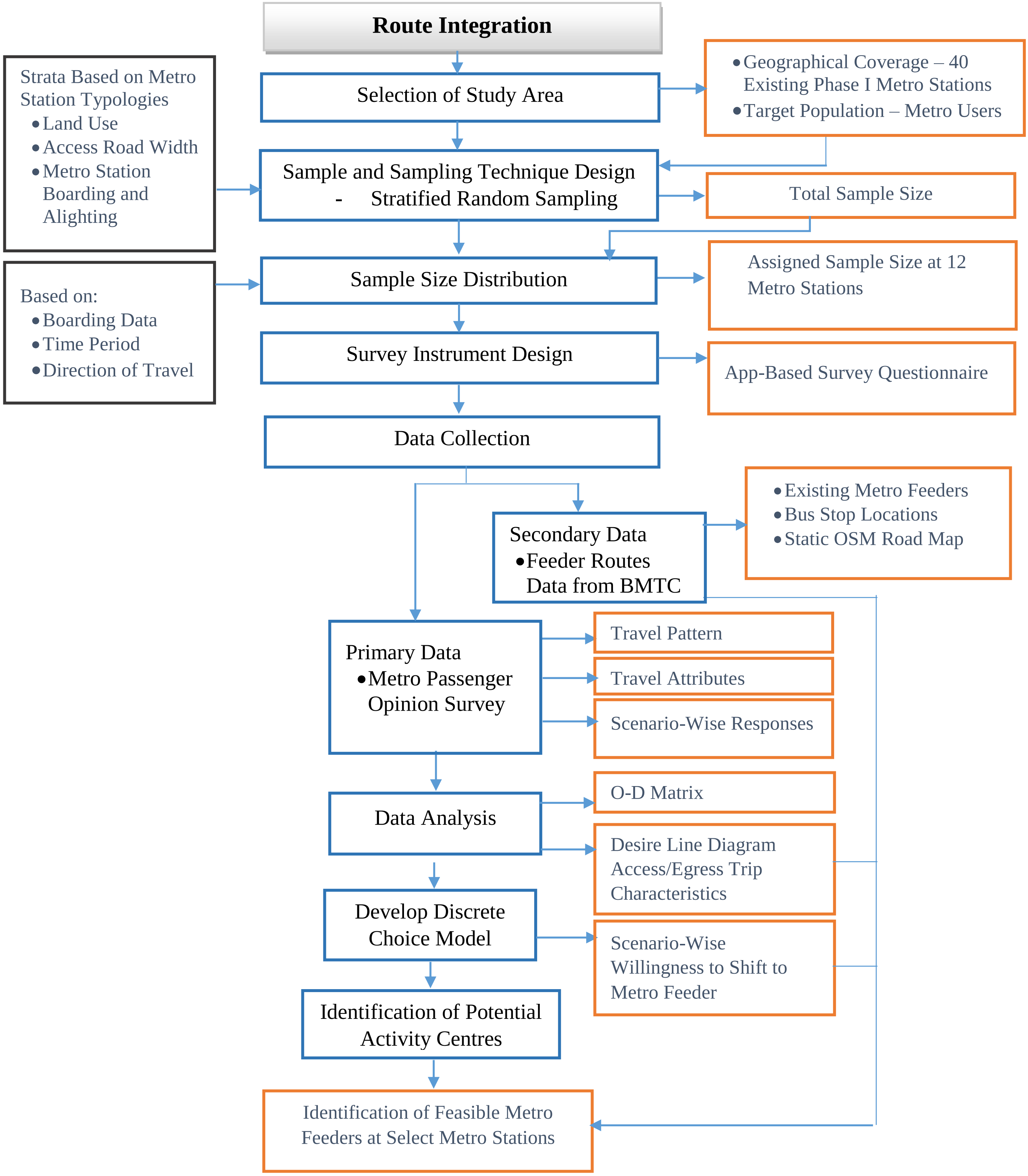

Figure 1: Process of Metro - bus route integration

6.2. Sample and Sampling Design

6.2.1. 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 listed below:

1. Existing land use within a radius of 500 metres around the Metro station
2. Access road width
3. Boarding data

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

Table 1: 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										1	Transport Hubs
Yeshwanthpur											
Baiyappanahalli											
City Railway Station											
Nagasandra										2	High Residential, 30-80 m Road, HB
Dasarahalli											
Yelachenahalli											
Rajajinagar											
Banashankari											
J. P. Nagar											
Vijayanagar											
Trinity											
Sandal Soap Factory										3	Non-Residential, 30-50 m Road, HB
M. G.Road		ü									
Mysore Road											
National College										4	Residential, 12-30 m Road, HB
Southend Circle											
R. V. Road											
Indiranagar											
Sampige Road											
Vidhana Soudha		ü									
Sir M. Visveshwaraya		ü									

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										5 A & 5 B	Residential, 30-80 m Road, LB
Deepanjali Nagar											
Mahalakshmi											
Halasuru											
Attiguppe											
Jalahalli											Mixed Land Use, 30-80 m Road, LB
Peenya Industry											
Peenya											
Goraguntepalya											
Cubbon Park		ü									
S. V. Road											
Chickpet		ü								6	Residential, 12-30 m Road, LB
K.R.Market		ü									
Kuvempu Road											
Srirampura											
Jayanagar											
Lalbagh											
Magadi Road											

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
- Low Boarding
- ü Other Additional Land Use (Defined by Colour)

Twelve representative Metro stations from each strata were selected for further study, as shown in Table 2: Metro passenger opinion survey locations and sample size 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. Further details of the sampling technique can be found in Annexure 2.

Table 2: Metro passenger opinion survey locations and sample size

Sr. No.	Metro Station	Typology	Total Sample Size
1	Majestic	1	173
2	Baiyappanahalli	1	209
3	Nagasandra	2	160
4	Banashankari	2	222
5	Mysore Road	3	172
6	M. G. Road	3	210
7	Indiranagar	4	251
8	Vidhana Soudha	4	153
9	S. V. Road	5	200
10	Attiguppe	5	181
11	Kuvempu Road	6	171
12	Goraguntepalya	5	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. For example, at Majestic Metro station, Metro passengers travelling in all the four directions were surveyed. Similarly, for terminal stations like Baiyappanahalli, Metro passengers travelling towards Mysore Road were surveyed. A detailed sample distribution is shown in Annexure 3.

6.3. Types of Data Collected from Various Sources

6.3.1. Secondary Data:

1. Station-wise boarding and alighting Metro passenger data
2. Existing land use data for Bengaluru

3. Existing feeder route data from BMTC
4. BMTC bus stop locations
5. Major activity centres around select Metro stations

6.3.2. Primary Data:

Metro Passengers Opinion Survey

- Travel pattern of Metro passengers
    - Origin-destination
    - Mode of travel for first and last mile connectivity – walking, two wheeler, car, cab, auto and bus
- Scenario-wise willingness to shift to Metro feeder for first and last mile

6.4. Instruments for data collection

6.4.1. Secondary Sources

A data requirement template was shared with the concerned agencies. The data collection template is given in Annexure 4.

6.4.2. Primary Surveys

For the primary data collection, a structured survey questionnaire was used to capture the required data. The questionnaire for this survey is given in Annexure 5. Open Data Kit (ODK), an Android-based mobile app, was used to collect the primary data[1].

Metro passenger opinion survey questionnaire comprised the following sections:

1. Passenger information (socio–economic profile)
2. Travel information
3. Scenarios for mode choice

6.5. Protocols for Data Collection and Ethics Followed

Secondary data for the current study was collected from BMTC and BMRCL. For the primary field survey at Metro stations, permission letters from BMRCL and BMTC were taken for conducting surveys within the Metro stations.

[1] Open Data Kit. 2018. 'Open Data Kit'. Home. 2018. https://opendatakit.org/

8. Data Collection and Analysis

8.1. Data collection

8.1.1. Primary Data

After the structured questionnaire was prepared, it was discussed with the stakeholders and revised to incorporate the suggested changes. This questionnaire was then tested by conducting a pilot survey at select Metro stations. This pilot survey revealed that the questionnaire took six minutes for a full response, whereas the frequency of the Metro was five minutes. Hence, the questionnaire was redesigned to capture the required data in less than five minutes.

This survey instrument was administered at 12 Metro stations, and 2,430 samples were collected. The primary survey attempted to collect responses from an equal number of men and women respondents.

The entire primary survey was carried out across a span of two working weeks. 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 2. The locations were duly identified based on the Metro station typology. The survey was carried out using ODK suite, which replaced paper-based forms. Specially trained field investigators and enumerators under the close guidance of supervisory staff were utilised for this purpose. All the data thus collected was compiled and subjected to a thorough verification and analysis.

The data from the primary survey was extracted in an Excel format. This data was then checked for completeness, invalid samples and data entry errors. After all these filters, a clean data set was considered for analysis.

8.1.2. Secondary Data

The Metro-feeder data received from BMTC was considered to understand the existing feeder route characteristics (origin, destination, route length and Metro stations covered). This data was also used to understand the underserved Metro stations and to avoid suggesting overlapping feeder routes.

8.1.3. Data Digitisation

Data digitisation consisted of plotting origin and destination of respondents based on landmarks and locations collected during Metro passenger opinion survey. To achieve this, the Geographical Information System (GIS) location—latitude and longitude of the passenger—was required. This was accomplished by writing a script in Python (a programming language), which fetches each survey respondent's landmark from the collected dataset and uses the Google Maps Application Programming Interface (API) to retrieve the GIS information. The script then filters out the latitude and longitude from the resultant GIS information and places the resultant latitude and longitude in the corresponding respondent's opinion in the dataset.

8.2. Data Analysis

A detailed socio-economic profile of respondents was prepared (Annexure 6). Out of 2,432 respondents interviewed, 54% were male and 46% were female. 49% of the Metro users were in the age group of 19–30 and about 42% of Metro users were in the age group of 31–50. 53% of the respondents had a monthly HH income within a range of INR 20K–50K. 70% respondents were from the working class; out of the total working respondents, 77% were on their daily work trips.

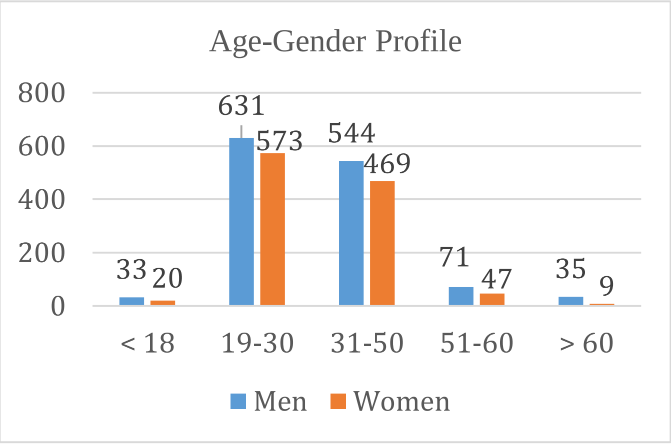

Figure 2: Age-gender profile of respondents

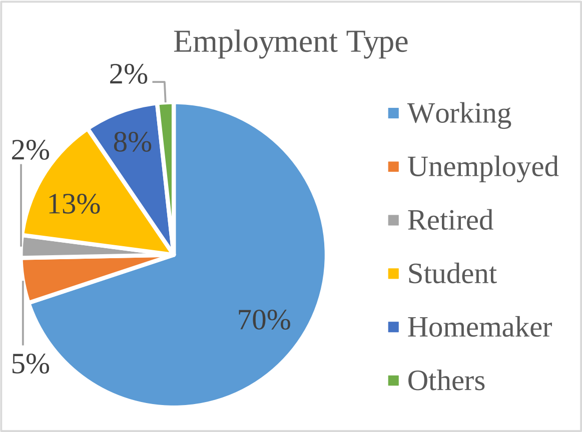

Figure 3: Employment profile of respondents

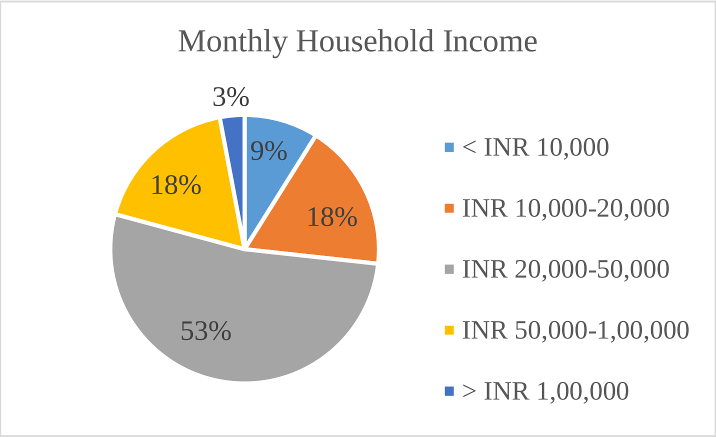

Figure 4: Income profile of respondents

8.2.1. Travel Pattern of the Respondents

Purpose and Frequency of Travel

The purpose and frequency of travel of Metro passengers are presented in Figure 5 and Figure 6. Of the total trips, 68% were for work trips, followed by educational trips (12%). 68% of the respondents were on their daily trips, followed by 18% who travelled weekly.

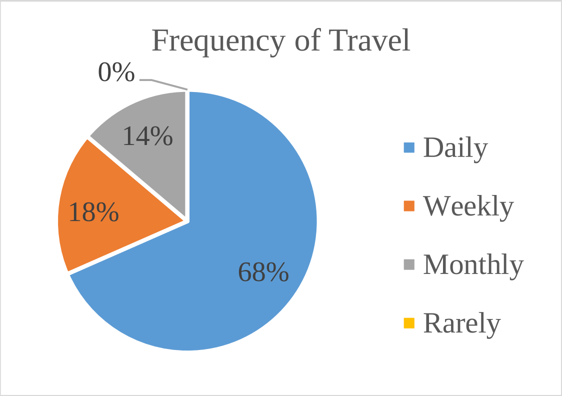

Figure 5: Frequency of travel

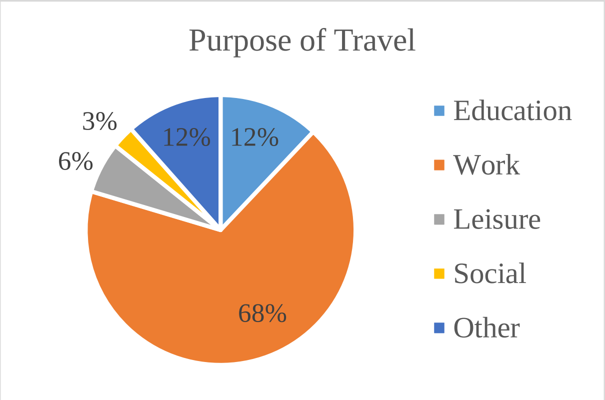

Figure 6: Purpose of travel

8.2.2. Formation of Origin - Destination Matrix

From the survey, each respondent's access (from origin to boarding Metro station) and egress (from alighting Metro station to destination) trip was plotted. All the origins and destinations of the survey respondents were assigned to the corresponding wards and plotted to understand the travel patterns of the respondents. Figure 7 represents Metro Phase I corridors (East–West & North–South), Metro stations, ward boundary and number, access trips and egress trips. The access and egress trips were classified based on the number of trips between ward and Metro station. This desire line diagram, served as an input for proposing new Metro feeder routes.

