# To understand the influence of metro rail on the urban fabric of a city – case studies - Bengaluru

**R. Hemasree[1,*], C.V.Subramanian[2]**

[1] Research Scholar, Periyar Maniammai Institute of Science and Technology, Thanjavur, India

[2]Professor, Periyar Maniammai Institute of Science and Technology, Thanjavur, India

**Abstract:**

The migration of people looking for better economic prospects and their residential demands result in the sprawl of the city Most cities in the World look up to a Metro mode of Transit as a solution to ease congestion in the Core of the city and to outreach the city. One needs to conduct surveys to understand the advantages of Metro, frequency and the reason for the trip, mode of reaching the station, and private car data. On the other hand, selective case studies of other cities bring insights into Mass Rapid Transit Systems-MRTS use, the solution they brought forth, the problems they caused, and the way toward the future. The bustling economic activities demand foresight in ever-growing traffic transport problems forcing the city to have its own Metro network-Namma Metro next to Delhi and Hyderabad. 11 years after the inauguration of the first Line-purple line from Byyappanahalli to Mahatma Gandhi Road, it is important to study the influence of Namma Metro on the city. The survey with close-ended questions was conducted on riders, non-riders, and people living in the metro corridors, and data were analyzed. The Namma Metro in Bengaluru has several advantages, including a decrease in air pollution, time savings for passengers, a decrease in accidents, a decrease in traffic congestion, and fuel savings, all of which influence the socioeconomic position of commuters on the purple line corridor. The influence of Namma Metro can be summarised by location, neighbourhood, environment, and socio-economic conditions.

**Keywords***: 1.*Urban Planning, 2.Sprawl, 3.Mass Rapid Systems, 4.Metro rail, 5.Case study, 6.Namma Metro, 7.Bengaluru

**Introduction:**

An "MRTS-Mass Rapid Transit System" is any form of public shared transportation, such as buses, railways, and ships, that can carry lots of people quickly and without making reservations from one place to another. It is also known as public transportation. Rapid transit, which includes subways and surface light rail systems, is a type of public transit that is used for inter-city or intra-city travel. Fixed networks, such as railways, or not a fixed network of routes, like buses, can be used for mass transit. It has the potential to be more cost-effective, environmentally sustainable, and time efficient. Furthermore, it is the most effective method of minimizing the burgeoning city's ever-increasing traffic congestion. Mass transportation has the advantage of using fewer rights of way and creating fewer infrastructures than highways and roads. The limitations of the system include the obligation to travel on a predetermined schedule rather than one that is personally chosen and to enter and depart the system only at predetermined locations.

As per a report, "a second large urban rail revolution is spreading around the World,"(Peter & Jeffrey, 2015). Currently, nations in the US, Australia, Canada, the Middle East, Europe, and Asia are experiencing a "trend back to urban rail." Urban rail is now being developed in both the conventional automobile-dependent cities and the oil-rich Gulf area cities (Peter, et al., 2016); (Manaugh & El-Geneidy, 2012), which is an indication that future transportation will revolve

around the train. All of these patterns were predicated on the faster-than-average traffic in Asian cities and re-urbanization tendencies focused on TODs, which are increasingly the locations for knowledge economy employment and improved accessibility (Peter & Jeffrey, 2015).

Indian cities have long lacked both a city railway network and short-distance train lines connecting the suburbs. These cities are confronted with an explosive combination of rapid population expansion and a steep increase in the number of privately owned automobiles as city people have been forced to rely only on buses, privately owned cars, and two or three-wheelers for transportation. The use of low-quality gasoline and inefficient engines in vehicles and buses contributes to the toxicity of the existing air pollution problem. The MRTS in India is classified as follows (Figure 1).

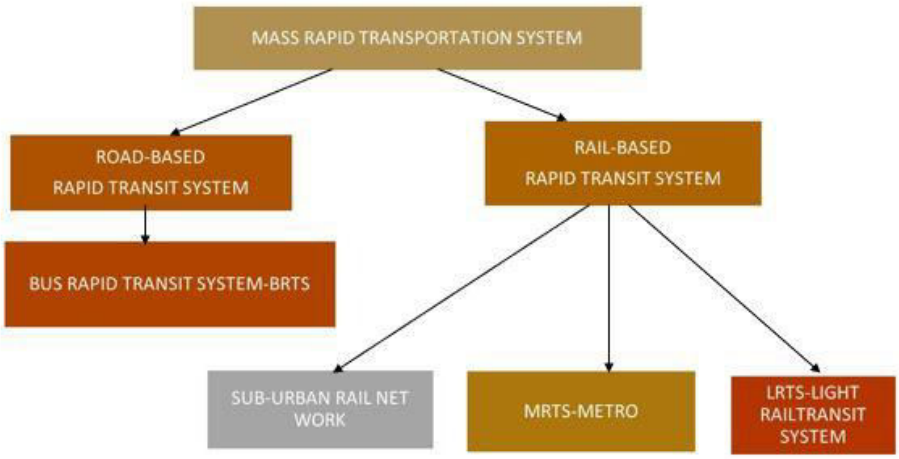



**Figure 1 : Mass rapid transit system in India**

With tremendous enthusiasm, Chinese and Indian cities adopted this trend, planning or constructing 82 Metro rail projects in Chinese cities during the previous ten years and counting in India of 51 numbers. "In India, metro urban rail is currently operational in nine cities with a built-out 379km network; another eight cities are building out 277km of the metro rail network; and a further 20 cities have rail transit under initiation with any city over a million now eligible for Federal assistance (Metro Rail News, 2017)." Although all initiatives have political support, they are unable to be built since they need so much finance.

The Metro trains have an impact on real estate and prices, thus there is a need for growth regulation among Metro rail authorities and an Urban Design organization, which will work on creating various standards so that the genuine metropolitan regeneration that occurs as a result of Metro trains in urban cities(Hemasree & Thirumaran, 2019).

