

# Influences and Impressions of Metro Rail Transit Systems in Urban Spaces: A Review

R. Hemasree\*, C. V. Subramanian

Department of Architecture, Periyar Maniammai Institute of Science and Technology, India

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**Abstract** Indian cities have undergone a tremendous urban transformation, particularly in the previous three decades. Urbanization is on the rise, infrastructure is being built quickly, and the social fabric is diversifying, all of which have an impact on the physical environment. It's important to observe that in India, Applied Planning Policies frequently address Urban Transformation brought on by the socioeconomic requirements of the city and aggressive market forces. The quality of a country's transportation infrastructure is one of the most important indicators of its wealth. The main Indian metropolises' economic success has increased as a result of the increased international trade, financial flows, and inter- and intra-city travel. The transportation industry is broad and diversified, but it also confronts its own set of problems that may be solved by using energy-efficient technology and a customer-focused approach. The construction of a Mass Rapid Transit System (MRTS) project is often anticipated to increase property prices in any given city. Customers, household members, and employees may commute from their homes to their places of employment and to other locations with ease thanks to the MRTS system. It provides the fastest, safest, and most dependable method of commuting. Bengaluru, the capital and largest city of Karnataka, is served by the Bangalore (Namma) Metro, an urban MRTS with two lines and 51 stops. The study on the effects of metro trains on land use, socioeconomic features, and historic structures is thoroughly reviewed in this publication. The evaluation made it clear that additional study is necessary to determine how the effect of metro rails may be "quantified" in ways that are straightforward and approachable. Users must notice a noticeable

difference in trip times from the baseline before they will find the system more enticing than alternative public transportation options.

**Keywords** Metro Rail, Infrastructure, Transport Systems

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## 1. Introduction

Settlements in rural areas surrounding cities continue to expand in both the developed and developing worlds. Commuters from these areas typically drive their own cars to cities, contributing to traffic, parking, and environmental difficulties, as well as putting a load on the city's transportation system. Due to rising traffic demand, cities all over the world are experiencing major issues with traffic congestion, traffic accidents, and environmental pollution. Cities in underdeveloped nations are more severely affected by these issues. The ineffectiveness of the public transit system has made these issues worse. Cities in India are hardly an exception, particularly those where the population has surpassed 1 million. India had more than 142 million registered automobiles in 2011, and that number is growing at a rate of around 10% per year. Two-wheelers (2Ws) account for the majority of this population of vehicles (72%), followed by passenger automobiles (13.6%) and freight vehicles (5.0%). There is an attempt to increase the public transport share by introducing and increasing the existing MRTS lines in each of Indian Cities.

The metro rail, also known as a rail-based mass rapid transit system (MRTS), is becoming more and more popular throughout the world, including India. Numerous studies relating to the quantification of the benefits of these projects in terms of fuel savings, emissions saved, a decrease in air and noise pollution, and a decrease in road accidents along its corridor were required as a result of the debate over whether or not the significant public investment in such capital-intensive projects was justified. These advantages are anticipated from MRTS developments as passengers switch from individualized as well as from other modes of transit to MRTS (thus removing motor vehicles on the road).

## 2. Methodology for Review of Literature

To provide a thorough perspective, it began with a systematic search for studies focusing on the influence of railway transportation networks on socioeconomic characteristics and land use. Web of Science and Scopus databases were used for the database search. Keywords