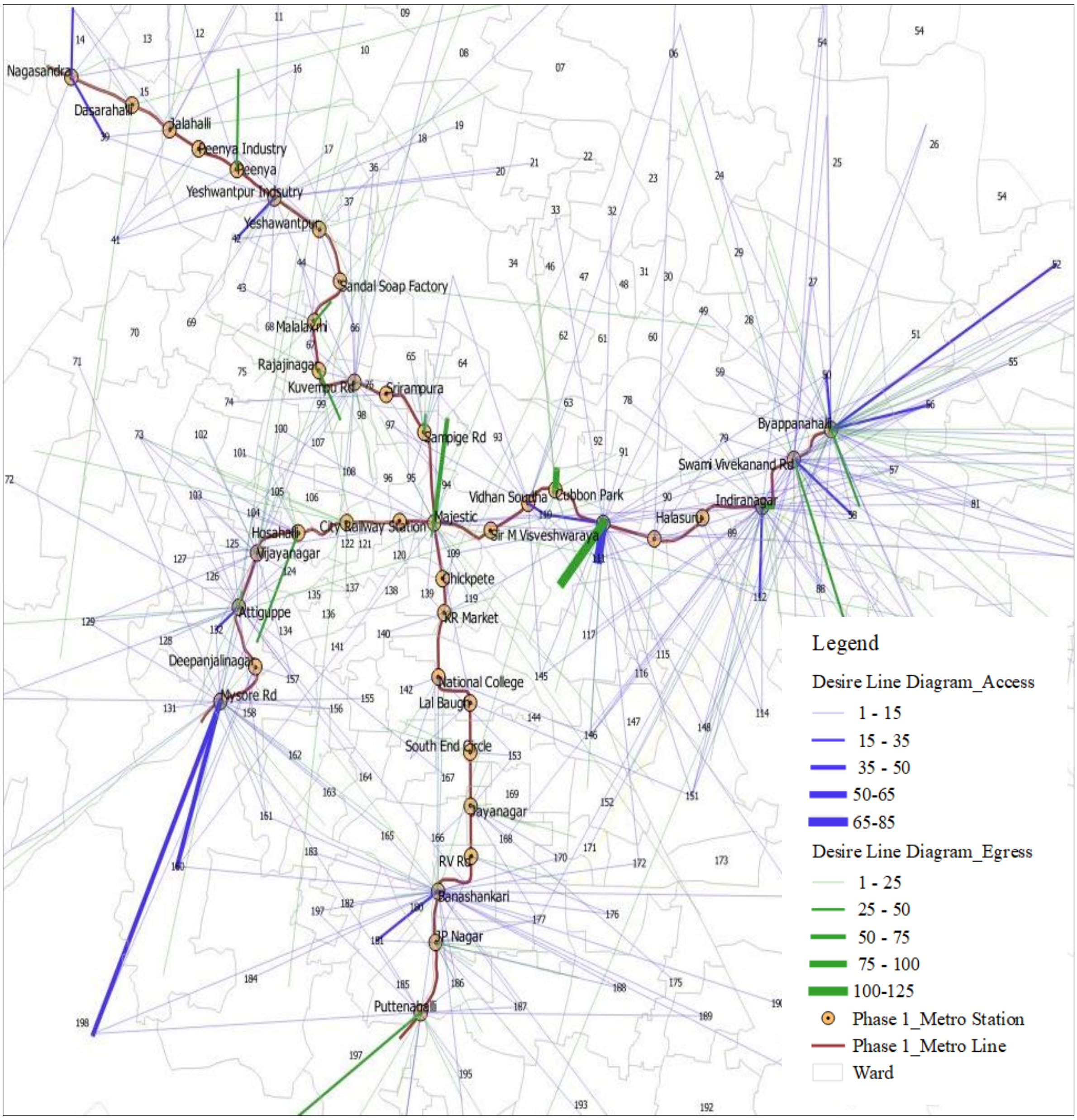

Figure 7: Desire line diagram

8.2.3. Access and Egress Mode

The survey showed that almost 47% access trips and 57% egress trips of the respondents were on foot. Bus was the second preferred mode for access (18%) and egress (15%). Table 3 shows the access and egress mode share.

Table 3: Access and egress mode share

Mode of Travel	Access		Egress	
	Count	Percentage	Count	Percentage
Walking	1,131	47%	1,380	57%
Car	82	3%	19	1%
Two Wheeler	419	17%	190	8%
Auto	279	11%	346	14%
Bus	436	18%	376	15%
Cab/Taxi	75	3%	102	4%
Share Taxi	8	0%	16	1%
TOTAL	**2,430**	**100%**	**2,428**	**100%**

8.2.4. Access and Egress Distance

26% of the access trips and 33% of the egress trips of the respondents are less than 0.5 km, as shown in Table 4. The maximum share of access trips (37%) and egress trips (36%) fall in the rage of 0.5-2 km.

Table 4: Access and egress distance

Distance	Access		Egress	
	Count	Percentage	Count	Percentage
< 0.5 km	631	26%	793	33%
0.5–2 km	901	37%	874	36%
2–5 km	596	25%	512	21%
> 5 km	302	12%	252	10%
TOTAL	**2,430**	**100%**	**2,431**	**100%**

8.2.5. Relationship between Mode of Transport and Travel Time

Table 5 shows the relation between access mode share and the time taken for the respective journeys. Out of the 47% of the access trips by walking, it is observed that 36% of the respondents take less than 10 minutes to reach the Metro station whereas 10% of the respondents take 10-20 minutes. Cab users take 10-20 minutes to reach the Metro station, whereas the majority of the two wheeler users reach the Metro station in 0-20 minutes.

Table 5: Access time–mode relationship

Mode	**Mode Wise Access Trips w.r.t Time (minutes)**							**Access Trips Mode Share**
	0-10	**10-20**	**20-30**	**30-40**	**40-50**	**50-60**	**>60**	
Walk	**36%**	**10%**	0%	0%	0%	0%	0%	47%
Two Wheeler	7%	7%	2%	0%	0%	0%	0%	17%
Auto	4%	6%	1%	0%	0%	0%	0%	11%
Cab	0%	1%	1%	0%	0%	0%	0%	3%
Bus	3%	8%	4%	1%	1%	1%	0%	18%
Car	1%	1%	0%	0%	0%	0%	0%	3%
Share Taxi	0%	0%	0%	0%	0%	0%	0%	0%
Total Access trips								100%

Table 6 shows the relation between egress mode share and time taken for the respective journeys. Out of the 57% egress trips by walking, 44% of the respondents take less than 10 minutes to reach their destination from the alighting Metro station whereas 13% take 10-20 minutes. Most of the two wheeler and auto users take less than 20 minutes to reach their destination.

Table 6: Egress time–mode relationship

Mode	**Mode wise egress trips w.r.t Time (minutes)**							**Egress Trips Mode Share**
	0-10	**10-20**	**20-30**	**30-40**	**40-50**	**50-60**	**>60**	
Walking	**44%**	**13%**	0%	0%	0%	0%	0%	57%
Two Wheeler	4%	3%	1%	0%	0%	0%	0%	8%
Auto	5%	8%	2%	0%	0%	0%	0%	14%
Cab	1%	2%	1%	0%	0%	0%	0%	4%
Bus	2%	5%	4%	1%	1%	1%	0%	15%
Car	0%	0%	0%	0%	0%	0%	0%	1%
Share Taxi	0%	0%	0%	0%	0%	0%	0%	1%
Total Egress trips								100%

It shows that 85% respondents spend less than 20 minutes for their access trips. Similarly, 88% spend less than 20 minutes for their egress trips. Only the respondents using bus as first or last mile connectivity spend more than 30 minutes for their access or egress trip.

In summary, the access and egress trips within a radius of 0.5 km are not considered for mode choice analysis and identification of feeder routes. This is because Metro users within a walkable range are not potential users for feeder services. For feeder route analysis, 74% of the access trips and 67% of the egress trips are considered.

9. Findings and Discussion

Results of the detailed analysis are described in the following section.

9.1. Expected Shift to Metro Feeder Service

In this study to estimate the probability of shift from the current access and egress modes of transport to Metro feeder service, the Discrete Choice Model (DCM) was used. The socio-economic data, travel characteristics data and the willingness to shift to Metro feeder service from current modes of transport (captured during the Metro passenger opinion survey) served as an input for DCM. A detailed explanation of the DCM is given in Annexure 7.

To understand this shift, a Multinomial Logit Discrete Choice Model (Koppelman and Bhat 2006) was developed using BIOGEME[2] considering the revealed preference (RP) and stated preference (SP) survey data (collected from the Metro passenger opinion survey). The current mode of transport was considered from the RP data and the preferred mode of transport was considered from the SP data. The probability of shift was calculated for different scenarios.

The Metro passenger opinion survey was designed to collect current mode (two wheeler, cars, auto, cab, shared taxi, bus) travel time and travel cost data. Therefore, the scenarios to understand the willingness to shift to a new mode (Metro feeder) was defined in terms of these two parameters for AC and non-AC services. Details of the scenarios are given in Table 7.

Table 7: Scenario details

Scenarios	Travel Cost	Frequency	Comfort
Scenario 1	Equivalent to existing AC bus fare	15 minutes	AC Service
Scenario 2	20% reduction in existing AC bus fare	10 minutes	
Scenario 3	Equivalent to existing ordinary bus fare	15 minutes	Non-AC Service
Scenario 4	20% reduction in existing ordinary bus fare	10 minutes	

The expected shift to Metro feeder service, at select 12 Metro stations, from the current mode of access is shown in

[2] Biogeme is an open-source software product designed for the maximum likelihood estimation of parametric models in general, with a special emphasis on discrete choice models.

Table 8. For access trips, Goraguntepalya, SV Road, Mysore Road and Indiranagar appear favourable for feeder bus services. A maximum willingness of 44% is estimated at SV Road Metro station for Scenario 2. The probability of shift calculations for SV Road Metro station are detailed in Annexure 7.

Table 8: Probability of shifting to Metro feeder service - Access

Survey Location	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Attiguppe	37%	40%	31%	35%
Baiyappanahalli	39%	42%	32%	36%
Banashankari	38%	41%	32%	36%
Goraguntepalya	39%	43%	34%	38%
Indiranagar	39%	42%	33%	38%
Kuvempu Road	34%	38%	30%	34%
MG Road	37%	40%	32%	36%
Majestic	35%	38%	29%	34%
Mysore Road	39%	42%	32%	37%
Nagasandra	37%	40%	31%	36%
SV Road	42%	44%	34%	38%
Vidhana Soudha	37%	41%	32%	36%

Table 9 shows the scenario-wise and station-wise willingness of respondents to shift to Metro feeder service for their egress trips. The maximum willingness to shift is estimated at Indiranagar and SV Road Metro station. For these two Metro stations, Scenarios 2 and 4 get a comparatively high figure.

Table 9: Probability of shifting to Metro feeder service - Egress

Survey Location	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Attiguppe	32%	38%	33%	38%
Baiyappanahalli	30%	35%	31%	36%
Banashankari	32%	37%	32%	38%
Gorguntepalya	32%	38%	33%	38%
Indiranagar	33%	39%	34%	39%
Kuvempu Road	27%	33%	28%	33%
MG Road	30%	35%	31%	36%
Majestic	29%	35%	30%	35%
Mysore Road	31%	36%	31%	37%
Nagasandra	31%	37%	31%	37%
SV Road	34%	40%	35%	40%
Vidhana Soudha	31%	38%	32%	38%

For the stations identified where there is a maximum potential to shift to feeder services, the study proposes preliminary feeder services. The preliminary feeders were proposed based on a combination of maximum desire lines, activity centres, road inventory and existing feeder routes.

9.2. Potential Metro Stations for Feasible Metro Feeders

Based on the DCM results and desire line diagram, Metro stations which have a potential for BMTC feeders service have been identified. The list of identified Metro stations is given below:

- SV Road
- Baiyappanahalli
- Mysore Road
- Goraguntepalya
- Banashankari
- Yelachenahalli

As SV Road and Baiyappanahalli are already well connected with BMTC Metro feeder routes, new feeder routes for the remaining stations were proposed. The proposed routes were designed such that the travel time for one trip should not exceed 30 minutes. The station-wise proposed feasible routes are shown in the maps below. The feasibility of the proposed routes needs to be validated by the stakeholder (BMTC).

9.3. Proposed Feeders at Banashankari Metro Station

Table 10: Details of proposed feeder routes at Banashankari Metro station

Origin	Destination	Via Route	MS Covered	Type	Route Length
Banashankari MS	Banashankari MS	Chikkalasandra, Padmanabha Nagar, Banashankari 2nd stage	Banashankari, JP Nagar, RV Road	Circular	11.2 km

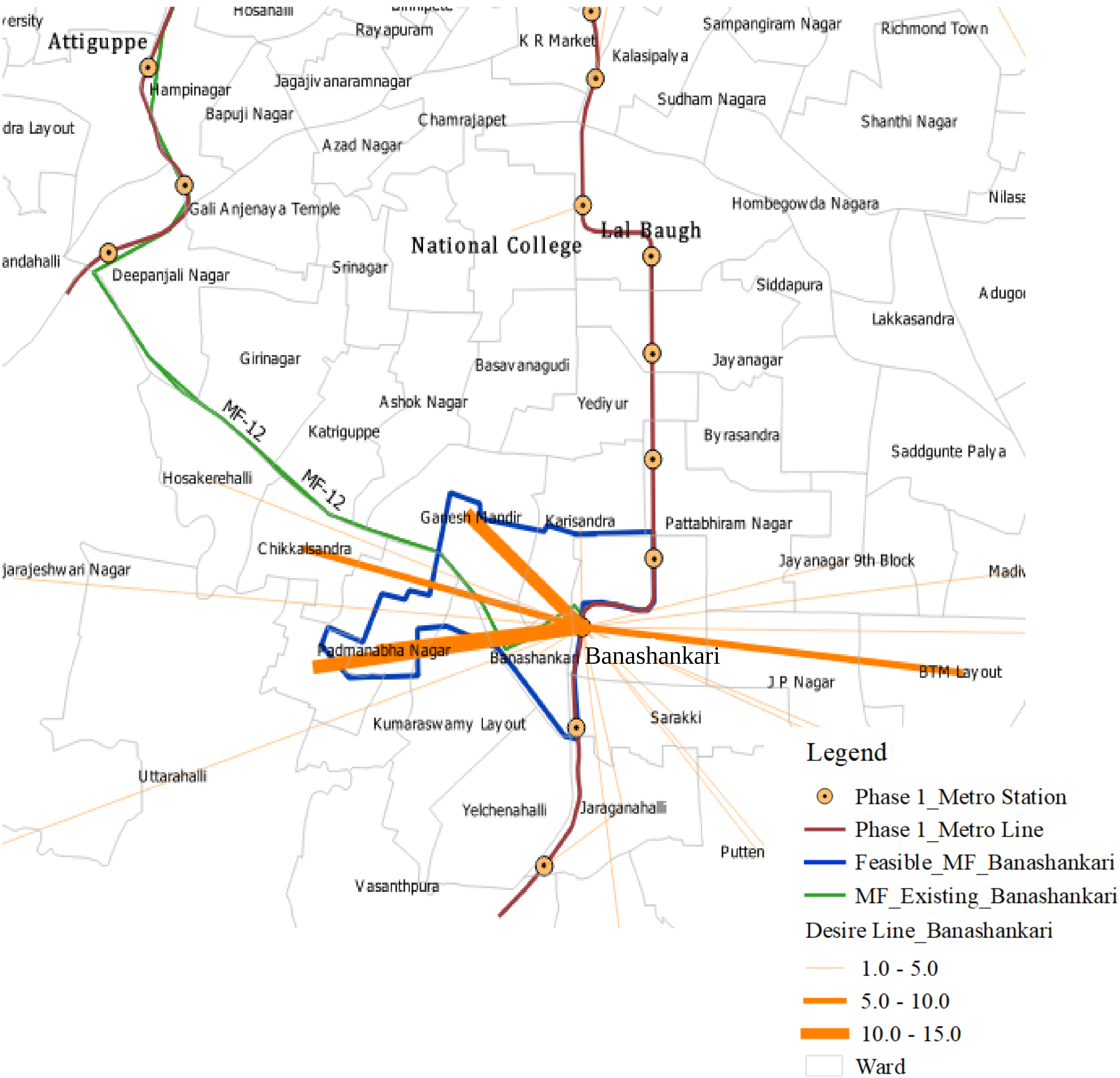

Figure 8: Proposed feeder routes at Banashankari Metro station

9.4. Proposed Feeders at Goraguntepalya Metro Station

Table 11: Details of proposed feeder route at Goraguntepalya Metro station

Origin	Destination	Via Route	MS Covered	Type	Route Length
Goraguntepalya	JP Park Chodeshwari BS	Mathikere Circle, Yeshwantpur RTO, Yeshwantpur TTMC	Sandal Soap Factory, Yeshwantpur, Goraguntepalya	Trunk	5.2 km