## 1 Literature Review

Since urban train transport ridership research is frequently conducted at the station level, the effect of developed habitat features in station areas on station-level urban transit travelers has garnered considerable attention. The possibility that people will use urban rail transit increases as both the population and the intensity of employment rise. The Ordinary Least Squares (OLS) model was used in nine cities of Us to evaluate the relationships between built features and station-level ridership using cross-sectional data on the typical daily boarding of rail transit (Kim, et al., 2018). Another study was carried out to create a time-of-day origin-destination Direct Ridership Model (DRM) using information from the Chinese public transit system Nanjing's smart cards. It uses a “Gradient-boosting Regression Trees model” (GBRT) to provide a more sophisticated data

mining strategy to probe the non-linear relationships among urban habitat variables and ridership from station to station. The findings indicate that the bulk of indicators is related to station-to-station ridership in a discontinuous non-linear fashion, regardless of the time period. The constructed environment on the origin side effects station-to-station ridership more during the morning peak hours than the destination side; however, during the afternoon and evening peak hours, the opposite is true. The results also imply that transfer times, rather than detour and route length, are a more important issue (Gana, et al., 2020). According to a recent study using the GBRT model, the density of population and occupation saturation had only a significant influence on station occupancy when they fall within certain ranges and negligible impacts once they surpass these ranges (Ding, et al., 2019). The results are inconsistent in terms of land use mix. By using an integration of distance-decay functions and a multiple regression model, respectively, and a mixed geographically weighted regression model, respectively, it was found that the land use variable was positively associated with urban rail transit ridership. (Jun, et al., 2015). Further research has focused on the effect of street network design on urban rail transit ridership because it has been shown to alter people's tendency to walk to urban rail transit stations and consequently ridership. Urban rail transit ridership has been shown to be substantially associated with a number of street network metrics, including intersection density, road length, and road density. Usually, these criteria are selected as independent ones(Cervero, 2010)(Liu, et al., 2020). Numerous studies have demonstrated that the impact of a variable on travel behaviour can vary depending on that variable's scope. (Wu, et al., 2019)(Tu, et al., 2018). Various performance indicators, including Level of Service (LOS), Service Time Ratio (STR), Passengers Waiting Index (PWI), Total Travel Ratio (TTR), and Interconnectivity Ratio, are calculated in a separate study using the access, egress, transfer, waiting, and main haul time components of travel time (IR). Users spend between 72.6% and 84.4% of their main haul time on access-egress journeys, according to post-COVID-19 LOS research. Users only wait and transfer during main haul travels, based on the STR, which accounts for 10.9% to 12.6% of their total journey time. (Khursheed & Kidwai, 2022). Thus, from the above literature, it can be concluded that more in-depth smart card data extraction may be a more fruitful method of investigating the connection between built environment characteristics and station-to-station ridership. The high-speed rail and other MRTS are influencing urban life in a big way. One of the studies conducted in China also revealed that High-Speed rails impact urban sprawl, employment opportunities, and change in land use in a dominant way, but also warns of the negative impacts due to the implementation of High-Speed rails in China (Perl, et al., 2021).

Recently during the pandemic of Coronavirus, the living style of people changed across the world. One of the studies in Iran evaluated the Covid 19-pandemic impact on transportation revealed that in people using public transport has decreased drastically in rural Iran compared to Urban Iran and also the educational trips in Urban Iran have decreased in very large numbers compared to other trips (Nadimi, et al., 2022).

Three case studies have been studied extensively in this report. Case studies of Shanghai, China, Case study of Recife metro, Brazil, and case study of Delhi, India have been presented below in the tabular column (Table1-3). Based on the extensive study of case studies, a similar kind of case study for evaluation of the Impact of Namma Metro on Bengaluru city has been attempted in this paper

## 2 Methodology

Closed-ended questions were employed in a well-structured framework for this inquiry. When developing the questionnaire, the questions needed to examine the socioeconomic impact of Namma Bengaluru's metro trains operating for more than a decade on the city's urban environment. The questionnaire was sent out to various Metro riders and people living in Metro corridors. The questionnaire was framed with around 25 questions covering the personal factors to

general factors affecting the socio-economic factors of using Metro. The questionnaire was also disseminated via a Google forms link on social media sites.

The needed sample size to examine the impact of Namma Metro on Bangalore city was calculated using a finite population sampling approach. The information obtained from the survey and Google forms were analyzed to determine how Metro Phase 1 has affected the neighborhood. Phase 1 of the purple line Namma Metro was inaugurated in the year 2011 and a study after a decade will throw light on the impacts and influences caused by the infra-development influx to the city.

The sample size to analyse the social and economic impact of Namma Metro on Bangalore city was calculated by using Krejci and Morgan sampling method(Krejcie & Morgan, 1970).

$$\boldsymbol{n = \frac{z^2 * N * \sigma_p^2}{(N-1)e^2 + z^2\sigma_p^2}} \qquad \textbf{(1)}$$

Where, n= Sample size, N= population of city, Z= Critical value, $\sigma$= Standard deviation, e= acceptable error

The confidence level used for the determination of sample size is 95% with a critical value of Z as 1.96. The population of Bangalore city is around seventy-three lakhs as per the 2011 census, while acceptable error (e) is assumed to be 0.05 and the standard deviation to be 0.5. The sample size obtained by considering the above constants is 384.