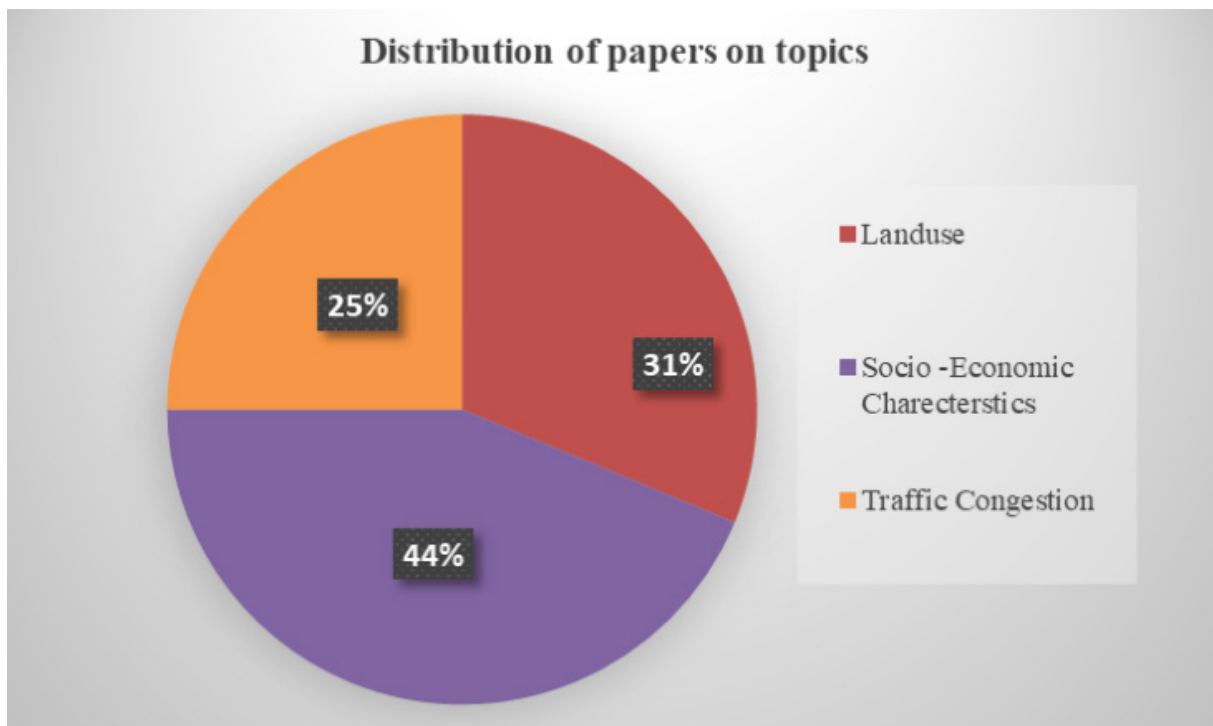
such as land use, heritage structures, and traffic congestion were searched in the title, abstract, and keywords of academic articles in English, including journal papers and conference proceedings, published between 2013 and 2021, as metro operations began in Bangalore, India after 2013. The distribution of papers from various sources has been presented in Table 1.

**Table 1.** Papers from different sources

Sl. No	Source	Nos.	Papers covered from
1	National	9	2018-2021
2	International	7	2013-2021

In this section, comprehensive review of the studies of various investigators on (i) impact of metro rails on land use, (ii) impact of metro rails on socio-economic characteristics, (iii) impact of metro rails on traffic congestion, both Indian and other countries of the world, have been presented.

The distribution of papers on different topics with methodology is presented in Figure 1 and Figure 2.