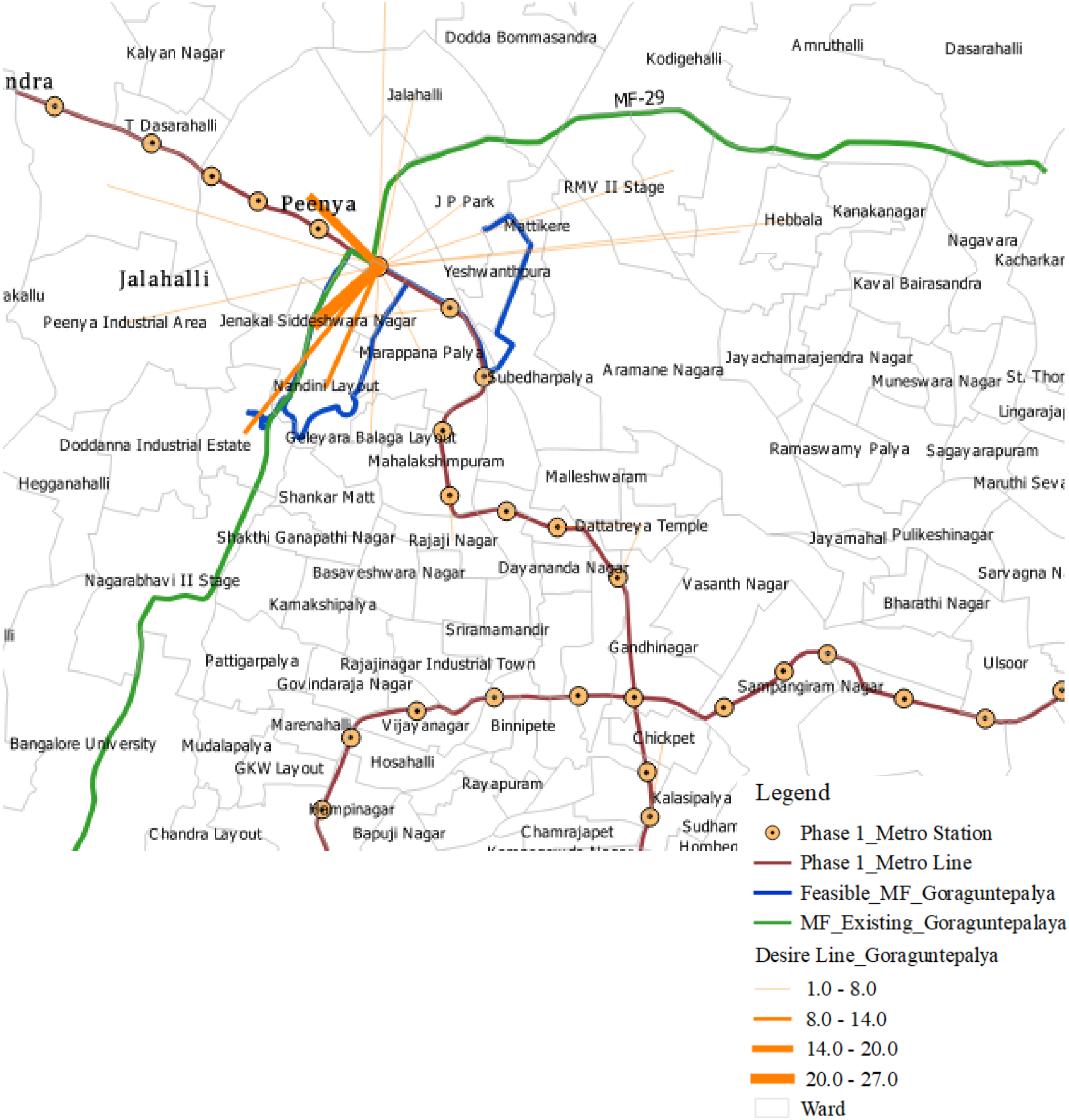

Figure 9: Proposed feeder routes at Goraguntepalya Metro station

9.5. Proposed Feeders at Mysore Road Metro Station

For Mysore Road Metro station, two feeder routes (MF -12, MF-14) are currently operated by BMTC. The access trips towards Rajarajeshwari nagar is already served by MF -14 and the other access trips towards Hemmigepura is well connected with the existing bus routes. So for this metro station, new Metro feeder was proposed connecting adjacent metro station (Deepanjali nagar), satellite bus station, and adjacent residential & commercial areas.

Table 12: Details of proposed feeder routes at Mysore Road Metro station

Origin	Destination	Via Route	MS Covered	Type	Route Length
Mysore Satellite BS	Mysore Satellite BS	Girinagar, Srinagar	Mysore Road, Deepanjali Nagar	Circular	10 km

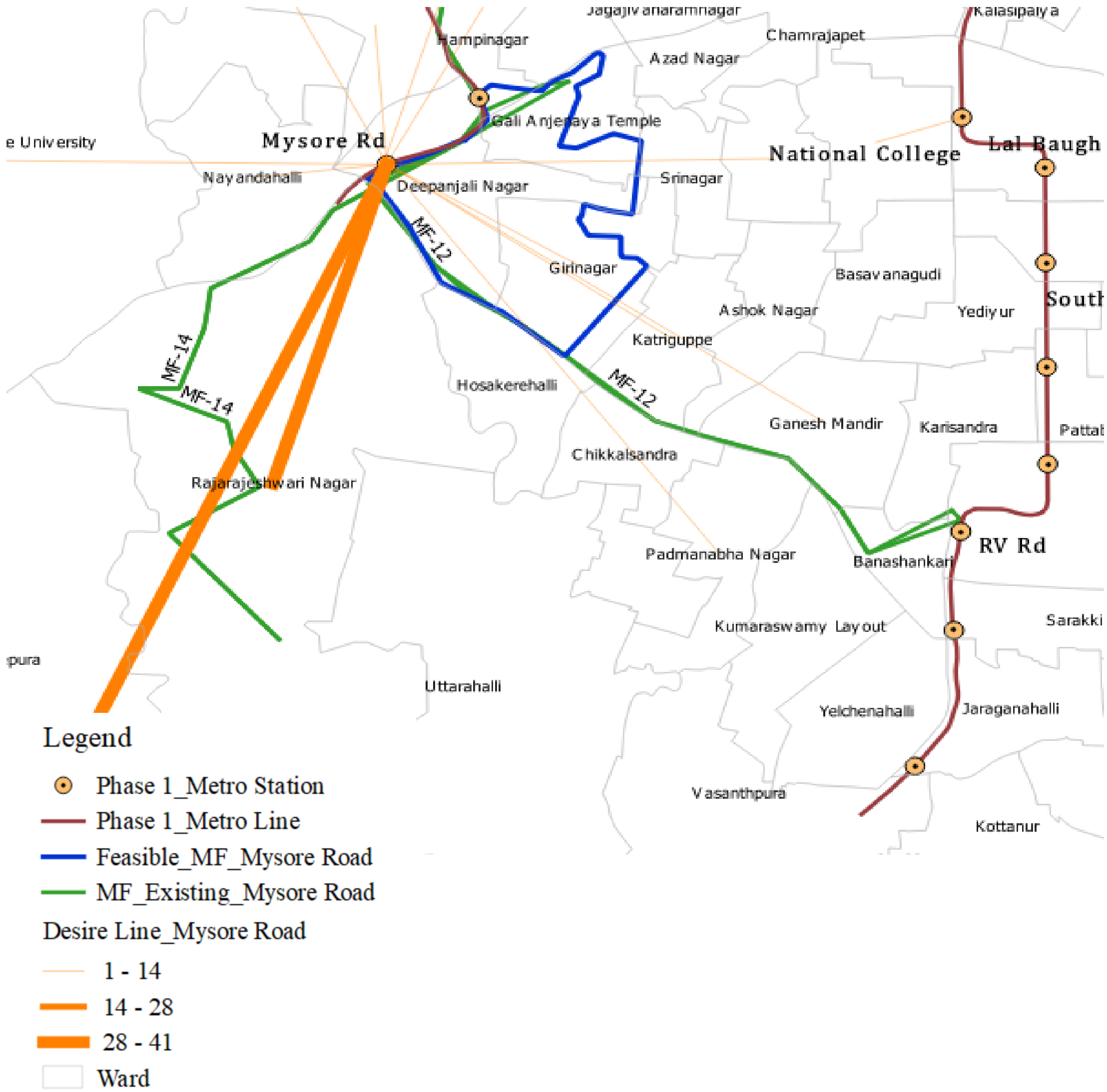

Figure 10: Proposed feeder routes at Mysore Road Metro station

9.6. Proposed Feeders at Yelachenahalli Metro Station

The proposed Metro feeder is based on connecting potential activity centres, adjacent Metro station (J P Nagar) and the areas for which this Metro station is closest. This proposed feeder also connects underserved BMTC routes (e.g. Gottigere to Yelachenahalli Metro station). The trips towards Kanakpura Road were not considered for proposing new Metro feeder service, as this location is well connected with existing BMTC bus services.

Table 13: Details of proposed feeder routes at Yelachenahalli Metro station

Origin	Destination	Via Route	MS Covered	Type	Route Length
Yelachenahalli MS	Yelachenahalli MS	Gottigere, Kottanur, Sarakki	Yelachenahalli, JP Nagar	Circular	12.9 km

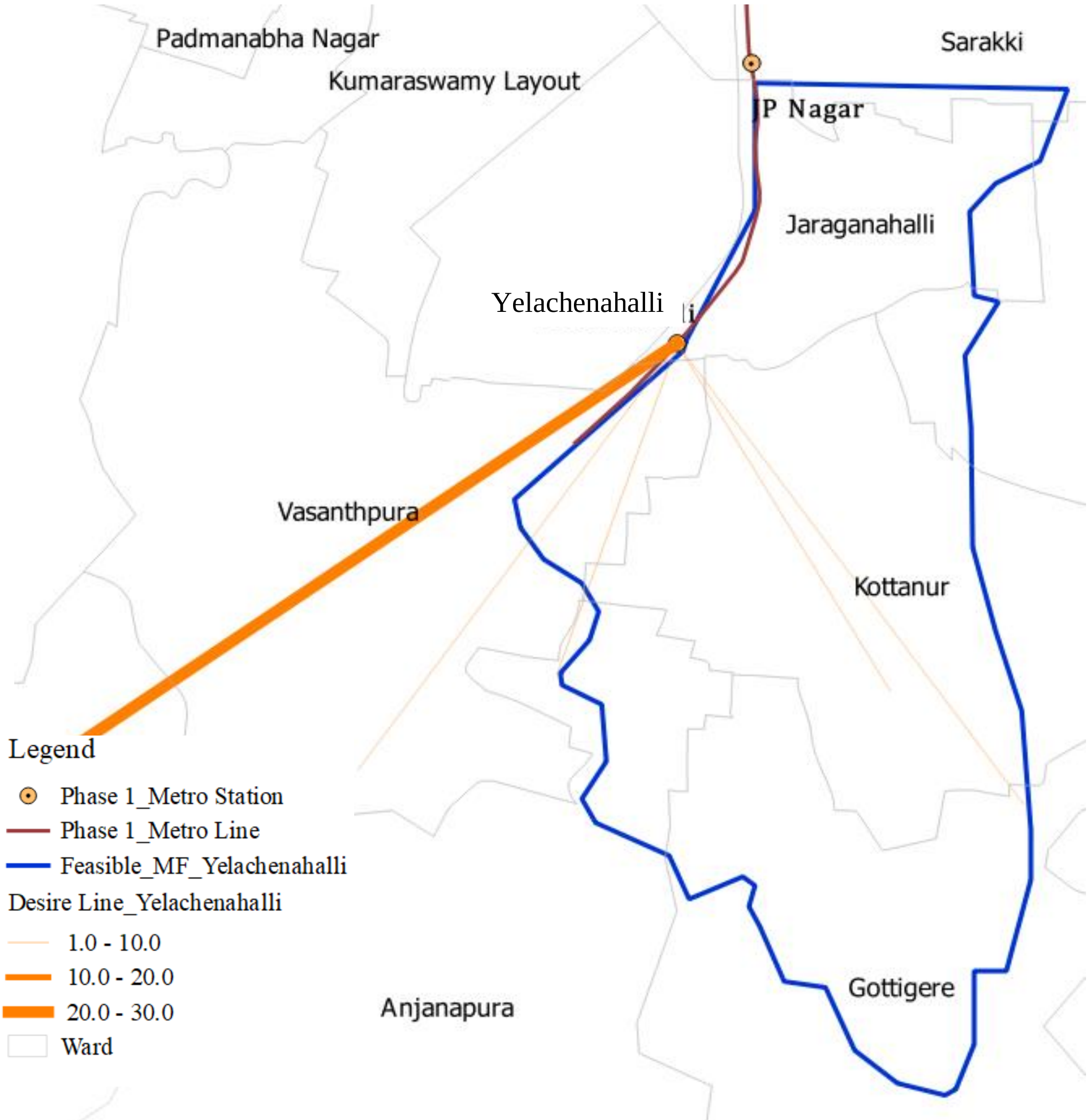

Figure 11: Proposed feeder routes at Yelachenahalli Metro station

10. Conclusions and Recommendations

Through this study, socio-economic and trip characteristics of current Metro users were collected through an opinion survey. The survey captured the users' willingness to shift to feeder service for both access and egress trips, under four scenarios (with varying frequency and travel cost). DCM was used to analyse the probability of shift from their current mode of transport to feeder service. The Metro stations where there is a maximum probability of shift are considered for proposing new feeder routes. Access and egress trip travel patterns, existing feeder services and activity centres were considered to propose new feeder routes.

The proposed feeder routes can serve as a basis for running trial services. This study methodology can be considered for future Metro feeder design.