| **Shanghai, China-Case Study(Haixiao & Ming, 2008)** | | | | |
|---|---|---|---|---|
| Sl. No | Details of the projects | Parameters & observation | | Result |
| 1 | Rail Transit Impacts on Land Use: Evidence from Shanghai, China, Haixiao Pan, and Ming Zhang | The analysis was with respect to only 200m and the space between 200m and 500m sandwiched in between away from the railway station | | In more accessible regions close to train stations, more capital-intensive land uses and higher development intensity occur. |
| | Description: Changes in land use associated with rail transit, All the 3 metro lines were considered | To understand the land use for each of the buffer spaces the various land uses such asresidential, commercial, official, Institutional, industrial, factories, open spaces. and transportation is grouped together. | The inner buffer is used for residential purposes to a lesser extent than the outside buffer. On the other hand, the inner buffer for all three metro lines contains more commercial-purpose land use comparable to the outer buffer. | Hedonic price modeling states, if the space is 100m closer to the station, will earn about 152yuan/sqm |
| | | Development Intensity: The development intensity will be categorized from low to high. For this purpose, the change in FAR of a 500m radius is assessed. | In both stations of Line 1 and 2, the inner buffer is densely built more than the outer buffer around the Line 1 and Line 2 metro stations. In contrast, the inner buffer on Line 3 was even less developed than the outside buffer. | The rail transit system in Shangai acts as the pulling force for new construction or regeneration of the region. |

| | | | | |
|---|---|---|---|---|
| | Property Value Impacts: | Structural characteristics are the density of the site, gross floor area, age, use the building is put into, interior completed, or only civil structure only. | The findings reveal that the sale of residential areas is also affected by various factors linked to the neighborhood and location apart from the distance from the station. | |
| | | Neighborhood characters, Local traits mostly consist of amenities, such as the availability of parks, stores or other retail establishments, schools, hospitals, and sports facilities. | | |

| **Recife, Brazil - Case Study**(Oliveira & Leonor, 2009) | | | | |
|---|---|---|---|---|
| **Sl. No** | **Details of the project** | **Parameters & observation** | | **Result** |
| | **Paper Title & Author:** The Recife Metro – the Impact on Urban Development after 20 years, Mauricio Oliveira de Andrade & Maria Leonor Alves Maia | The Hedonistic Pricing Technique was used to determine how the price of any urban land responds to the recent metro influx to the city. When all other qualities or components that can explain the worth of an item are kept constant, volatility in the price of any attribute equals the hedonistic or implicit price. | | The final result of the study establishes a formula that derives and explains the land value of a place or neighborhood to various factors and closeness to<br>1. City center,<br>2. Variable according to existing land use<br>3. Transport hub or intermodal hub<br>4. Size of the site<br>5, Security concerns due to the neighboring environment<br>6. Any MRTS station<br>7. A variable according to the development indexes and<br>8. Occupancy index as per the density<br>The study establishes a scientific way of quantifying the influence of the transport mode on property prices. |
| | **Description of the study and study area:** To research the link between modes of transportation and land use in the Recife area of Brazil and how the urban growth is affected by rail transit system. Brazil's Recife Metropolitan Railway With a population of 3 million, Recife is one of the major metropolitan areas in northeastern Brazil. With a population of 4,054,866, Recife is the state capital and largest city of Pernambuco in the northeastern region of South America. | **Location-related characteristics:** The separation between the main area, the closest metro stop, and the closest significant transit center. | Had little impact, according to a comparison of the value of land in the areas along several transit tracks. The model shows a concentration of the increase in value around metro stations. | |
| | | **Neighborhood-specific characteristics:** Infrastructure, the primary use of the land, the HDI, the median household income, population density, and the number of homicides per 10,000 people are a few examples. | The rise in the value is likely the use of the metro among the residents of the informal settlements | |
| | | **Physical Qualities:** **S**ize, dominating breadth, prevailing terrain, and geometrical or practical characteristics of the transit route. | The type and extent of modifications that must be made and their impacts are dictated by, conflicts between economic, political, and social pressures. | |

| **Delhi, India - Case Study**(CentralTransportation Planning and Environment Division, 2007) | | | | |
|---|---|---|---|---|
| **Sl. No** | **Details of the project** | **Parameters & observation** | | **Result** |
| 3 | **Paper Title & Author:** Contribution of Delhi Metro Rail Corporation (DMRC) towards Betterment of Delhi's Environment | A checklist was created based on the data collected and was presented | | The Delhi Metro will contribute to reducing the pollution load brought on by car traffic, which is rapidly rising. Therefore, there will be huge reductions in both fuel usage (about 7 million liters of diesel, 31.5 million liters of gasoline, and 16.68 million kilo grammes of CNG, as specified in the text) and foreign exchange losses (a staggering Rs. 1722 million). |
| | | **Project Location Impact** | 1. Had a negative impact on rehabilitation and resettlement, Change of land use and Ecology, Drainage, and utility problems.<br>2. Had no impact on historical and cultural monuments | |
| | **Description of the study and study area:** To conduct the Environmental Impact Assessment (EIA) of Delhi metro, India. Delhi is a union territory and city in India, home to New Delhi, the nation's capital. It is surrounded by Haryana on three sides, while Uttar Pradesh borders it on the east. 1,484 square kilometers make to the NCT (573 sq mi). The city proper of Delhi, India's second biggest after Mumbai, with a population of over 11 million people as per the 2011 census. The construction of rail-based metro systems in 11 cities throughout the nation was made possible by the Delhi Metro, India's first modern metro rail project. | **Project design Construction Impact** | 1. Had no impact on platform inlets and outlets, ventilation and lighting, and risks due to earthquakes.<br>2. Had a negative impact on railway station refuse | |
| | | **Project construction impact** | 1. Had a detrimental effect on soil erosion, pollution, and health risks at construction sites, as well as risk to existing buildings and traffic diversion. | |
| | | **Project operation impact** | 1. Had negative impacts of oil pollution, noise and vibration, and water demands | |
| | | **Environmental impact** | 1. Had a favorable effect on increased employment possibilities, economic growth, service and safety, traffic congestion reduction, and fuel efficiency.<br>2. Less smog in the air. savings in the construction of roads | |

## 3 Study Area

The capital of the Indian state of Karnataka, which is located in the southern part of the country at 12.97° N and 77.56° E, is Bangalore, often known as Bengaluru. Bangalore is situated in the center of the Deccan Plateau's Mysuru Plateau. The city, which was once planned as a garden city, has changed over time to become India's industrial and software powerhouse. As domestic and international businesses were established during this time, Bangalore's IT sector expanded as the epicenter of economic activity. Bangalore's population has increased dramatically because of rapid urbanization and industrialization and is projected to reach 14.1 million by 2021. According to the 2011 Census, it is the third largest city in India and the fifth most affluent urban metropolis, with a metro population of just under 8.5 million.