**Figure 1.** Distribution of papers on topics

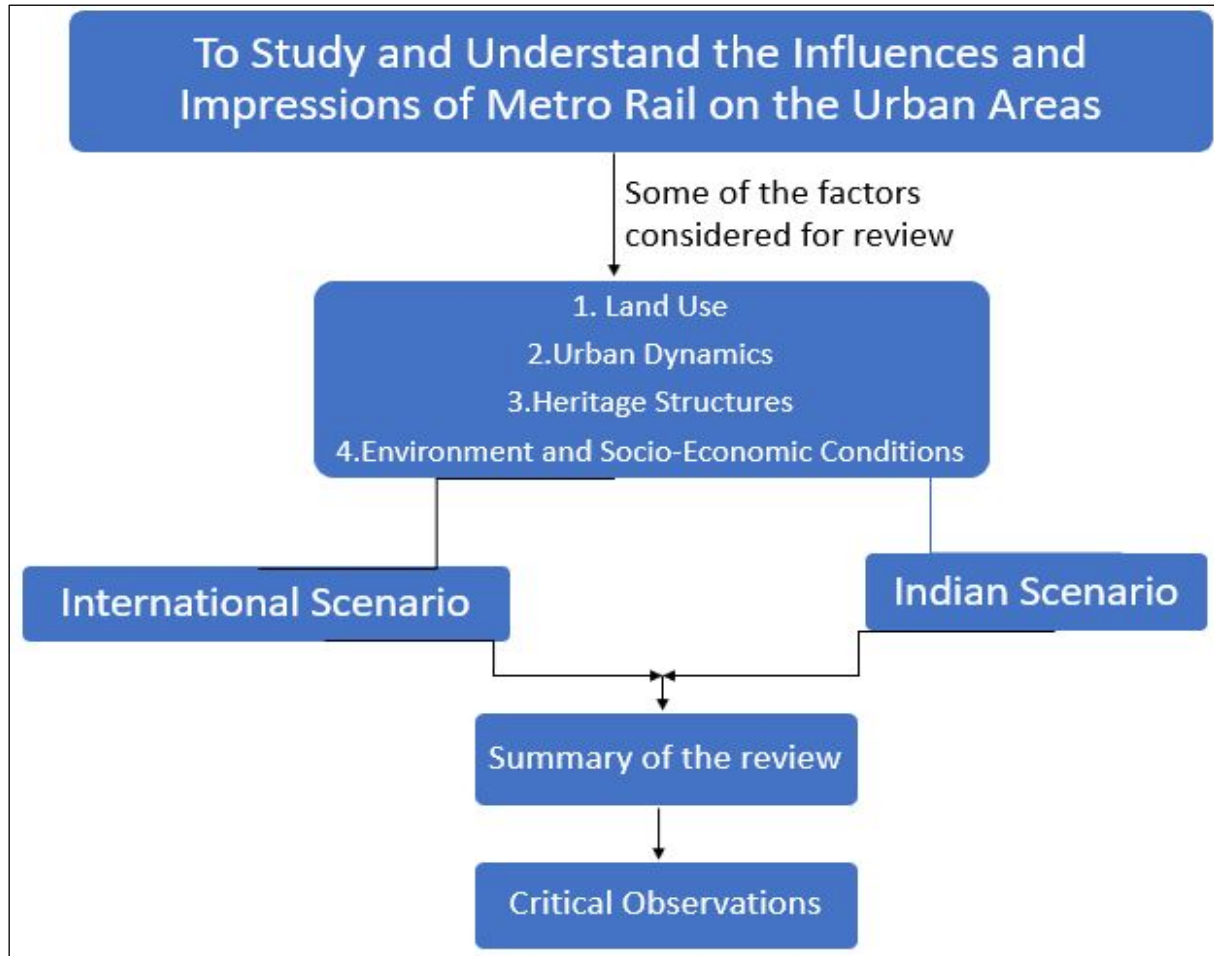


Figure 2. Methodology

### Review of Metro Rail's Influence on Land Use, Traffic Congestion and Heritage Structures (International Scenario)

The main goals of this project in the city of Sao Paulo, Brazil were to create wide open spaces, reinforce the activity center through intermodal transportation integration, and encourage private investment in both residential and commercial structures [1]. In the city of Sao Paulo, a legal mechanism known as Urban Operation permits a developer to expand over the statutory maximum within the Master Plan in exchange for purchasing municipal bonds. As a result, this revenue is used to improve the infrastructure in the UO region. Influences, Impression & Impact of Metro rail transit system in Urban spaces The Batata Square Urban Renewal Project, which is the focus of this research, is part of the "Faria Lima Urban Operation," 2 and its main objective is to revitalize a severely deteriorated area that was previously home to a chaotic and dangerous bus station as well as a bustling but illegal street market. The project area has been increased to allow for the building of a new metro station (Faria Lima station) and the relocation of present bus stations, resulting in the construction of Pinheiro's Station, a new bus station

adjacent to the subway and commuter railway stations. The following are the primary recommendations for each location. New public areas in Batata Square (parks, exhibitions and performances by artists, new public lighting, pedestrian roads).