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Annexure I

Feeder Routes – February 2018

Route No.	Origin	Destination	Route Length (km)	Schedules	Metro Station
MF-1	SV Road MS	Whitefield TTMC	8.5	56	SV Road, Baiyappanahalli
MF-1A	SV Road MS	SV Road MS	23	14	SV Road, Baiyappanahalli
MF-2	HAL Main Gate	TC Palya	23	19	SV Road, Baiyappanahalli
MF-2A	SV Road MS	HAL Main Gate	5	16	SV Road, Baiyappanahalli
MF-3	Baiyappanahalli MS Back Gate	K R Puram	7.1	27	Baiyappanahalli
MF-5	Central Silk Board	Old Baiyappanahalli	9.8	18	SV Road
MF-6	Central Silk Board	SV Road MS	9.9	83	SV Road
MF-8	Kalyananagara Bus Stand	Baiyappanahalli MS Back Gate	7.8	28	Baiyappanahalli
MF-12	Banashankari TTMC	Vijayanagar	10.1	59	Vijayanagar, Attiguppe, Deepanjalinagar, Mysore Road, Banashankari
MF-13	Vijayanagar	Vijayanagar	20.4	11	Attiguppe, Vijayanagar
MF-14	BEML Layout 5th Stage	Mysore Road Satellite Bus Stand	8.5	7	Mysore Road, Deepanjalinagar
MF-23	Jalahalli MS	Vidyaranyapura	8.5	63	Jalahalli
MF-24	Nagasandra MS	Chikkabanawara	4.3	69	Nagasandra
MF-26	Kanakagiri Horamvu	Baiyappanahalli MS Back Gate	7.6	15	SV Road, Baiyappanahalli
MF-27	Nagasandra MS	Nagasandra MS	13.5	82	Nagasandra
MF-28	Peenya 2nd stage	Peenya 2nd stage	9.7	29	Peenya
MF-29	Nagavara	Kengeri TTMC	28.9	28	Goraguntepalya
V-MF-1	SV Road MS	SV Road MS	24	29	SV Road, Baiyappanahalli

Route No.	Origin	Destination	Route Length (km)	Schedules	Metro Station
VMF-1A	SV Road MS	SV Road MS	28	27	SV Road, Baiyappanahalli
VMF-1B	SV Road MS	Whitefield TTMC	11	64	SV Road, Baiyappanahalli
VMF-10	Central Silk Board	K R Puram	13	14	SV Road, Baiyappanahalli
VMF-11	SV Road MS	ITPL	11	15	SV Road, Baiyappanahalli
VMF-15	Baiyappanahalli MS Back Gate	Hebbal	12	20	SV Road, Baiyappanahalli

Annexure II

Stratified Random Sampling

Stratified Random Sampling is a method of sampling where the population is divided into homogenous groups ($N_1, N_2, N_3 \ldots$) known as strata. Simple Random Sampling (SRS) method is then used in each stratum to drawn samples. The advantage of this method is that it narrows the difference between different types of individuals through classification, which extracts representative samples and reduces the sample size (Shi 2014).

Steps in stratified random sampling:

The first step involved in the stratified random sampling method was to divide the population into different strata. Since the study area was the Phase I Metro corridor, the entire area was divided into different strata based on the Metro station typology. Six different strata were formed and the total population for these strata ($N_1, N_2, N_3 \ldots$) was the sum of the boarding passengers.

The sample size was calculated for each stratum using the SRS formula:

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

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

$$n = n_1 + n_2 + n_3 + \text{------} + n_h$$

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

Annexure III

Sample Size Distribution

Period of Survey – Jan 24 to Feb 9, 2018

Sl No	Metro Station	Date	Time Period			Total Sample Size	Direction			
			T1	T2	T3		N	S	E	W
1	Majestic	24.01.2018 25.01.2018	80	34	59	**173**	58	44	40	31
2	Baiyappanahalli	29.01.2018 08.02.2018	42	137	30	**209**	0	0	0	209
3	Nagasandra	29.01.2018 08.02.2018	36	91	33	**160**	0	160	0	0
4	Banashankari	29.01.2018 07.02.2018	63	99	60	**222**	222	0	0	0
5	Mysore Road	30.01.2018	94	41	37	**172**	0	0	172	0
6	MG Road	31.01.2018 06.02.2018	60	100	50	**210**	0	0	105	105
7	Indiranagar	30.01.2018 06.02.2018	77	131	43	**251**	0	0	126	125
8	Vidhana Soudha	31.01.2018 06.02.2018	35	88	30	**153**	0	0	76	77
9	SV Road	31.01.2018	79	86	35	**200**	0	0	0	200
10	Attiguppe	01.02.2018 08.02.2018	86	55	40	**181**	0	0	91	90
11	Kuvempu Road	01.02.2018 08.02.2018	53	80	38	**171**	85	86	0	0
12	Goraguntepalya	01.02.2018 07.02.2018	88	82	40	**210**	105	105	0	0
	TOTAL					**2,312**				

Annexure IV

Secondary Data Collection Template

Feeder Route No.	Origin	Destination	Route Length

Annexure V

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

Age group

Less than 18	19–30	31–50	51–60	Above 60

1. Employment type:
   a) Working
   b) Unemployed
   c) Retired
   d) Student
   e) Homemaker
   f) Others

2. Monthly household income

Less than INR 10,000	INR 10,000–20,000	INR 20,000–50,000	INR 50,000 –1,00,000	More than INR 1,00,000

3.

Origin (Landmark, Nearest Bus Stop & PIN Code)	Destination (Landmark, Nearest Bus Stop & PIN Code)
Boarding Metro Station	Alighting Metro Station

4. Purpose of travel

Education	Work	Leisure	Social	Other

5. How often do you make this trip?

Daily	Weekly	Monthly

6. How long have you been using Metro?

Less than 3 months	3 to 6 months	6 to 9 months	More than 9 months

7. What was your previous mode of travel?

Cycle	Two Wheeler	Auto	Bus Route No. ________	Private Car	Taxi/ Cab	Commuter Rail

8. If the answer is BMTC, what prompted you to shift to Metro?

Sl 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?

Walk	Car	Two Wheeler	Auto	Bus Route No. ________	Cab/ Taxi	Share Taxi

10. Home to Metro station distance

Less than 0.5 km	0.5–2 km	2–5 km	More than 5 km

11. Travel Time to reach Metro station: ____________________ minutes

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?

Walk	Car	Two Wheeler	Auto	Bus Route No. ________	Cab/ Taxi	Share Taxi

14. Metro station to final destination distance

Less than 0.5 km	0.5–2 km	2–5 km	More than 5 km

15. Travel time to reach your destination from the Metro station: ________________ minutes

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

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

18. Do you pay for parking? Yes/No

19. Scenarios and ranking (Would you shift to Metro feeder if ...)

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

*IVTT – In Vehicle Travel Time

20. Any other suggestions for improvement?

Annexure VI

Socio-Economic Profile of Respondents

Profile of Respondents	Category Range	Respondents	
		Count	Percentage
Gender	Male	1,314	54%
	Female	1,118	46%
TOTAL		**2,432**	**100%**
Age	<18	53	2%
	19–30	1,205	50%
	31–50	1,013	42%
	51–60	119	5%
	Above 60	44	2%
TOTAL		**2,434**	**100%**
Employment Type	Working	1,698	70%
	Unemployed	116	5%
	Retired	58	2%
	Student	326	13%
	Homemaker	189	8%
	Others	42	2%
TOTAL		**2,429**	**100%**
Monthly Household Income	< INR 10, 000	207	9%
	INR 10,000–20,000	420	18%
	INR 20,000–50,000	1,271	53%
	INR 50,000–1,00,000	427	18%
	> INR 1,00,000	70	3%
TOTAL		**2,395**	**100%**

Annexure VII

Discrete Choice Model

The study developed a Multinomial Logit Discrete Choice Model to understand Metro users' willingness to shift to Metro feeder service from the current mode of transport, based on their stated preference (SP) and revealed preference (RP) (Metro Passenger Opinion Survey). The socio-economic data, travel characteristics data and the willingness to shift from the current mode (captured in the survey) serve as inputs to the model.

The general expression for the probability of choosing an alternative 'i' (i = 1, 2, … j) from a set of j alternatives is:

$$P_r(i) = \frac{exp\ (V_i)}{\sum_{j=1}^{J} exp\ (V_j)}$$

Where

P_r (i) is the probability of the decision-maker choosing the alternative i, and

V_j is the deterministic utility function of the alternative j, which is generally represented by:

$$V(X_i) = \gamma_1 \times X_{i1} + \gamma_2 \times X_{i2} + \cdots \dots \dots .. \gamma_k \times X_{ik} + ASC$$

Where

γ_k is the parameter which defines the direction and importance of the effect of the attribute k on the utility of an alternative,

X_{ik} is the value of the attribute k for the alternative i, and

ASC is the Alternative Specific Constant (Error term which is unobserved and unmeasured).

The respondents were given four scenarios and asked to choose between the given mode (Metro feeder) and their current access/egress mode. The scenarios differ in travel cost, travel time and comfort (AC and non-AC service). The scenarios considered for the study are shown in Table 7.

Travel time for the proposed Metro feeder bus was considered based on in-vehicle time and out-vehicle time. The in-vehicle time was estimated by dividing the respondents' distance between origin and destination by the average journey speed in Bengaluru, that is, 15 kmph (Urban Mass Transit Company Limited 2011). The out-vehicle time was estimated considering walking time of five minutes (Diyanah, Hafazah, and Mohd Zamreen 2012) to reach the bus stop and waiting time at the bus stop based on the frequency of bus.

Travel time and travel cost for all the other current access/egress modes were calculated. Travel time was estimated by dividing the distance between the origin and the destination of the respondents by the average journey speed in Bengaluru. Travel cost for two wheeler and car was based on the petrol price and mileage of the respective modes. For auto, fare was calculated by taking a minimum charge of INR 25 for the first 2 km and INR 13 for each additional km (travel2karnataka 2017). For bus, fare was considered from the BMTC stage-wise fare data (BMTC 2018a).

Model Structure

Utility of a mode is defined in terms of mode attributes such as travel time and travel cost as well as socio-economic characteristics (Raturi and Verma 2017). The Multinomial Logit Model was developed by considering Metro users' access and egress modes and Metro feeder service (bus). Separate models for first mile (access) and last mile (egress) were developed. Ordinary bus users were also considered in the model, to understand their willingness to shift to Metro feeder services under different scenarios. Shared taxi users for the first mile model and cars and shared taxi users for the last mile model were excluded as the number of respondents under those categories was very less.

Utility function for each alternative in RP & SP is given in Equations 1 and 2 respectively. Utility equations corresponding to SP are multiplied with a parameter λ, an unknown parameter to reflect the impact of unobserved factors that are necessarily different in real-choice situations than in hypothetical survey situations (Train 2002). The explanatory variables considered are Alternative Specific Constant (ASC), travel cost (Cost), travel time (Time) and household income (Income). Two wheeler was considered as the base or reference alternative, so the ASC of two wheeler was fixed to zero.

$$U_j^{RP} = ASC_j^{RP} + \beta_1 \times Time_j + \beta_2 \times Cost_j + \beta_{3j} \times Household\ Income \quad (1)$$

$$U_j^{SP} = (ASC_j^{SP} + \beta_1 \times Time_j + \beta_2 \times Cost_j + \beta_{3j} \times Household\ Income)\lambda \quad (2)$$

Estimated Parameters

The model considered data from 6,899 observations for the first mile and 4,787 observations for the last mile. The contribution of each attribute to the utility of an alternative is indicated by the sign of its coefficients. A positive value indicates a direct correlation on the utility and the negative value indicates an inverse correlation (Bajracharya 2008). The negative sign of travel time and travel cost indicates that higher the travel time and cost, lower is the probability of choosing that alternative.

First Mile Model

The coefficients estimated from this model for the probability of shift to Metro feeder for the first mile are presented in Table 14. A negative sign of travel time indicates that higher the travel time, lower is the probability of choosing Metro feeder service. Also, a negative sign of income indicates that higher the monthly household income, lower is the probability of choosing Metro feeder service.

Table 14: Estimated coefficients –First mile model

Attribute	Value	p-value
ASC_AUTO_SP	0.569	0
ASC_BUS_SP	3.22	0
ASC_CAB_SP	-1.57	0
ASC_CAR_SP	0	
ASC_MF_SP	3.99	0
ASC_TW_SP	2.16	0
ASC_WALK_SP	4.31	0
B_COST	3.23	0
B_INCOME_BUS	-0.178	0
B_INCOME_MF	-0.00871	0.51
B_INCOME_WALK	-0.146	0
B_TIME	-5.23	0
LAMBDA	0.973	0

Last Mile Model

The coefficients estimated for the probability of shift to Metro feeder for the last mile are presented in Table 15. A negative sign of travel cost and travel time indicates that higher the travel cost and travel time, lower is the probability of choosing Metro feeder service. Also, a negative sign of income indicates that higher the monthly household income, lower is the probability of choosing Metro feeder service.

Table 15: Estimated coefficients–Last mile model

Attribute	Value	p-value
ASC_AUTO_SP	0.676	0
ASC_BUS_SP	0.928	0
ASC_CAB_SP	-0.486	0
ASC_MF_SP	1.59	0
ASC_TW_SP	0	
ASC_WALK_SP	2.11	0
B_COST	-0.406	0.05
B_INCOME_BUS	-0.0559	0
B_INCOME_MF	0.0586	0
B_INCOME_WALK	-0.0349	0.02
B_TIME	-4.85	0
LAMBDA	1.2	0

Initiative 2: Infrastructure Integration

Initiative 2: Infrastructure Integration

Abbreviations and Acronyms

Abbreviations	Full Form
ATM	Automatic Teller Machine
BBMP	Bruhat Bengaluru Mahanagara Palike
BDA	Bengaluru Development Authority
BMRCL	Bangalore Metro Rail Corporation Limited
BMTC	Bengaluru Metropolitan Transport Corporation
Comm.	Commercial
CSTEP	Center for Study of Science, Technology and Policy
GoK	Government of Karnataka
HB	High Boarding
IPT	Intermediate Public Transport
LB	Low Boarding
P./Semi Public	Public/Semi Public
PT	Public Transport
RMP	Revised Master Plan
TTMC	Traffic and Transit Management Centre

Executive Summary

Bengaluru Metropolitan Transport Corporation (BMTC) and Bangalore Metro Rail Corporation Limited (BMRCL) are the primary public transport service providers in Bengaluru, and aim to provide safe, reliable, clean and affordable transportation. To achieve this aim and to make public transport the preferred mode of transport in Bengaluru, it is important to integrate these services.

In this context, Government of Karnataka has engaged Center for Study of Science, Technology and Policy (CSTEP) as a technical research institution to suggest ways for integration of BMRCL and BMTC. This study focuses on infrastructure integration[1], which comprises identification of planning interventions and design elements for each Metro station typology.

This study focussed on best practices and accessibility design case studies to arrive at a list of planning interventions and design elements for infrastructure integration. Metro stations were classified into different typologies based on land use within a radius of 500 metres (around the Metro stations), boarding and alighting of Metro commuters as well as access road width to each Metro station. For each Metro station typology, the planning and design elements were assigned to arrive at the desired elements matrix.

For 40 Metro stations (Phase I), a detailed assessment of land use and access road width data was done based on the Revised Master Plan, 2015. The boarding data for all the Metro stations was considered in the analysis. Detailed site visits were carried out at six Metro stations (one from each typology) to validate Metro Station Typology-Elements Matrix.

From the study, it was observed that infrastructure integration requires planning interventions and design elements. The important planning interventions such as bus stops, bus bays, pick-up and drop-off points and pedestrian crossings required upgradation. These planning interventions will help in smooth transfers of commuters between multiple modes of transport. It was also observed that design elements such as signages, footpaths, lighting, ramps, and railings were incomplete or missing. These design elements are needed for better accessibility in and around the metro stations. The Metro Station Typology-Elements Matrix provides a set of guidelines for future Metro station design for better infrastructure integration.

[1] For this study, the terms infrastructure integration and physical integration will be used interchangeably.

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1. Introduction

Given that BMRCL is a mass rapid transport service provider for Bengaluru, it is essential that there is seamless connectivity at metro station area which would ease of access. Hence, there is a need to provide enabling infrastructure elements at the existing Metro stations as well as plan for future Metro stations. This can be done by preparing a guideline which would allow planners to categorise the Metro stations into different typologies and plan for associated infrastructure elements. This would allow commuters to move seamlessly across multiple modes of transport at the Metro stations and may increase the public transport mode share. This study identifies required physical/infrastructure elements (planning interventions and design elements) according to the Metro station typology, for seamless multimodal connectivity.