Bangalore Metro, named "Namma Metro," not only enhances the splendor of the Bengaluru skyline but also significantly improves transit comfort. Aside from that, Namma Metro is a big environmentally friendly addition to Bengaluru City, considerably contributing to the reduction of carbon emissions. The Namma Metro Lane traveling through Bangalore's CBD region has aided in pedestrianism, which has surely aided in decongestion, hence aiding in sustainable growth. (Hemasree, 2019)

The Bangalore Metro Purple Line is a rapid transport system in Bengaluru, India. This line has 22 stations and runs from Byppanahalli to Kengeri over a distance of 25.72 kilometers. On the purple

line of the Bangalore metro, 15 metro stations are under construction; when all metro stations are completed, the total length of the purple line would be 42.53 kilometers.

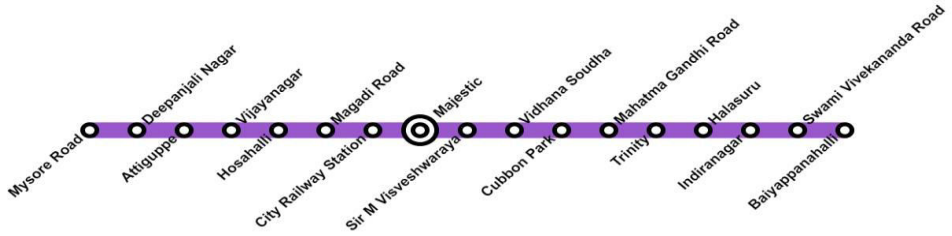



**Figure 2 : Bengaluru metro Rail Phase-1**
Source: BMRCL

## 4 Data Collection and Data Analysis

In this paper, Part of Purple Line Phase-1, was considered for the evaluation impact of Socio-economic characteristics of Namma Metro on Bengaluru city. A study conducted at a Metro station along the purple line showed that it has helped in the decongestion of the traffic and thus aiding in the sustainable development of the city. One more survey and study conducted at the Byppanahalli station from 9 am to 5 pm, to understand the relevance of the location of the Metro station to the context of urban space also concluded that Metro rail systems help in promoting the non-motorized transport and also reduction in traffic congestion, pollution in a positivity note but also suggested for better planning of parking and other facilities for better use of Metro rail system (Hemasree & Subramanian, 2019) .

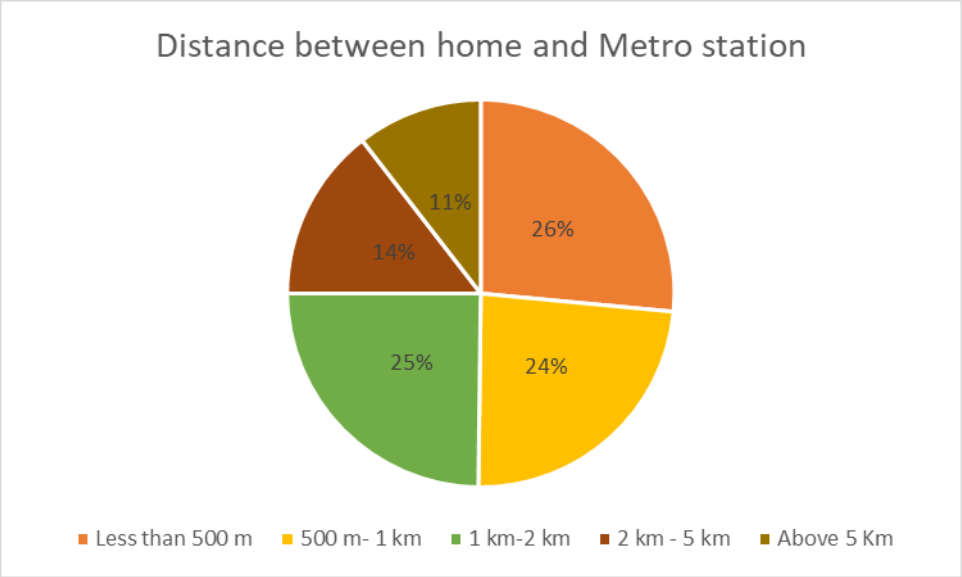
An online random sample survey and study was conducted along the corridor Byppanahalli to Majestic of purple line i.e., the East-West corridor for this paper on the users and on the people residing in the corridors. The survey was conducted for the people along the E-W corridor and hence the ¼ sample size is considered for sampling which is around 96. The study was conducted on the metro riders and also on the people living in Metro corridors. Around 165 replies were gathered from the questionnaire, and following analysis, 97 responses from Metro users and 69 responses from those living in Metro corridors were found eligible in terms of responses to all questions.

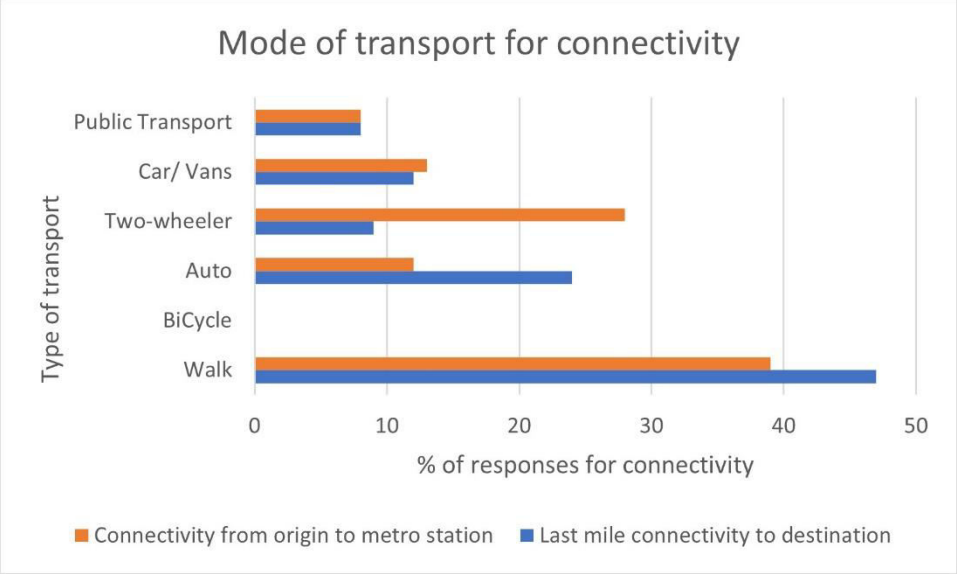
The questionnaire was divided into the following section.

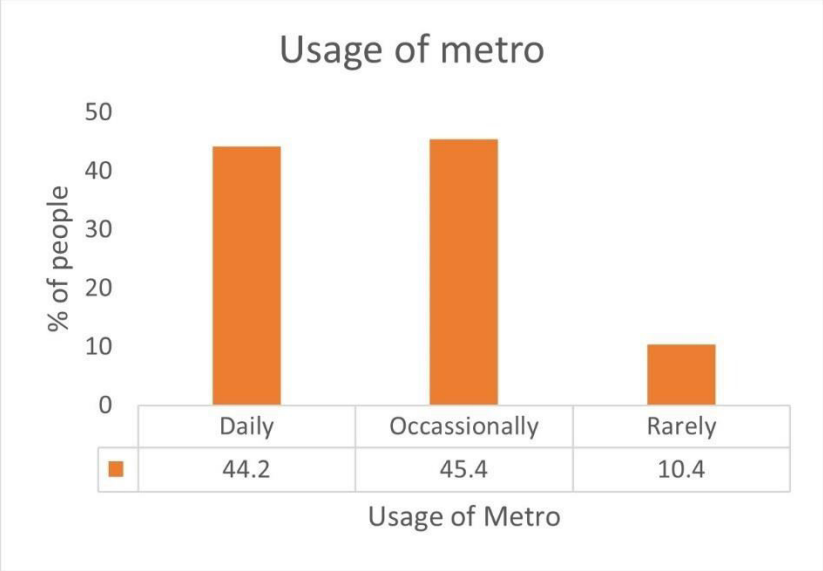
- Personal Information (Gender, Age, Monthly income)
- Metro train-related information (Mode of transport for connectivity, Connectivity from origin and destination, Distance from Metro station, amount spent on Metro usage)
- Environmental-related information (Land value, Aesthetics, Pollution, Traffic)

### *4.1 The responses from the metro riders:*

The commuters using Metro were provided with the questionnaire and the response to those questions are shown in the graphs below (Figure 3)


Distance between home and Metro station
26%
24%
25%
14%
11%
Less than 500 m
500 m- 1 km
1 km-2 km
2 km - 5 km
Above 5 Km


Mode of transport for connectivity
Public Transport
Car/ Vans
Two-wheeler
Auto
BiCycle
Walk
Type of transport
0
10
20
30
40
50
% of responses for connectivity
Connectivity from origin to metro station
Last mile connectivity to destination


Usage of metro
50
40
30
20
10
0
% of people
Daily
Occassionally
Rarely
44.2
45.4
10.4
Usage of Metro