Planning interventions in this study indicate the strategies to be implemented at Metro stations for seamless multimodal connectivity. Planning interventions include bus stops, bus bays, interchange points, parking facility, etc. Design elements include way-finding, signage, lighting, bus stop shelters, ramps, lifts, staircase, etc. Both of these are important for BMRCL and BMTC infrastructure integration, which would help BMTC feeder service to improve connectivity to BMRCL. More information on feeder services can be found in the Route Integration section.

2. Log Frame / Theory of Change / Programme Theory

Infrastructure integration comprises planning interventions and design elements at Metro stations for:

- Ease of access between different modes of transport
- Ensuring safety of commuters
- Providing a convenient and comfortable commute
- Saving transfer time

	Intervention Logic	Verifiable Indicators of Achievement	Sources and Means of Verification	Assumptions
Overall Objectives	*What are the overall broader objectives to which the activity will contribute?* To suggest planning interventions and design elements that will provide ease of access for commuters at Metro stations	*What are the key indicators related to the overall objectives?*	*What are the sources of information for these indicators?* • Primary survey/site visit[2] • Secondary data	
Specific Objectives	*What specific objectives is the activity intended to achieve to contribute to the overall objectives?* • To identify the required planning and design elements for infrastructure integration • To analyse feasibility of their implementation for different Metro station typologies	*Which indicators clearly show that the objective of the activity has been achieved?* • List of feasible physical elements (planning interventions and design elements) • Implementation of suggested elements by the local authorities (may extend beyond the study period)	*What are the sources of information that exist or can be collected? What are the methods required to get this information?* • Station accessibility plans • Site visits to obtain list of existing and missing elements	*Which factors and conditions outside the PI's responsibility are necessary to achieve that objective? (external conditions)* *Which risks should be taken into consideration?* • Willingness of competent authority to share the data • Willingness of competent authority to implement the recommendations

[2] For this study, the terms primary survey and site visit may be used interchangeably.

Expected results	*The results are the outputs envisaged to achieve the specific objective.* *What are the expected results? (enumerate them)* • Metro Station Typology – Elements Matrix • Suggested list of elements for select Metro stations	*What are the indicators to measure whether and to what extent the activity achieves the expected results?* Data availability and site visits as per the schedule	*What are the sources of information for these indicators?* • Secondary literature on Metro station typology & physical elements • Validation of elements checklist	*What external conditions must be met to obtain the expected results on schedule?* • Permission from competent authority to carry out site visit • Willingness of competent authority to share the data • Availability of literature
Activities	*What are the key activities to be carried out and in what sequence in order to produce the expected results?* *(group the activities by result)* 1. Secondary literature review for: • Identifying required planning interventions and design elements • Classification of Metro stations into various typologies • Preparing Metro station typologies-elements matrix 2. Conducting primary survey/site visit at select Metro stations for comparing existing elements with required elements 3. Suggesting feasible elements for select Metro stations	**Means:** *What are the means required to implement these activities, e. g. personnel, training, studies, etc.* • Urban planning experts • Transport planning experts • Training for conducting site visits and infrastructure planning • Surveys	*What are the sources of information about action progress?* • Site visits • Interaction with competent authority on implementation	*What pre-conditions are required before the action starts?* • Acceptance by the authority to go ahead with the study • Work plan for carrying out and completing the study

3. Progress Review

The progress review provides a brief overview of the existing infrastructure provided by different agencies in and around Metro stations.

3.1. Overview of Existing Infrastructure

BMTC provides the bus service, while Bruhat Bengaluru Mahanagara Palike (BBMP) is responsible for providing required infrastructure such as bus stops, bus bays, etc. Similarly, while BMRCL runs the Metro service, different agencies are responsible for construction and maintenance of planning interventions and design elements. One key understanding from secondary literature and site visits is that there are multiple agencies that function independently and don't necessarily coordinate with each other on infrastructure integration. For example, the following issues were observed in and around Metro stations:

- Lack of pedestrian facilities
- Lack of seamless multimodal transfer facilities
- Lack of passenger information systems

4. Problem Statement

To examine the existing infrastructure at Metro stations and to develop a station accessibility matrix for providing seamless connectivity.

As mentioned in the earlier section, there is lack of proper infrastructure integration between BMRCL and BMTC. For example, even though there is a bus stop in the close vicinity of M. G. Road Metro station (towards Trinity Circle), it is difficult to locate it from the Metro station exit gate. Also lack of display indicating the destination routes of BMTC buses may deter commuters from using the available bus service. Yet another Metro station, Majestic, which is a multimodal transport hub, has good physical connectivity to all the modes but lacks in signage that would lead the commuters to their intended destinations (way-finding). In addition to this, some entrances and exits have been kept closed for security reasons, which presents challenges from an accessibility point of view.

Evaluation Question

What are the physical elements required for infrastructure integration in and around Metro stations?

This study identifies the physical elements required to overcome the above-mentioned challenges and identify the feasible elements at select Metro stations. It provides a guideline for the required physical elements according to the typology of the Metro station (as defined in Metro Station Typologies).

5. Objectives and Issues for Evaluation

Objectives

- To develop a Metro Station Typology-Elements Matrix
- To assess accessibility measures at select Metro stations

Scope

Target population: The target population are current Metro users as well as non-users of Metro who stay within a radius of five km (from Metro stations). They are the potential commuters[3] who might shift to Metro with improvement in infrastructure integration at Metro stations.

Geographical coverage: This section covers an area within a 500 metre radius from all the existing 40 Metro stations. Figure 1 illustrates the geographical coverage of the study around Yeshwanthpur Metro station.

Figure 1: Geographical coverage around Yeshwanthpur Metro station – 500 m radius

Source: (BDA 2016)

[3] Metro passenger opinion survey as part of route integration study revealed that major access and egress trips are within a radius of 5 km.

6. Evaluation Design

6.1. Information Sources

Secondary Literature:

Global best practices of infrastructure integration were identified as sources of information.

1. Towards a Walkable and Sustainable Bengaluru EMBARQ India (Embarq 2014)
2. Guidelines for station site and access planning – Washington (WMATA 2008)
3. Urban Street Design Guidelines, Pune (PMC and ITDP 2016)
4. NMT Policy and Strategy - Volume 2: Policy Framework, City of Cape Town (Directorate Transport 2005)
5. Universal Access Policy for the City of Cape Town (Tukushe 2014)
6. Portland Pedestrian Design Guide (Office of Transportation 1998)

Primary Site Visits:

Primary site visits at 6 Metro stations (refer Table 2) were carried out in order to:

1) Validate the Metro station typology
2) Compare the existing set of elements with the requisite set of elements

6.2. Research Methods

Secondary Data Literature:

As this study intends to understand the physical elements required for multimodal integration, it is necessary to understand the best accessibility practices in and around Metro stations. Global best practices helps to understand various physical elements that are necessary for infrastructure integration. This review also helps to understand the function of each identified element and contextualise it for Bengaluru Metro stations.

Primary Data Collection: Site Visits

After studying the global best practices and preparing the list of required physical elements for infrastructure integration, there is a need to contextualise this information to the study area. Site visits help validate Metro station typologies and examine the feasibility of introducing the identified elements for select stations. This study identifies the gaps between the best practices and the ground reality.

6.3. Evaluation Criteria or Indicators

This study focuses on the physical elements for infrastructure integration. Thus the compliance of existing elements with the desired elements for respective Metro station typologies forms the basis of evaluation.

7. Evaluation Methodology

7.1. Procedure Adopted for Infrastructure Integration

A systematic methodology was followed to achieve the expected results. Figure 2 shows the methodology flowchart adopted for this study.

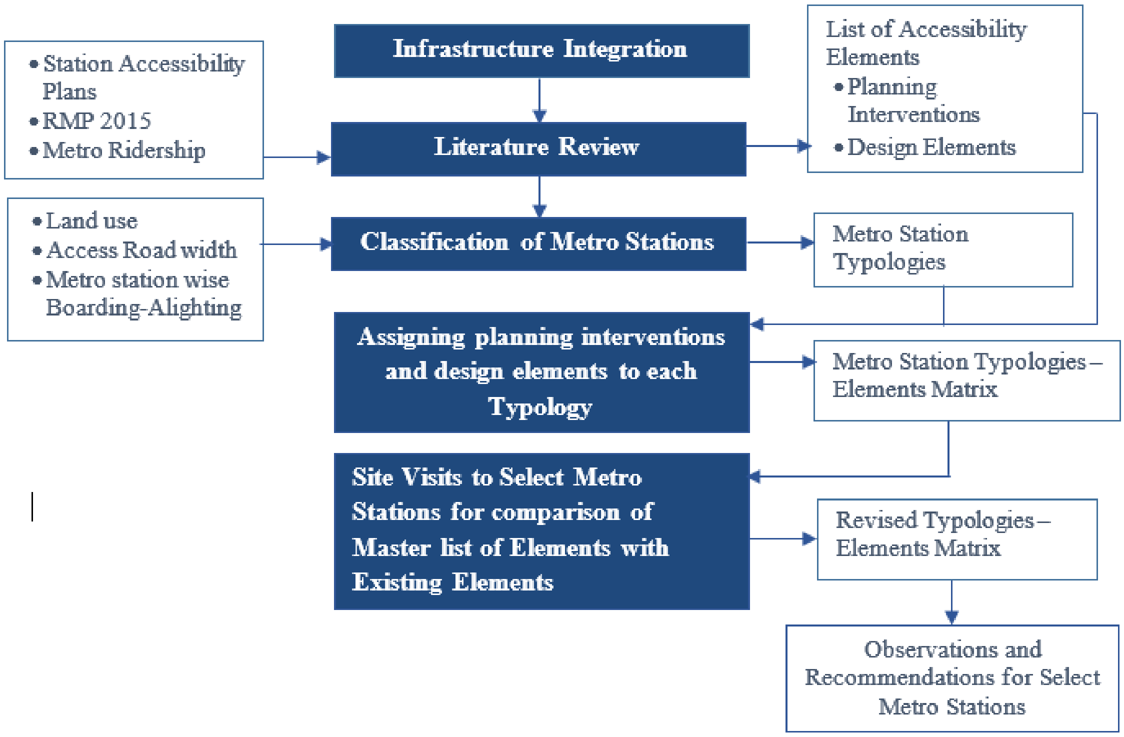

Figure 2: Methodology for infrastructure integration

7.2. Sample and Sampling Technique

In this study, the 40 Metro stations were classified based on existing land use, access road width and Metro station boarding and alighting data. One representative Metro station for each typology was surveyed through primary site visits.

7.3. Metro Station Typologies

The Metro stations were divided into different typologies based on parameters such as land use in the influence area (500m radius), access road width and boarding type – high boarding (HB) and low boarding (LB). The 6 station typologies are described below:

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

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

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

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

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

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

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

Table 1 shows the six different typologies of Metro stations.

Table 1: Metro station typologies

Station Name	Predominant Land Use				Access Road Width			Boarding Data		Type	
	Residential	Comm/ P-Semi-public	Industrial	Transport	50m - 80m	30m - 50m	12m - 30m	HB	LB		
Majestic										1	Transport Hubs
Yeshwanthpur											
Baiyappanahalli											
City Railway Station											
Nagasandra										2	High Residential, 30-80m road, HB
Dasarahalli											
Yelachenahalli											
Rajajinagar											
Banashankari											
J. P. Nagar											
Vijayanagar											
Trinity											
Sandal Soap Factory										3	Non-Residential, 30-50m road, HB
M. G. Road		ü									
Mysore Road											
National College										4	Residential, 12-30m road, HB
South End Circle											
R. V. Road											
Indiranagar											
Sampige Road											
Vidhana Soudha		ü									
Sir M. Visveshwaraya		ü									

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

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
- Low Boarding
- ü Other Additional Land Use (Defined by Colour)

After deriving the Metro station typologies shown in the above table, one Metro station from each type was selected for detailed study and site visits. The list of the Metro stations selected for further study is given in Table 2.

Table 2: Typology-wise Metro stations selected for the study

Station Name	Type
Yeshwanthpur	Type 1
Banashankari	Type 2
Sandal Soap Factory	Type 3
South End Circle	Type 4
S. V. Road	Type 5
K. R. Market	Type 6

7.4. Type of Data Collected from Various Sources

Secondary Literature: The secondary literature helped to prepare a list of physical elements required for station accessibility improvement. These elements were categorised as

1. Planning interventions
2. Design elements

Table 3 shows the required planning interventions and design elements for station accessibility.

Primary survey: The primary survey helped validate the Metro station typology and examine the feasibility of introducing the identified elements for select stations.

7.5. Instruments for Data Collection

Primary Survey: For the primary survey, a data collection template was prepared. This template is given in Annexure . The template helped identify the existing physical elements at select Metro stations and compare them with the global list of elements prepared from the secondary survey.

7.6. Protocols for Data Collection and Ethics Followed

For the secondary data collection, references in the form of published data and literature were used to arrive at Metro station typologies as well as the list of required physical elements. For the primary survey, permission letters from BMRCL, BMTC and the Commissioner of Police, Bengaluru, were obtained to conduct the site visits. Care was taken so that the regular movement of passengers as well as the duties of workers were not hampered.

8. Data Collection and Analysis

8.1. Procedure of Data Collection and Cleaning

Secondary Data Collection: Published reports were studied to identify the list of physical elements in and around Metro stations. Based on these studies, a list of physical elements recommended for infrastructure integration was prepared (Annexure). This list was revised to arrive at a finite list of elements to suit the Bengaluru context (Table 3).

Primary Data Collection: Primary data was collected by conducting site visits at 6 select Metro stations which represent six different Metro typologies. A template was prepared based on the secondary literature, to record the site visit observations (Annexure).

8.2. Procedure Adopted for Data Cleaning

The list of physical elements derived from the secondary literature was finalised to arrive at a finite list of elements to suit the Bengaluru context.

8.3. Data Analysis

Secondary Data Analysis:

Table 3: List of physical elements at Metro stations from global best practices

Intervention Criteria	Best Practice	References
Pedestrians and Cyclists		(PMC and ITDP 2016)
Right of way (ROW) including the pedestrian zone	Arterial Road – 30-80m Distributor Road – 12-30m Local Roads – 6-15m	
Pause points at regular intervals	500m	(Embarq 2014)
Multimodal shift points	500m	
Cycle parking spaces	At Metro station	
Public Transport Users		(PMC and ITDP 2016)
Bus stops		
Intermediate public transport (IPT) stands		
Private transport users		
Drop-off and pick-up points		
Public Amenities		(Embarq 2014)
Retail stores/ Eateries /ATMs	400m	
Street Network Modification		(WMATA 2008)
Tactile paving	400m	
Curb ramps	At Metro stations	
Way-finding	400m	
Walkways, elevators, escalators	At Metro stations	
Refuge islands and medians	400m	

Information kiosks	50m	
Garbage bins	50-200m	
Drinking water fountains	50-200m	

Primary Data Analysis:

A detailed analysis of six select Metro stations, one from each typology, is given below.

8.3.1. Typology 1 – Yeshwanthpur Metro Station

Figure 3: Study area for Yeshwanthpur Metro station

This typology includes the Metro stations having multiple transport modes in the vicinity of 500 metres. Yeshwanthpur Metro station has a railway station (Yeshwanthpur railway station), inter-city bus service (private and KSRTC), intra-city bus service (BMTC bus stops) within a radius of 500 metres. Figure 3 shows the area with its land use within 500 metres as well as 1 km radius of Yeshwanthpur Metro station.

Table 4: List of typology-wise required elements and existing scenario – Yeshwanthpur

Required Elements	Existing Scenario
Footpaths	Yes
Pedestrian crossings, interchange connections	No
IPT bays, pre-paid IPT counters	No (Only IPT Stops)
Way-finding	No
Pick up, drop off	No

Figure 4: Access points at Yeshwanthpur Metro station

Figure 4 illustrates the different access points at Yeshwanthpur Metro station for analysis. The access points D, E, F and G are adjoining the railway station and A, B and C are on the opposite side. Access B faces the railway yard.