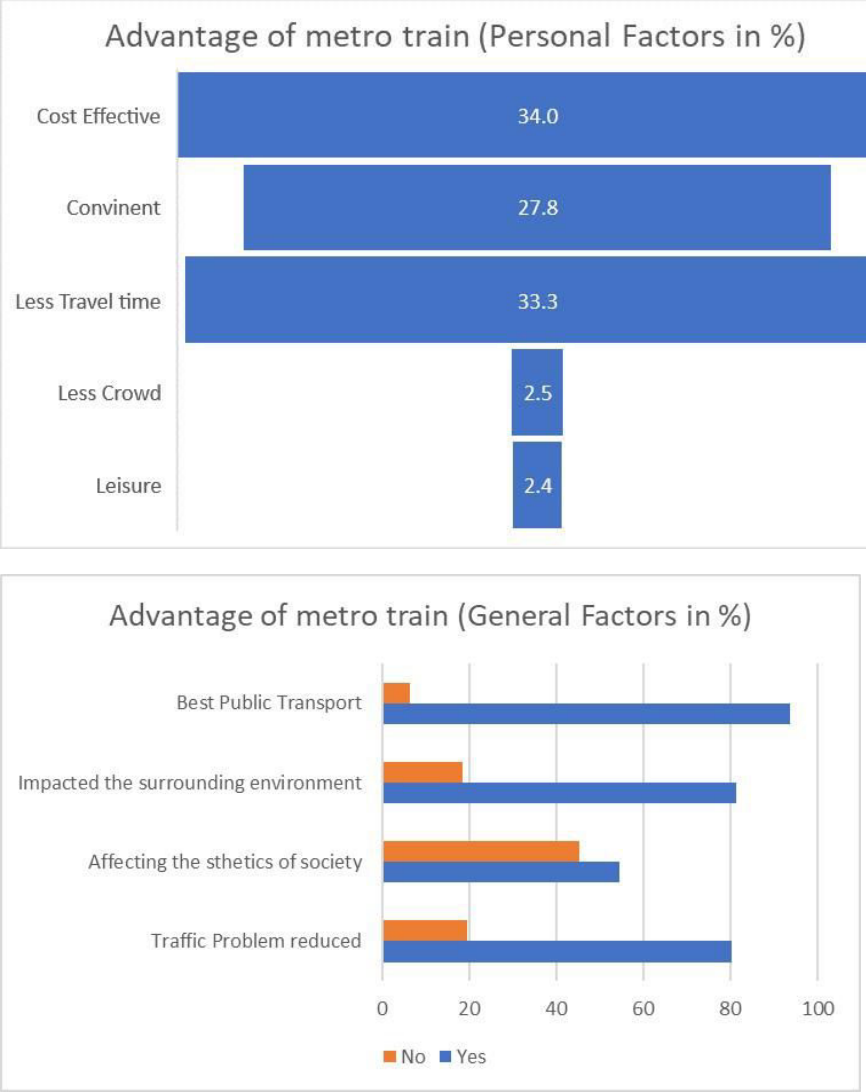



**Figure 3 : Responses from the commuters of Metro.**

From the responses the following observations were made:

1. Majority of the Namma Metro users are within 2 km distance from the Metro station and maximum of them reach the station from their origin to destinationfrom metro station by walking compared to other modes of transport, public transport is the least.
2. The Metro users feel it is more cost-effective, convenient, and has less travel time.
3. Metro riders also feel, that is the best public transport reducing traffic problems, without much impacting the aesthetics of society and the surrounding environment.

### *4.2 The responses from the people living in metro corridors:*

People living in the Metro corridors were asked to rank the importance of the metro's influence during the study. A questionnaire was prepared to understand the impact on the surrounding environment due to the Namma Metro construction. The questionnaire included the aspects such as the impact on the surrounding environment, loss of buildings, dust, air pollution, and visual aesthetics of the locality, reduction in traffic and transportation problems. The responses obtained from the survey are shown below in Figure 4.

From the responses the following observations were made:

1. People along the Metro corridors also feel, that's the best public transport reducing the traffic problems, without much impacting the aesthetics of society and the surrounding environment.
2. People along the Metro corridors also feel a lot of pollution was caused during construction and have lost some important structures and trees along the lane.

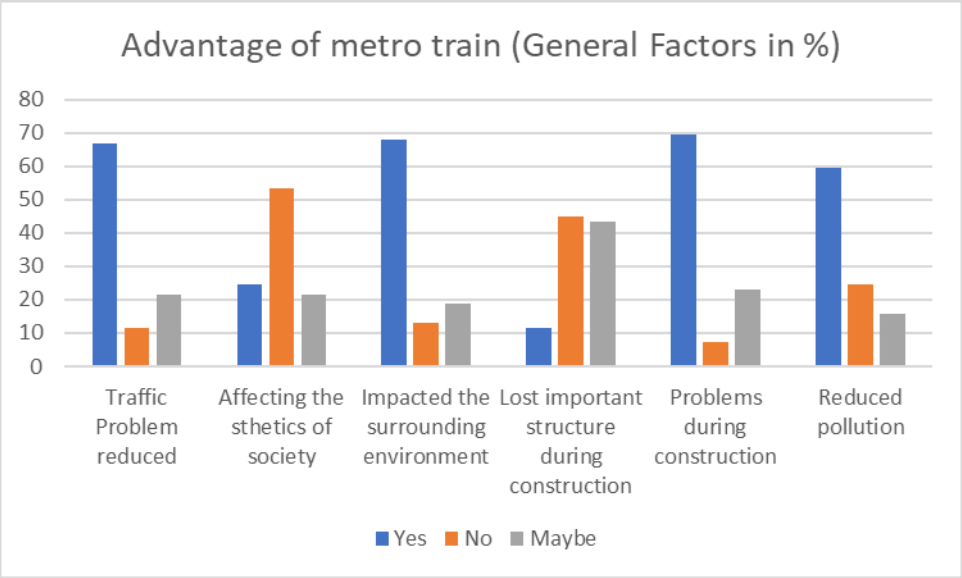



**Figure 4 : Responses from the people residing along Namma Metro corridors.**

## 5 Results:

The "Discrete Choice Models" (DCM) are put up as an improvement and expansion of the conventional theory of choice (Ranjan, Lal, & Susaeta, 2016). They are predicated on the idea that choosing one economic agent often involves forgoing the choices of the other agents because the options or solutions are often mutually incompatible. Contrary to the microeconomic perspective, DCM holds that the environment that influences a person's behavior in making choices is unpredictable and particular to each circumstance. It is influenced by several variables, including the socioeconomic traits of the chosen feature and the individual in question, as well as the conditions that define the environment of choice.

The "Multi-Nominal Logistic model "(MNL), one of the discrete choice models, is the most popular and used in a variety of contexts. As a result, the multinomial logic model will enable us to calculate the probability that a person I will select option j under specific conditions defining the environment of choice. All factors determining the context of choice can be described as a linear (or nonlinear) function of this probability ($X_k$).

This probability can be expressed in formal terms as follows:

$$\boldsymbol{P_{ij} = F_{ij}\left(\sum_{k=1}^{K} \propto_k X_k\right)} \qquad \textbf{(2)}$$

$P_{ij}$ is the probability that an individual i makes the decision j.

The parameter k is difficult to estimate. They represent the weight of each explanatory variable ($X_k$) in determining the probability $P_{ij}$. $F_{ij}$ is the explanatory variables' distribution function.

In this paper, the Satisfaction of the public transportation of the Namma metro with respect to Metro users and with respect to people living along the metro corridors has been calculated using MNL.