Access point A

- There is a 1.5 metre wide footpath being used for parking (two-wheelers and four wheelers) and commercial activities, causing hindrance to pedestrian movement as well as obstructing the Metro entry signage. These encroachments need to be minimised for better pedestrian movement and improve accessibility to feeder buses.
- The Metro signage at the service road leading to access A is placed parallel to the road, hence it is not noticeable to the drivers coming from Tumkur Road. It should be oriented perpendicular to the road.

Figure 5: Parking on footpath at access point A

Figure 6: Commercial activities at access point A

Access point B

- This entry has only a lift and no staircase or escalators. Hence this entry can be dedicated for use by sick, aged or differently abled people.
- The footpath has a railing on one side that provides a sense of safety, especially for the differently abled and aged people. A vehicle bay has been provided at this entry but is utilised by freight vehicles. This space can be used as an IPT bay for this entry.

Figure 7: Access point B

Figure 8: Footpath at access point B

Access point C

- This access point has a one-way escalator going up as well as staircase.
- It is connected to the road level as well as the adjoining property which is approximately 1-1.5 metres below the road level.
- The footpath along this access point is not in a good condition and needs to be repaired. To avoid accidents, a railing is required on the off-road side of the footpath where there is a level difference.
- Since this access is on a service road, feeder and IPT services can be provided.


Figure 9: Access point C


Figure 10: Footpath at access point C

Access point D

- This entry has only a lift and no staircase or escalators. Hence this entry can be dedicated for use by sick, aged or differently abled people.
- There is a narrow footpath with a garbage dump on one side and untreated road space on the other. This untreated space can be used to widen the footpath and provide bus stops and IPT stops.

Figure 11: Access point D

Figure 12: Footpath at access point D

Access point E

- This access only has one lift and is meant to serve the railway travellers coming to the Metro station.
- This entry is not visible from the railway station side and hence railway travellers were seen using access F which opens right in front of the railway station.

Figure 13: Access point E

- Proper signage needs to be provided for people coming from the railway station, to identify this access point.

Access point F

- This access connects the Yeshwanthpur railway station to the Yeshwanthpur Metro station. Hence this access is majorly used by the public coming from or going to the railway station, that is, mostly by outstation travellers.
- Even then this access only has a stairway leading to the concourse, making people climb the whole staircase with their luggage.
- A signage to identify access point E will help the railway travellers.

Figure 14: Access point F

Figure 15: Staircase at access point F

Access point G

- This access point has a one-way escalator going up and a stairway to reach the concourse.
- This access also has a connection to the Yeshwanthpur Metro station.
- The regular Metro users coming from railway station use this access point.
- There is a narrow but well-maintained footpath outside this access.
- Currently the feeder buses tend to stop right in front of the entry, which hampers the vehicular movement on that road. But there is scope for provision of feeder bus stop without any physical intervention at this access (Figure 17).

Figure 16: Access point G

Figure 17: Footpath at access point G

8.3.2. Typology 2: Banashankari Metro Station

This typology includes the Metro stations having predominantly residential land use with access road width of 30 – 50 metres or 50 – 80 metres and high boarding. Figure 18 shows the area and land use in 500 metres radius of Banashankari Metro station.

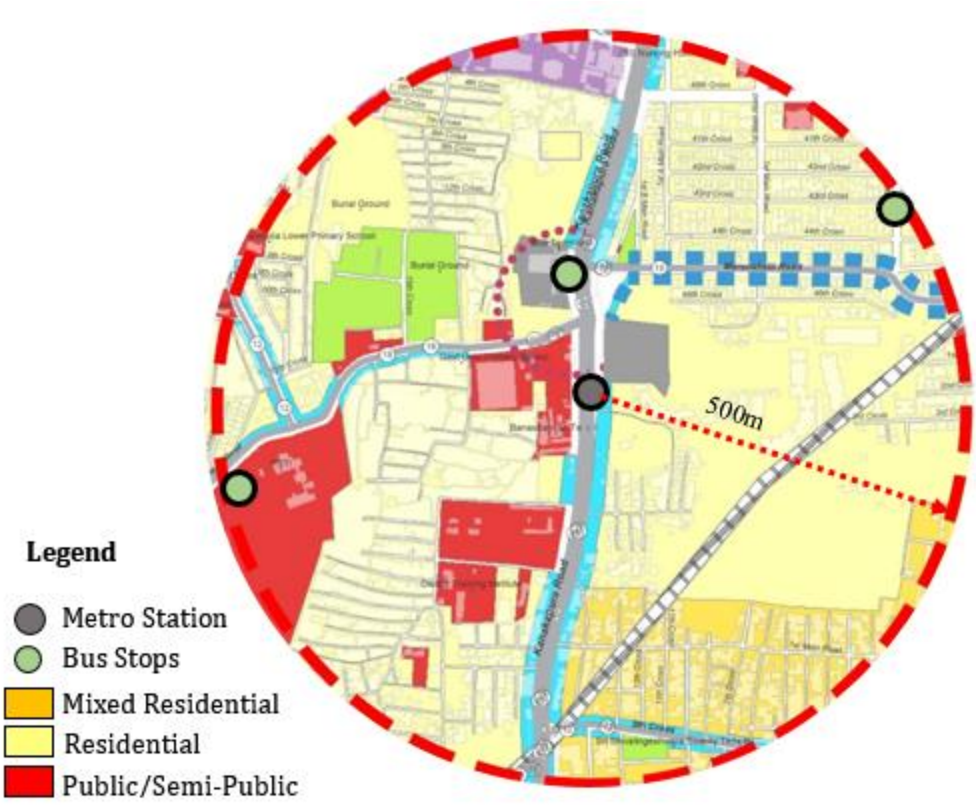

Figure 18: Study area for Banashankari Metro station

There are two BMTC bus stops and Banashankari TTMC within a walkable distance (<500 m) from Banashankari Metro station.

Table 5: List of typology-wise required elements and existing scenario – Banashankari

Required Elements	Existing Scenario
Bus bays/stops	Yes (Bus stops)
IPT bays	Yes (IPT stops)
Private vehicle parking	Yes (Two wheeler)
Footpaths	Yes

Figure 19 shows the access points at Banashankari Metro station. The access points C and D are on the Banashankari temple side, while A and B are on the opposite side of the temple.

Figure 19: Access points at Banashankari Metro station

Access point A

- This access point has a one-way escalator going up and a staircase to reach the concourse. Hence this is not preferred by differently abled or aged people.
- There is an unorganised two wheeler parking space, which extends to access B causing hindrance to pedestrian movement. This parking needs to be organised for ease of access.
- This access opens towards the Banashankari TTMC on the opposite side of the road. It is very difficult for pedestrians to reach the Banashankari TTMC from this access point.
- The Banashankari TTMC junction needs to be redesigned to ensure safe pedestrian crossing and easy access from the Metro station.
- A feeder bus stop can be designed at this access by utilising the service lane.

Figure 20: Access point A


Figure 21: Two-wheeler parking at access point A

Access point B

- This access point has an escalator, a lift as well as a staircase to reach the concourse.
- This point provides access to all the major activity centres around Banashankari Metro station – Banashankari Temple, Banashankari TTMC and Sarakki Market.
- A safe pedestrian pathway from this access to the TTMC needs to be designed.

Figure 22: Access point B

Figure 23: Parking at access point B

Access point C

This access was yet to be opened for public when the site visit was carried out.

Figure 24: Access point C

Access point D

- This access point has an escalator and a staircase to reach the concourse.
- The signage for this access gets blocked due to the commercial activities along the street.
- The footpaths are wide enough and provide a good scope for IPT transfer points.
- There is little scope for private parking and feeder bus stop at this access point.

Figure 25: Access point D

Figure 26: Footpath and IPT stop at access point D

8.3.3. Typology 3 – Sandal Soap Factory Metro Station

This typology includes the Metro stations situated in the non-residential areas with access road width of 30-50 metres and high boarding. This Metro station has only one bus stop within a radius of 500 metres (Figure 27).

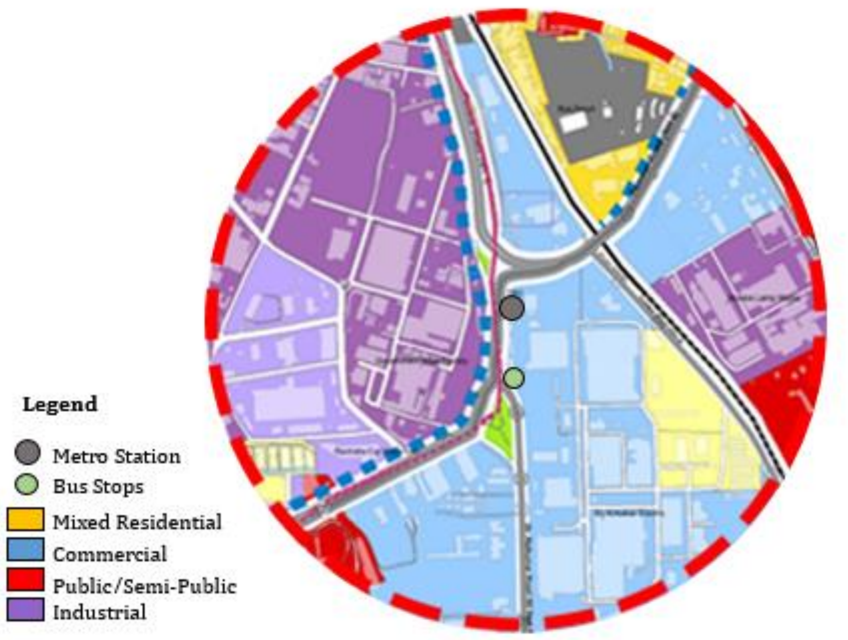

Figure 27: Study area for Sandal Soap Factory Metro station

Table 6: List of typology-wise required elements and existing scenario – Sandal Soap Factory

Required Elements	Existing Scenario
IPT bays, pre-paid IPT counter	No
Bus bays/stops	Yes
Footpaths	Yes
Way-finding	No

There are three access points to this Metro station - Access point A towards Dr Rajkumar Road, B on West of Chord Road and C on the East of Chord Road.

Figure 28: Access points at Sandal Soap Factory Metro station

Access point A

- This access has a staircase and escalator to reach the concourse. This is an access for the general public.
- There is a bus stop right next to this access point, which is the only bus stop in 500 metres radius of this Metro station.
- Signage for this access is blocked due to trees. Another signage needs to be put near the bus stop.
- Footpath is narrow and encroached by commercial activities.
- There is no dedicated space for IPT stops, but there is a scope to provide this facility beside the bus stop.

Figure 29: Access point A

Figure 30: Bus stop at access point A

Access point B

- This access caters to the differently abled passengers and hence has a lift with staircase. There is a ramp to reach the lift lobby.
- There is a well-maintained 1.2 metre wide footpath at this access. This space has been bifurcated to provide space for hawkers and pedestrians (Figure 32).
- There is a paid two and four wheeler parking space at this access point.

Figure 31: Access point B

Figure 32: Footpath at access point B

Figure 33: Parking at access point B

Access point C

- This access is not open to the public.
- It has two and four wheeler parking space.
- The footpath is very narrow and not pedestrian friendly. The parking space could be redesigned to accommodate a new, wider footpath (for proper pedestrian movement) as well as the required parking.

Figure 34: Access point C

Figure 35: Parking at access point C

8.3.4. Typology 4 – South End Circle Metro Station

This typology includes Metro stations located in a predominantly residential area with access road width of 12-30 metres and high boarding. This Metro station has 10 bus stops and institutions such as Vijaya College within a radius of 500 metres. Figure 36 shows the area covered within a 500 metre radius from the South End Circle Metro station (with land use and bus stops).

Figure 36: Study area for South End Circle Metro station

Table 7: List of typology-wise required elements and existing scenario – South End Circle

Required Elements	Existing Scenario
IPT bays/stops	Yes
PV parking	Yes
Footpaths	Yes

There are three access points to this Metro station. Figure 37 illustrates the three access points for further analysis. Access point A is located towards Banashankari, access point B is a central entry on the Eastern side of the Metro station and the access point C is located on the North of the Metro station.

A is accessible for people driving towards the South, whereas B and C are accessible for people driving to the North.

Figure 37: Access points at South End Circle Metro station

Access point A

- This access point has an escalator and a staircase to reach the concourse. There are no ramps and lifts, hence this access is not accessible for differently abled and aged people.
- There is a Metro signage at this access, but is blocked due to the IPT stop.
- There is a wide footpath which narrows down at this access point.

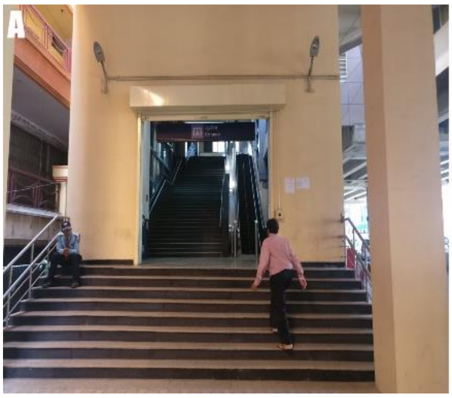

Figure 38: Access point A

Figure 39: Autos at access point A

Access point B

- This access has an escalator and stairs, hence it is not accessible for the differently abled and aged people.
- Two wheelers are usually parked on the footpath and four wheelers on the road along the footpath. This area can be segregated to accommodate IPT and feeder bus pick-up/ drop-off.

Figure 40: Access point B

Figure 41: Four-wheelers parked at B

Access point C

- This is a barrier-free access point with a ramp and a lift. This access does not have stairs and escalators.
- There is a signage stating lift entry on the doorway of this access, but there is no signage elsewhere to lead to this access point.
- The footpath leading to this entry is not in a walkable condition (Figure 43).
- There is an ad hoc private parking besides this access. This can be converted to a pick-up/drop-off point.

Figure 42: Access point C

Figure 43: Footpath at access point C

8.3.5. Typology 5 – S. V. Road Metro Station

This typology includes Metro stations with residential or mixed-use areas within a 500 metre radius (of the Metro station), access road width of 30-80 metres and low boarding. There are three BMTC bus stops in this area (Figure 44).

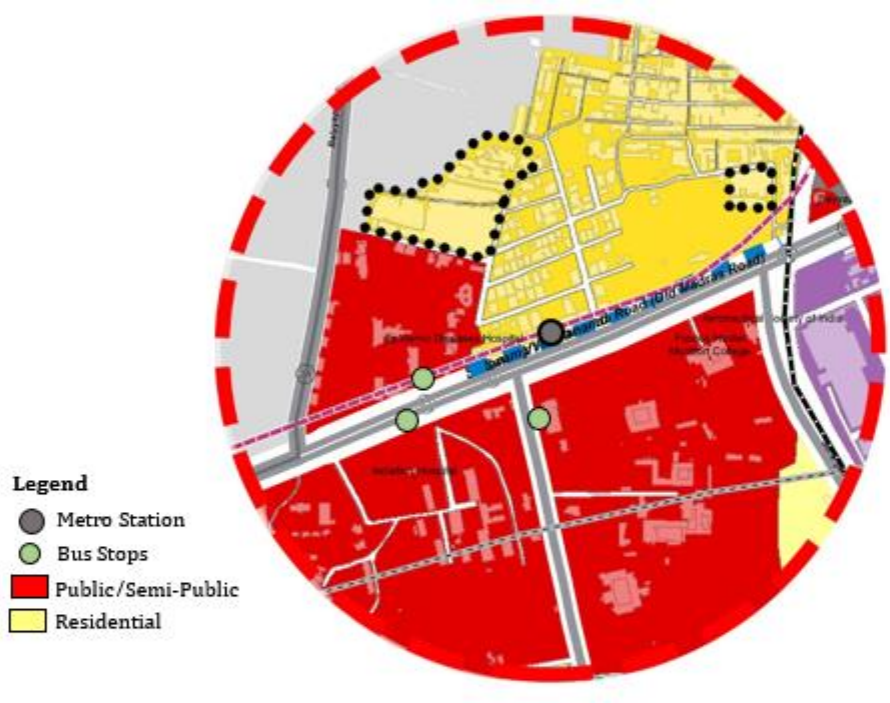

Figure 44: Study area for S. V. Road Metro station

Table 8: List of typology-wise required elements and existing scenario – S. V. Road

Required Elements	Existing Elements
Footpaths	Yes
Bus bays	Yes
IPT bays	No
Commercial activities	Yes
Way-finding	Partially (explained in text)

This Metro station has five access points. Access points A and B are accessible for the people coming from the West (Indiranagar), and C, E and D are accessible to the people coming from the East (ITPL, Baiyappanahalli). Figure 45 shows the locations of all the access points for S. V. Road Metro station.

Figure 45: Access points at S. V. Road Metro station

Access point A

- This access point has a lift, an escalator and a staircase to reach the concourse, which can be accessed by a ramp. Hence this entry is accessible to all commuters.
- As this access point is covered, it needs both proper lighting and signage, which it currently lacks. The signage is not visible due to street hawkers and other commercial activities.
- This access is at the bus bay and needs a proper pedestrian movement plan.

Figure 46: Access point A

Figure 47: Commercial activities at A

Access point B

Figure 48: Access point B

- This access point has an escalator and stairs to reach the concourse. Hence it is not convenient for differently abled passengers.
- This access does not have a signage and the way leading to this access is not well lit.
- The footpath is wide enough and in a good condition.

Access point C

- This access point has a staircase and an escalator to reach the concourse.
- This access is perpendicular to the passenger movement; it can be easily noticed and requires no special signage.
- The footpath is wide enough and in a good condition.
- It has a signage pointing to the access point for differently abled commuters (Figure 50).

Figure 49: Access point C

Figure 50: Signage at access point C

Access point D

- This access is dedicated for differently abled passengers and hence only has a lift.
- This access has ramps on both sides running parallel to the footpath and hence can be accessed from both directions.
- There is clear signage at the all the nearby access points, pointing the differently abled passengers to this access (Figure 52).
- The footpath is wide and in a good condition.

Figure 51: Access point D

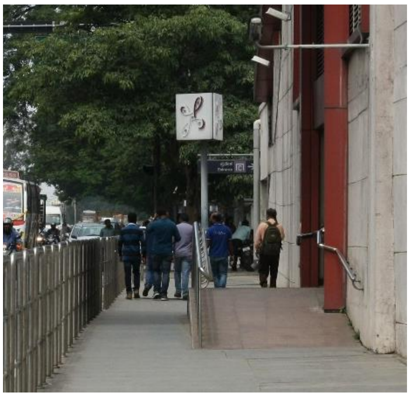

Figure 52: Signage at access point D

Access point E

- This access is at the other end of access C.
- It has a staircase and an escalator to reach the concourse.
- Even though the footpath is in a good condition, it is occupied by street hawkers and has a garbage dump adjacent to the road.

Figure 53: Access point E

Figure 54: Footpath at access point E

8.3.6. Typology 6 – K. R. Market Metro Station

This typology includes Metro stations having mixed land use, access road width of 12-30 metres and low boarding. There are nine BMTC bus stops in the study area (Figure 55).

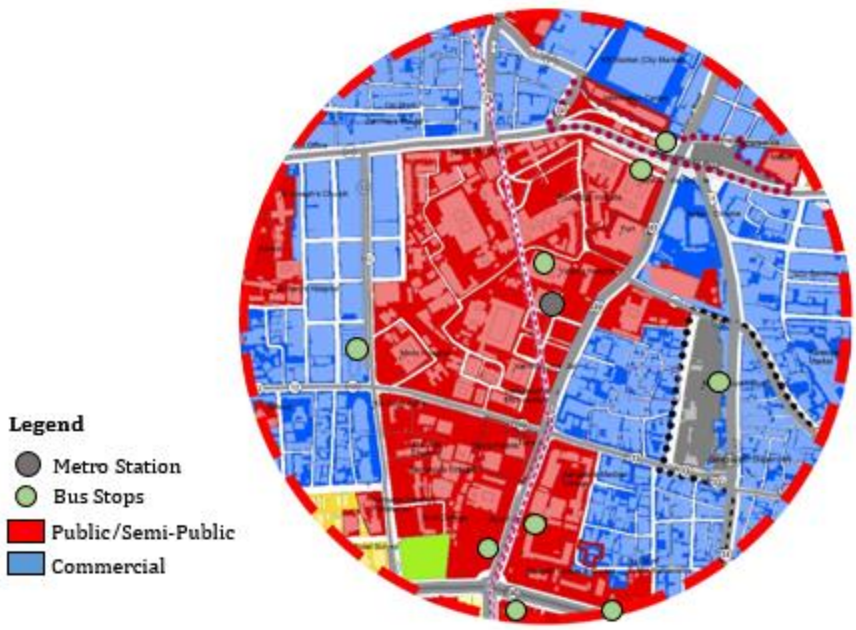

Figure 55: Study area for K. R. Market Metro station

Table 9: List of typology-wise required elements and existing scenario – K. R. Market:

Required Elements	Existing Scenario
IPT transfers	No
Footpaths	Yes
PV parking (two wheeler)	No

This Metro station has five access points (Figure 56). The point A is towards K. R. Market. The access point B is centrally located on the East side of the road. Access point C is located opposite Tipu Sultan's Summer Palace. Access D is adjacent to C, and E is near the Ganapathi Temple.

Figure 56: Access points at K. R. Market Metro station

Access point A

- This access is for the general public and has a staircase and an escalator leading to the concourse.
- The footpath is almost 1.5 metres wide and in a good condition.
- There is a two wheeler parking space at this access, which is not properly distinguished from the walking area. Clear segregation of vehicular and pedestrian movement is required (Figure 58).

Figure 57: Access point A

Figure 58: Parking space at A

Access point B

- This access has a staircase and an escalator.
- Pedestrian bollards are placed only on the other side of the Metro station after the ramp. Thus, vehicles are able to easily enter the pedestrian zone and reach the Metro station gate (Figure 60).
- Encroached two wheeler parking right at the gate of this access point causes hindrance to pedestrian movement.

Figure 59: Access point B


Figure 60: Bollards at access point B

Access points C and D: Not open to the public

Figure 61: Access point C

Figure 62: Access point D

Access point E

- This access point has a lift to reach the concourse and a ramp as well as stairs to reach the lift lobby.
- This access has a 1.5 metre wide footpath which is in a good condition.
- As this access stands alone on a wide footpath, no special signage is required.

Figure 63: Access point E

9. Findings and Discussion

After the site visits were carried out, the revised infrastructure element matrix according to the Metro station typologies was prepared. The revised matrix is given in Table 10.

Table 10: Metro station typology-infrastructure elements matrix

Metro Station Typology	Required Infrastructure Elements
1	• Footpaths, pedestrian crossings, interchange connections (Jani and Kost 2013), • IPT bays, pre-paid IPT counters • Way-finding • Pick-up, drop-off
2	• Bus bays/stops (Gandhi et al. 2015) • IPT bays • Private vehicle parking • Footpaths
3	• IPT bays, pre-paid IPT counter • Bus bays/stops • Footpaths • Way-finding
4	• IPT bays ('Complementary Paratransit Plan User Guide' 2016) • PV parking (Govt. of NCT of Delhi 2017) • Footpaths
5A	• Footpaths • Bus bays • IPT bays • Commercial activity space
5B	• Bus bays • IPT bays • Footpaths • Way-finding
6	• IPT transfers • Footpaths • PV parking (two wheeler)

A few elements such as footpaths, pedestrian crossings, ATMs and retail outlets are common passenger amenities that have to be provided in and around Metro stations. But, some elements have to be prioritised based on the Metro station typologies defined in this report. For the Metro stations located in the transport hubs of the city, elements such as interchange connections, way-findings, pre-paid IPT counters and pick-up/drop-off points are essential. For the Metro stations in areas with predominant residential land use and wide roads, elements such as bus bays and private parking are essential. For commercial areas with wide roads, elements such as bus bays and IPT bays are more suitable; for residential/mixed land-use areas with narrow roads (< 30 m), elements such as IPT stops and private vehicle parking are preferred.

10.Conclusion and Recommendations

Conclusion

Most of the Metro stations have the required infrastructure such as footpaths and IPT stops; however, in many cases these are not well maintained. Some of the issues with the footpaths are:

- Narrow width
- Encroachment
- Poor condition of pavers and stone slabs
- Garbage along the footpath

There are buses and autos that stop at the Metro stations, but most of the Metro stations do not have a dedicated feeder or IPT stop/bay. Hence these vehicles (bus and autos), stopping at the Metro station access points, not only cause hindrance to the vehicular movement along the road, but also to the pedestrian movement along the footpath.

Apart from this, signage is another concern. Even though there are sign boards at Metro stations, they are often visually blocked.

Recommendations

In the infrastructure integration study, design elements and planning interventions at Metro stations were examined through primary and secondary analysis. Metro station typologies were developed considering land use, access road width and Metro station ridership. Select Metro stations (one from each typology) were considered for primary site visits and analysis. Based on the analysis, infrastructure element matrix was developed and required design and planning interventions were suggested.

Following are the set of recommendations for infrastructure integration:

- For better accessibility in and around Metro stations, physical design should be an integral part of the Metro planning process.
- For seamless multimodal transfers, encroachments on footpaths or service roads need to be removed.
- Adequate crossings (foot overbridges/underpass) need to be provided for safe movement of pedestrians.
- Dedicated transfer facilities for buses and IPT can be provided at Metro stations.
- The way-finding to and from Metro stations needs to be re-designed to make it more user friendly.
- Proper signages for public amenities within Metro stations are required.
- Transfer signages at interchange stations need to be improved for smoother transfers between the green and purple lines.
- The Metro Station Typology – Elements Matrix provides a guideline for effective physical integration for future Metro station design.

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Annexure I

Literature Review – Global Best Practices and Guidelines

Intervention Criteria	Ideal Situation
Planning Interventions	
For pedestrians and cyclists	
ROW including the pedestrian zone	Arterial: 30-80 metres Distributor: 12-30 metres Local: 6-15 metres
Land use along the influential zone	
Pause points in regular intervals	500 metres
Multimodal shift points	500 metres
Cycle parking spaces/points	At the Metro stations
For public transport users	
Bus stops	400 metre radius
Auto/Other IPT stands	400 metre radius
Non-encroached/Dedicated IPT Stands	
For private transport users	
Non-encroached/Dedicated parking spaces	
Fuel stations	300 metres
Drop-off/Pick-up points	At the Metro stations
For private transport users: Share cabs (Ola, Uber, etc.)	
Non-encroached/dedicated parking spaces	
Drop-off/Pick-up points.	At the Metro stations
Pooling strategies based on specific results from O-D survey	
Design Elements	
Street network modification	
Pavement type - permeable pavers	
Tactile paving	
Kerb ramps	
Tactile paving	
Refuge islands and medians	
Lighting pole	Height – 12 metres; Distance between poles – 35 metres
Seating - inbuilt/externally added	50-200 metres
Drinking water fountains	50-200 metres
Information kiosks	At Metro stations
Frame boards (advertisements)	50-200 metres
Smartphone charging points	50-200 metres

Plantations	
Garbage bins	
Retail stores	400 metres
Pedestrian/Cycle access plan	
Way-findings	At Metro stations
Signage (showing direction, time and distance)	50-200 metres
Lost spaces – below Metro pillars	Can be used for advertisement

Annexure II

Primary Data Collection Template

Metro station name: ____

Sl. No.	Required Elements	Existing Elements	Remarks

Initiative 3: Institutional Integration

Initiative 3: Institutional Integration

Abbreviations and Acronyms

Abbreviations	Full Forms
BBMP	Bruhat Bengaluru Municipal Corporation
BIEC	Bengaluru International Convention Centre
BMLTA	Bengaluru Metropolitan Land Transport Authority
BMRCL	Bangalore Metro Rail Corporation Limited
BMRDA	Bengaluru Metropolitan Regional Development Authority
BMTC	Bengaluru Metropolitan Transport Corporation
CDP	City Development Plan
CMP	Comprehensive Mobility Plan
CSTEP	Center for Study of Science, Technology and Policy
DULT	Directorate of Urban Land Transport Authority
GO	Government Order
LAMATA	Lagos Metropolitan Area Transport Authority
LTA	Land Transport Authority - Singapore
NUTP	National Urban Transport Policy
PTC	Public Transport Committee
SPV	Special Purpose Vehicle
STIF	Syndicats Transportes Îles-de-France
TD	Transport Department
TfL	Transport for London
TransLink	South Coast British Columbia Transportation Authority
UDD	Urban Development Department
UMTA	Unified Metropolitan Transport Authority

Executive Summary

The Bengaluru Metropolitan Transport Corporation (BMTC) and Bengaluru Metro Rail Corporation Limited (BMRCL) are the primary public transport service providers in Bengaluru, with an aim to provide safe, reliable, clean and affordable transportation. To achieve this aim and make public transport as the preferred mode of transportation in Bengaluru, it is necessary for these two organisations to integrate their services.

In this context, the Government of Karnataka has engaged the Center for Study of Science, Technology and Policy (CSTEP) as a technical research institution, to suggest ways in which BMRCL and BMTC may be integrated. This study focuses on the institutional aspects of integration.

The study on institutional integration provides suggestions on a governance mechanism that will allow BMTC and BMRCL to work in close co-ordination, to increase the public transport modal share. Institutional integration of these two agencies has to be seen in the larger context of urban transport planning integration at a city or regional level driven by a specialised agency, which brings multiple agencies together. This agency would be responsible for strategic planning and policy formulation. In the case of Bengaluru, such an agency already exists in the form of the Bengaluru Metropolitan Land Transport Authority (BMLTA). This agency would set the mandate for different transport utilities, including BMTC and BMRCL. The integration of BMTC and BMRCL would then focus on the tactical and operational functions, including commercial and safety regulations, infrastructure and service planning and co-ordination of common services.

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1. Introduction

BMRCL and BMTC are the two major public transport service providers in Bengaluru, with a combined ridership of approximately 5.5 million trips per day. However, there is a need felt by the government for these two agencies to collaborate and increase the total mode share of public transport. For this to happen, these agencies will have to collaborate rather than compete with each other. Collaboration between two public transport agencies, with independent mandates, can only take place if they are institutionally linked through a formal mechanism. This institutional mechanism would need to be nested at multiple levels. At the highest level, there is a need to create an independent agency, which would be in-charge of co-ordinating all the land transport strategic planning and policy formulation, at the metropolitan level. A second level would look after regulation, infrastructure and service planning, while a third level would take care of public transport operations.

2. Progress Review

The progress review provides a brief overview of the current attempts of institutional integration in Bengaluru.

2.1. Overview of Existing Institutional Integration

The domain of urban transport in Bengaluru is characterised by a high degree of fragmentation, with multiple agencies in-charge of different roles. As can be inferred from

Table 1, policies affecting urban transport are governed by the Urban Development Department (UDD) and Transport Department (TD). The municipal corporation (BBMP) is responsible for the construction and maintenance of roads and bus shelters. The city has two transport utilities, BMTC and BMRCL, which also have a transport planning role; they decide where to run their services. Most importantly, the preparation of the Comprehensive Development Plan (CDP) for the Bengaluru Metropolitan Area is done by the Bengaluru Development Authority (BDA). In addition, the Bengaluru Metropolitan Region Development Authority (BMRDA) in responsible for preparing a structure plan, which is a strategic guidance document for the Bengaluru Metropolitan Region (BMR).