### *5.1 Responses from non-metro users*

As mentioned earlier, 97 responses from Metro users and 69 responses from those living in Metro corridors were found eligible in terms of responses to all questions.
The following factors/choices were considered by 69 respondents for developing the MNL model using SPSS software for statistical analysis as shown in

**Table 1 : Descriptive statistics of the variables**

| Descriptive Statistics | | | | | |
|---|---|---|---|---|---|
| | **N** | **Minimum** | **Maximum** | **Mean** | **Std. Deviation** |
| Gender | 69 | 0 | 1 | 0.5217 | 0.50319 |
| Age | 69 | 1 | 5 | 2.9565 | 0.88176 |
| Education | 69 | 1 | 5 | 2.5507 | 0.88345 |
| Occupation | 69 | 1 | 6 | 2.5652 | 1.35558 |
| Monthly Income | 69 | 1 | 3 | 1.913 | 0.8178 |
| Years Residing | 69 | 1 | 5 | 2.6377 | 1.54321 |
| Impact_Property | 69 | 0 | 1 | 0.1014 | 0.30413 |
| Property_Compensation | 69 | 0 | 1 | 0.1014 | 0.30413 |
| Impact_Construction | 69 | 0 | 2 | 1.1594 | 0.53201 |
| Impact_Impstructure | 69 | 0 | 2 | 0.9855 | 0.94702 |
| Impact_Environment | 69 | 0 | 2 | 1.058 | 0.5658 |
| Impact_Asthetics | 69 | 0 | 2 | 0.6812 | 0.81336 |
| Impact_Pollution | 69 | 0 | 2 | 0.913 | 0.63568 |
| Impact Traffic | 69 | 0 | 2 | 1.1014 | 0.57253 |
| Metro_Bestpt | 69 | 1 | 4 | 2.0725 | 0.77305 |
| **Valid N (listwise)** | **69** | | | | |

From SPSS software, the MNL model was generated and from the MNL model, the following.

A table was generated (Table 2). From the following table, the following interpretations can be made:

The likelihood-ratio test evaluates the quality of fit between two statistical models that are in competition based on the ratio of their likelihoods, specifically one obtained by maximizing over the entire parameter space, and another obtained after applying a restriction. The two likelihoods should not differ by more than the sampling error if the observed data support the constraint (i.e., the null hypothesis).

- The factors such as the impact on the property due to metro construction and compensation paid for the property owners, and monthly income for the people residing along the metro corridor do not have any significant impact on the Satisfaction of the Metro as Public Transport from non-Metro users.
- The factors such as the impact on pollution, impact on traffic, gender, age, education, occupation, impact on construction, important structure, aesthetics of the locality, and impact

on the environment are statistically significant for the Satisfaction of the Metro as Public Transport from non-Metro users.

- Higher Pseudo R-square value shows that the reduced model can be used for the calculation of Satisfaction of the Metro as Public Transport from non-Metro users.

**Table 2 : Description of the Logit model developed.**

**Pseudo R-Square Cox**

| | |
|---|---|
| Cox and Snell McFadden | 0.857 |
| Nagelkerke | 0.955 |
| McFadden | 0.855 |

**Likelihood Ratio Tests**

| | Model fitting criteria | Likelihood Ratio Tests | | |
|---|---|---|---|---|
| **Effect** | **-2 Log likelihood of Reduced Model** | **Chi-Square** | **df** | **Sig** |
| Intercept | 22.729[a] | 0 | 0 | - |
| Impact_Pollution | 28.214[b] | 5.485 | 3 | 0.14 |
| Impact_Traffic | 82.35[c] | 59.622 | 3 | <0.001 |
| Gender | 63.679[b] | 40.95 | 3 | <0.001 |
| Age | 70.832 | 48.104 | 12 | <0.001 |
| Education | 74.736[b] | 52.007 | 12 | <0.001 |
| Occupation | 70.876[b] | 48.149 | 15 | <0.001 |
| Monthly_ Income | 0.176b | | 6 | |
| Years_Residing | 83.475[b] | 60.476 | 12 | <0.001 |
| Impact _Property | 22.729[a] | 0 | 0 | |
| Property_Compensati On | 22.729[a] | 0 | 0 | |
| Impact _Construction | 56.35[b] | 33.621 | 6 | <0.001 |
| Impact _Impstructure | 54.59[b] | 31.84 | 6 | <0.001 |
| Impact _Environment | 72.44[b] | 49.72 | 6 | <0.001 |
| Impact _Asthetics | 65.696[b] | 42.967 | 6 | <0.001 |

The difference between the final model and a reduced model's -2 log-likelihoods is represented by the Chi-square statistic. The final model's effect is removed to create the reduced model. The null hypothesis is that all of those effect parameters are 0.

(a). The degrees of freedom do not increase because eliminating the effect of this reduced model is comparable to the final model.
(b). Unusual singularities are found in the Hessian matrix. Indicating that one should combine some categories or some predictor variable to be eliminated.
(c). After the maximum number of step-halving, further the log-likelihood value cannot be improved anymore.

The final model for calculating the Satisfaction of the Metro as Public Transport from non-Metro users is as given below (Equation 2)

***Satisfaction of the Metro as Public Transport from non-Metro users=log (22.729 + 28.21*Impact pollution + 82.350*Impact-Traffic + 63.769*Gender + 70.832*Age + + 4.736*Education + 70.879*Occupation + 83.475*Years-Residing + 56.35*Impact_Construction + 54.569 Impact_Impstructure + 72.449Impact_Environment + 65.669*Impact-Aesthetics)***

(3)

### *5.2 Responses from the metro riders:*

As mentioned earlier, 97 responses from Metro users and 69 responses from those living in Metro corridors were found eligible in terms of responses to all questions.

The following factors/choices from 97 respondents were considered for developing the MNL model using SPSS software for statistical analysis.