Table 1: Bengaluru transport agencies and functions

No.	Functions	Institution
1.	Policies and framework affecting transport sector	UDD and TD
2.	Road building, road maintenance, street lighting, construction of select ring roads, grade separators, construction of bus shelters, traffic islands	BBMP
3.	Enforcement of traffic laws and regulations, management of traffic junctions and corridors, regulation of right of way, parking	Bangalore city traffic police
4.	Public transport systems (bus-based), construction and maintenance of bus depots, terminals and passenger centres	BMTC
5.	Public transport system – Metro rail	BMRCL
6.	Preparation of comprehensive development plan, formulations of regulations, construction of select ring roads and grade separators	BDA
7.	Planning of transport system in BMR	BMRDA
8.	Registration of motor vehicles, issue of licenses and enforcement of regulation of motor vehicle act	Regional Transport Office, Transport Department, GoK
9.	Monitoring of air quality and noise levels	Karnataka State Pollution Control Board
10.	Infrastructure and finance	Karnataka Urban Infrastructure and Finance Corporation Limited
11.	Construction and operation of rail system	Indian Railways
12.	Construction and maintenance of National Highways	National Highway Authority of India

Source:(BMRDA 2012)

With so many agencies handling different portfolios, they often work in a competitive manner on cross-cutting themes—this feature is present across multiple Indian cities.

In order to address this problem, in 2006, the National Urban Transport Policy (NUTP) was formulated. One of its tenets was decentralised urban transport planning, which would be facilitated by a new institution called the Urban Metropolitan Transport Authority (UMTA), for specific cities. This agency is supposed to facilitate co-ordination in the planning and implementation of urban transport programmes and projects, as well as integrated management of urban transport systems. Thus, in 2006, GoK (through a government order) set up the Bengaluru Metropolitan Land Transport Authority (BMLTA). Its role was to function as an umbrella organisation to coordinate planning and implementation of urban transport initiatives in an integrated manner. BMLTA is a committee comprising of senior government officials from transport, urban development, infrastructure and finance and planning departments, headed by the Chief Secretary (DULT 2018b). The functions of BMLTA include:

- Coordinate all land transport matters in BMR.
- Prepare a detailed Master Plan for Transport Infrastructure, based on the comprehensive Traffic and Transport Study for Bengaluru.
- Oversee the implementation of all transportation projects.
- Appraise and recommend transportation and infrastructure projects for bilateral Central assistance.
- Function as an empowered Committee for all Urban Transportation Projects.
- Initiate action for a regulatory framework for all land transport systems in BMR.
- Initiate steps, where feasible, for common ticketing systems.
- Take any other decision for integrated urban transport and land use planning, along with implementation of projects.

GoK also established the Directorate of Land Transport Authority (DULT) in 2007. The key objective of DULT was to ensure integration and coordination of land use planning and development of transport related infrastructure in Karnataka's urban areas. DULT serves as BMLTA's secretariat; hence BMLTA has never had any dedicated staff. Since its inception in 2006, BMLTA has conducted five meetings, from 2006–08 (DULT 2018a).

Currently, DULT is responsible for a number of initiatives in Karnataka including,

- The creation of cycling lanes in Bengaluru
- Feasibility studies for introduction of Bus Rapid Transit Systems (BRTS) in Hubli-Dharwad
- Preparation of a Comprehensive Mobility Plan (CMP) for nine cities in Karnataka
- Implementation of suburban railway systems for Bengaluru

- Other related projects (DULT 2017).

Currently BMLTA does not have the legislative support, nor the funds or fund raising and disbursal power to be effective in its mission. The website of DULT/BMLTA has evidence to show that DULT is conducting feasibility studies, as opposed to being the co-ordinating agency as per its original mandate.

Given the lack of institutional integration at the higher level, there is no official mandate for line agencies, including transport organisations like BMTC and BMRCL to integrate operations.

3. Problem Statement

High level of institutional fragmentation in urban transport planning and services in Bengaluru.

As mentioned in the earlier section, there is a high degree of fragmentation in Bengaluru's urban transport governance.

Table 1 aptly shows that planning functions are spread across multiple agencies, while service delivery agencies do not necessarily work in conjunction with each other.

Attempts at institutional integration or coordination, through the creation of a unified transport authority in the form of BMLTA, have not been successful. This is because BMLTA neither has the authority, nor appropriate funding sources, to implement its mandate.

Evaluation Question

What could be an appropriate governance structure for urban transport's institutional integration in Bengaluru?

This study provides suggestions on a governance structure for effective institutionalisation of urban transport in Bengaluru. Such a structure would comprise different levels, their associated functions and the different agencies responsible for carrying out those functions.

4. Objectives and Issues for Evaluation

Objective

To recommend an appropriate governance structure for urban transport's institutional integration in Bengaluru.

Scope

- Targeted population: The targeted population includes all the agencies responsible for urban transport planning and service delivery, in Bengaluru.
- Geographical coverage: The geographical coverage is BMR.

5. Evaluation Design

5.1. Information Sources

Secondary sources consulted for this study included global best practices on institutional integration. These included case studies from Singapore, London, Vancouver, Lagos and other global cities. The study also refers to certain institutional integration frameworks, which have been developed by the World Bank and academic institutions.

5.2. Research Methods

Secondary data collection: Case studies, global best practices and frameworks

The secondary data referred to for this study included case studies of cities that have successfully implemented institutional integration mechanisms. The secondary data consulted also concentrated on integration frameworks. Previous research on institutional analysis of urban transport in Bengaluru was also considered.

5.3. Evaluation Criteria or Indicators

An institutional integration framework, as defined by the World Bank, has been used to develop the Evaluation Criteria represented in Figure 1.

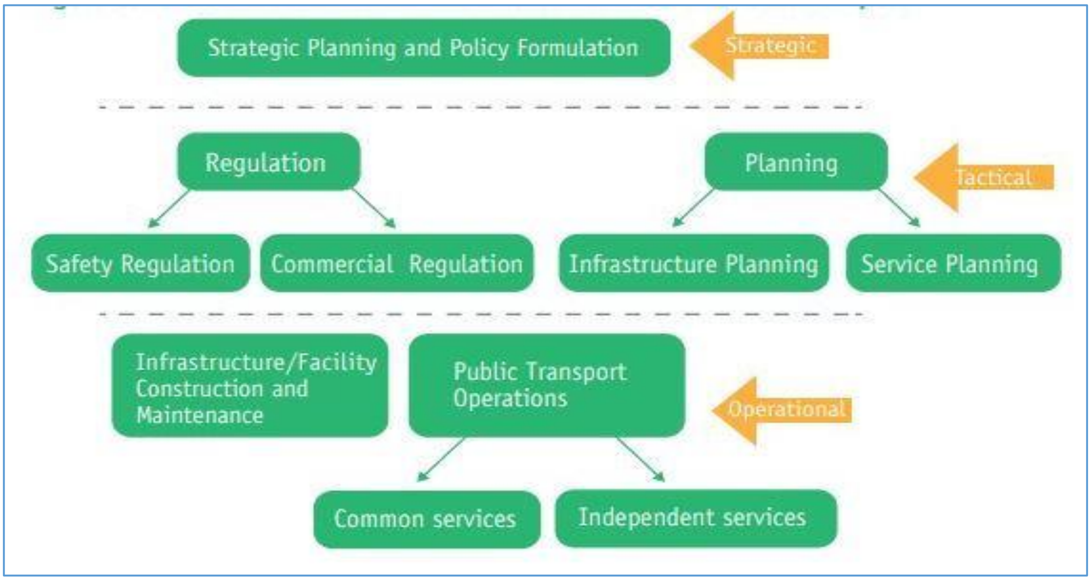

Figure 1: World Bank's institutional integration framework

Source: (Kumar and Agarwal 2013)

The indicators for institutional integration are defined in a three tier format, along with the associated functions at each tier and agencies responsible for these functions at each level.

- Tier I consists of strategic and policy functions, which involve the development of a vision and formulation of appropriate policies to realise the vision. These functions set the standards for more geographically focused planning activities. These functions should be performed by a lead agency. This agency should be supported by the appropriate legal and financial authority.
- Tier II is a tactical level, comprising of regulatory and planning functions. The functions at this level focus on issues of public transport pricing—from an equity and monopoly prevention point of view—infrastructure planning, investment decisions based on demand forecasting, economic and financial assessment and other relevant aspects. Functions at this level would also focus on service delivery, such as preparation for actual delivery of public transport services—whether the service needs to be carried out in-house, or if it can be outsourced. This level is especially critical since there is a clear demarcation between the planning and delivery responsibilities. In the case of Bengaluru, like many other Indian cities, public transport utilities often undertake both planning and service delivery activities, which may not be the best use of that organisation's resources. These functions can be performed by the lead agency, in dialogue with the urban transport planning and service delivery agencies.

- Tier III is the operational level, comprising of the construction, management and maintenance of transport infrastructure, such as inter-modal transfer points, passenger information systems, revenue sharing, security services, dispute resolution, etc. It also includes the actual operations of running public transport. These functions can be performed by urban transport service providers such as BMTC and BMRCL.

6. Evaluation Methodology

6.1. Types of Data Collected from Various Sources

Secondary literature: The secondary literature on global best practices, case studies and frameworks helped with the compilation of the following:

1. List of lead agencies and their responsibilities
2. Elements that form a part of the integration framework.

6.2. Protocols for Data Collection and Ethics Followed

For the secondary data collection, references in the form of published data and literature were used for identifying institutional best practices and case studies.

7. Data Analysis

Institutional integration, primarily involves a process of defining the roles and responsibilities of the lead agency. Thus this section focuses on the existing UMTAs, their structure and roles, and the contextualisation of these factors for Bengaluru.

7.1. Lead Institutions

Different cities are governed by their respective legal frameworks for the lead institute. For instance:

1. Municipal Authority (Ahmedabad and Seoul)
2. Separate organisation under a dedicated statute (London, Singapore and Paris)
3. Government Order establishing separate organisation without legislative backing (Bengaluru, Mumbai and Chennai)
4. Multiple jurisdictions agreeing to establish a separate organisation (Colombia).

While cities like Singapore or London have opted for lead agencies backed by legal mandate, cities like Ahmedabad have entrusted the municipal corporation to be this lead agency. Cities like Kochi are still in the process of setting up their lead agency, however the metro rail corporation has taken the lead in organising feeder bus services to and from metro stations, which is the case for Delhi too. There are different lead agency models that are being tested in India. However, none of these agencies have the authority to make significant changes.

7.2. Functions Performed by the Lead Agency

Once the lead agencies have been set up, the next step involves the definition of the functions it needs to perform. Figure 2 gives a glimpse into the functions performed by different lead agencies in some international cities.

City	Lead Agency	Strategic Planning	Transport Policy Planning	Fare Setting	Planning: Infrastructure Planning	Planning: Service Planning
Cities with a lead agency						
Lagos	LAMATA	✓	✓	✓	✓	✓
London	TfL	✓	✓	✓	✓	✓
Paris	STIF	✓	✓	✓	✓	✓
Singapore	LTA	✓	✓	✗	✓	✓
Vancouver	TransLink	✓	✓	✓	✓	✓

✓ Means this function is performed by the lead institution , and
✗ means it is not performed by the lead institution

Figure 2: Functions of lead institutions

Source: (Kumar and Agarwal 2013)

As can be seen in Figure 2, lead institutions normally have the mandate for transport policy planning and infrastructure and service planning. They decide the larger policy context (sustainable urban transport) and associated transport investments/infrastructure projects that are needed to achieve these sustainable urban transport goals.

7.3. Funding Sources

Each of the cities, which has a lead agency for transport planning, has dedicated funding sources. These sources of funding are shared in

Table 2. In many cities, local revenue or taxes are channelised to fund the operations of lead agencies. However, when it comes to investing monies in capital intensive projects, they have

to be procured from the state or central government. This is true even for places like Singapore and London, where a portion of capital investments in transport projects come from the federal government.

Table 2: Lead agencies and their sources of funding

City	Lead Agency	Funding Sources
London	TfL	Congestion charges Central and local government General revenue
Singapore	LTA	Management fee from Govt Administrative fee Government grants
Vancouver	TransLink	Fuel tax Property tax Govt transfers Transit fare
Paris	STIF	Transport tax Fare Public subsidies Employers
Lagos	LAMATA	State budget Road taxes Licence plate registration Vehicle registration Bus concessions

Sources:(Mobereola 2006; TransLink 2011; Land Transport Authority 2011; Transport for London and Mayor of London 2011)

What emerges, very clearly, is the need to establish a lead agency in order to get transport planning and implementation agencies on-board, in order to avoid institutional fragmentation. In many of the cases cited internationally, lead agencies are also in charge of land use planning for the jurisdictional area. This is not possible in Bengaluru because agencies such as the BDA are responsible for land use planning. Thus, a lead agency in the context of Bengaluru would be in charge of land transport planning. In addition, it would co-ordinate with BDA and other land use planning agencies to draw up transport plans for the city.

What is equally clear is that such a lead agency would need to have a legal mandate, accompanied by financial sources to fulfil its mandate. Such an agency would need to define its functions and the functions to be carried out by each agency related to urban transport.

In the case of Bengaluru, there is a need to re-organise the lead agency, BMLTA, by enacting a law that would give this agency sufficient power. It is also important to identify sources of funding, which would allow BMLTA to fulfil its mandate. By using the World Bank framework (cited earlier), this study recommends certain functions, which can be performed by BMLTA at the three levels—policy, regulation and planning, and operations—in order to be effective. These functions have been described, in detail, in the Recommendations Section.

8. Recommendations

Based on the results obtained from this study, the primary recommendation for BMLTA is that it be reorganised through legislation and funding, in order to implement urban transport investment decisions for the city. It would also need to effectively empowered in order to co-ordinate between multiple agencies involved in land use planning (BMRDA, BDA, BBMP), as well as transport infrastructure and service agencies (BMTC, BMRCL, Indian Railways). Specific functions to be performed by BMLTA, in the context of the institutional framework discussed earlier, have been suggested below.

8.1. Policy Level

- Revival of BMLTA through legislation, with dedicated sources of funding
- BMLTA could decide the nature of transport investments for the region, based on the principles of sustainable urban transport planning
- BMLTA could co-ordinate land use planning; specifically transport infrastructure provision, with city planning agencies (BMRDA, BDA and BBMP).

8.2. Regulatory and Planning Level

- BMLTA could set up a Public Transport Committee (PTC) to regulate public transport fares and integration of ticket payment systems
- The PTC could be funded by a dedicated transport fund (through collection of congestion fee from private vehicles and cab aggregators)
- BMLTA could decide the areas of operations by different public transport service providers (based on timely studies) so as to serve a larger population base and avoid competition between transport service providers.

8.3. Operational Level

- BMLTA could own and operate the interchange facilities and inter-modal terminals. This would help enhance inter-agency coordination and cooperation.

Discussion Points

Empowerment of lead agency: Different cities in India are experimenting with different forms of UMTA; some through an act of legislature, some through a Government Order and others through Urban Local Bodies. The experience of UMTAs in Indian cities has not been positive due to the lack of empowerment. Thus, if UMTAs are to fulfil their mandate of land transport planning, they need to be empowered legally and financially.

Defining functions of different agencies: Transport planning and operating agencies often work at odds with each other. Thus there is a need to clearly define their respective areas of operations so that they don't compete with each other, and adhere to the principles of sustainable transport. For this to materialise, they would be need to be insured against loss of revenue or ridership.

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