**Table 3 : Descriptive Statistics for the survey from people using Namma Metro**

| Descriptive Statistics- Metro users | | | | | |
|---|---|---|---|---|---|
| | **N** | **Minimum** | **Maximum** | **Mean** | **Std. Deviation** |
| Gender | 97 | 0 | 1 | 0.44 | 0.499 |
| Age | 97 | 1 | 5 | 2.62 | 1.278 |
| Education | 97 | 1 | 5 | 2.44 | 0.957 |
| Occupation | 97 | 1 | 6 | 2.69 | 1.475 |
| Monthly Income | 97 | 1 | 3 | 1.78 | 0.819 |
| Metro_Usagetime | 97 | 1 | 10 | 3.61 | 2.303 |
| Purpose | 97 | 1 | 5 | 2.63 | 1.074 |
| Dist_Origintometrostation | 97 | 1 | 5 | 3.13 | 1.448 |
| Dist_Metrostntodestn | 97 | 1 | 5 | 2.49 | 1.415 |
| Frequency_Metro | 97 | 1 | 5 | 2.36 | 1.634 |
| Expenditure | 97 | 1 | 5 | 1.81 | 0.894 |
| Metro_Othermodes | 97 | 1 | 4 | 3.12 | 0.949 |
| Impact Traffic | 97 | 1 | 5 | 1.63 | 0.651 |
| Impact_Asthetics | 97 | 1 | 7 | 4.72 | 1.858 |
| Impact_Environment | 97 | 0 | 1 | 0.94 | 0.242 |
| Metro_Bestpt | 97 | 0 | 1 | 0.8 | 0.399 |
| Valid N (Listwise) | 97 | | | | |

From SPSS software, the MNL model was generated and from the MNL model, the following.

A table was generated (Table 3). From the following table, the following interpretations can be made:

The omnibus test compares (Table 4) the current model to the null model using a likelihood-ratio chi-square test. The current model has a significant value of more than 0.05 and hence the developed model will not be statistically significant, which indicates that there are other parameters that need to be included or the sample size to be increased for a better statistical model.

**Table 4: Statistical Analysis of the survey from people using Namma Metro**

| Omnibus Tests of Model Coefficients | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Overall (Score) | | | Change from previous step (Score) | | | |
| -2Log Likelihood | Chi-Square | df | Sig. | Chi-Square | df | Sig. | Changed Chi-Square |
| 644.668 | 61.898 | 14 | <0.001 | 49.796 | 14 | <0.001 | 49.796 |

| Variables in the Equation | | | | | | |
|---|---|---|---|---|---|---|
| | B | SE | Wald | f | Sig. | Exp(B) |
| Gender | -0.001 | 0.242 | 0 | 1 | 0.996 | 0.999 |
| Age | -0.077 | 0.116 | 0.444 | 1 | 0.505 | 0.926 |
| Education | 0.034 | 0.137 | 0.06 | 1 | 0.806 | 1.034 |
| Occupation | -0.019 | 0.103 | 0.034 | 1 | 0.854 | 0.981 |
| Monthly Income | -0.013 | 0.167 | 0.006 | 1 | 0.937 | 1.013 |
| Metro_Usagetime | -0.012 | 0.056 | 0.044 | 1 | 0.834 | 0.988 |
| Purpose | 0.083 | 0.12 | 0.487 | 1 | 0.485 | 1.087 |
| Dist_Origintometrostation | 0.002 | 0.113 | 0 | 1 | 0.984 | 1.002 |
| Dist_Metrostntodestn | -0.051 | 0.099 | 0.267 | 1 | 0.605 | 0.95 |
| Frequency_Metro | -0.061 | 0.154 | 0.155 | 1 | 0.694 | 0.941 |
| Expenditure | 0.04 | 0.154 | 0.069 | 1 | 0.792 | 1.041 |
| Metro_Othermodes | 0.116 | 0.182 | 0.404 | 1 | 0.525 | 1.123 |
| Impact Traffic | 12.214 | 57.919 | 0.044 | 1 | 0.833 | 0 |
| Impact_Asthetics | 0.291 | 0.235 | 1.529 | 1 | 0.216 | 1.337 |

## 6 Conclusion

The Namma Metro in Bengaluru has several advantages, including a decrease in air pollution, time savings for passengers, a decrease in accidents, a decrease in traffic congestion, and fuel savings, all of which influence the socioeconomic position of commuters on the purple line corridor. The various parameters examined in the survey and their outcome can be summarized as follows (Table 5).

**Table 5 : Parameters and Observations from the Study area**

| Parameters & observation | |
|---|---|
| **Location-related characteristics:** Location with relation to the metro station, accessibility to the station, and ease of use. | Had a positive impact, as most people are using the Metro for their work trips, which reduces the time of travel and is convenient for travel. |
| **Neighborhood-specific characteristics**, such as reduced traffic problems, visual aesthetics of the area, and impact on the surrounding environment. | The metro commuters have a positive attitude towards the Metro as the survey says it reduces the traffic congestion problem and does not impact the aesthetics of the locality. It also promotes non-motorized transport. |

| | |
|---|---|
| **Environmental Characteristics:** Traffic and transportation problems, air and noise pollution, aesthetics of the locality, impact during construction of metro | People living in Metro corridors during the survey also gave positive feedback about the Metro services in terms of reduction of traffic jams, and reduction in air, noise, and dust pollution. Only during construction, they experienced some inconvenience due to dust and diversions along the construction road. |

From the output, it can be seen that -monthly income, impact on the property, and compensation paid for the damage during construction do not have any significance on the influence of the Namma metro nonusers.

From the output model developed to understand the impact of Namma Metro on the Metro train users, the variables do not significantly affect the model. Other parameters need to be added or the sample size to be increased to understand the influence of Namma Metro and here is the scope for further study and analysis.

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**Corresponding Author: hemasree.raj@gmail.com*