In Thessaloniki Metro, Greece, research was done to determine the interaction between transportation systems and land use [2]. The land use characteristics within a 500-meter radius of the Papafi station were investigated, as well as a Stated Preference (SP) survey and input from residents and visitors. GIS technology was used to create the appropriate maps for transportation and land use. The survey data was analyzed using a non-linear statistical method called Principal Components Analysis for Categorical Data. The presence of train infrastructure has a good impact on land, according to this study. This study helped us understand and analyses the expected changes in the region after the subway station was completed and put into operation. 290 samples were collected from people with different socio-economic conditions and educational backgrounds. More than 70% of the people surveyed prefer the subway as a means of transportation. Approximately 85% of those surveyed expect more entrepreneurs. Low-educated and high-paying people seem to be positive

about the idea that a new subway station will bring further development to the region, as opposed to low-educated and low-paying people. Private car passengers prefer to get off at this point and take the subway. If you have enough parking space, leave your car and take the subway to Thessaloniki.

This paper provides a model to transform the time distance of travelling light rail to the spatial distance in meters using meta cartography [3]. This study uses the Geographic Information System (GIS) Map Projection Spatial Transformation method to redefine the distance between two locations with the transformed distance, and then transform the original map into a time-distance map based on it. Temporal distance is visually represented in this work through spatialization. The results show that the distance between the station point, and the selected midpoint affects the effect of the light rail on the shape of the city. That is, if the station points are far from the center, the transformation will be large and vice versa. The effect of the light rail on the layout of the business center is primarily circular. The classic urban shape is condensed by time distance. The city has plenty of room to reduce travel time even more, and current business hubs could be modernized.

This thesis investigates places in the Stockholm metropolitan area's metro/rail routes that are appropriate for implementing Demand Responsive Transport (DRT) [4]. Following identification, a model is used to compare two possible operating strategies for feeder services in order to find the best solution at various phases of vehicle technology development in the disciplines of automation and electrification. The model employed, together with existing ones to adapt it to real-world circumstances, produces numerical results for the four steps considered, demonstrating the impact of travel demand and roadway sinuosity on the outcomes and best selection.

In China, a study was done to determine the vulnerability of heritage structures for the construction of a metro line. While urban rail transit systems have progressed swiftly, heritage buildings and historic monuments in the surrounding area may be subject to unanticipated damage. In an old city, a rail project has the potential to impact a huge number of historic buildings and landmarks. As a result, in order to better maintain these historic structures and monuments, decision-makers must be able to analyse these threats swiftly and effectively. This study develops a risk matrix built on Set Pair Analysis (SPA) concept to evaluate the safety of heritage buildings in the vicinity of metro construction. In this system, the danger ratings of nearby heritage buildings are ranked. This study also creates an assessment index system with 16 different indices grouped into four categories: heritage buildings, metro, soil, and management. The index system determines the interval values for each assessment factor. To improve the index weight's reliability, a linear weighting approach was applied. This study looks at both subjective and objective weights provided by the Analytic

Hierarchy Process (AHP) and the Clustering Weight Method (CWM). In addition, the proposed evaluation approach was employed in a case study to analyze the architectural potential hazard of a heritage building near the Zhengzhou Metro Line Three. The results of proposed model were found to be compatible with the Matter-Element (ME) method. The purpose of this study was to assess the performance of Dhaka's current transportation system [6]. The efficiency of the public transport system must be evaluated because it is a need for making a fastgrowing metropolis like Dhaka more livable. Despite the fact that the city has had public transportation since the 1960s, no attempt has ever been made to evaluate its effectiveness. The literature was used to identify a set of detailed and contextual performance assessment tool for assessing Dhaka's socio-economic state and measuring the public transportation system's current condition and performance. The five criteria that encompass both passengers and operators' viewpoints are service effectiveness, capacity factor, cost efficiency, utilization efficiency, and network efficiency. The results revealed that current system's service quality falls short of what other cities and the literature deem adequate. Measures of system, communication, and cost effectiveness all fell short of expectations. The only exception was the utilization efficiency metrics, which could be attributed to abuse of the vehicles and the persons involved in their operation. The need for travel grows in tandem with the population. For addressing public needs, public transit networks are critical. A study was done in Karachi, Pakistan, to better understand the requirement [7]. To meet Karachi's public transit needs, the Karachi Circular Railway is being reactivated. Passengers, on the other hand, are split on whether public transportation should be used for their daily commute. The purpose of this study was to determine if passengers' attitudes and beliefs about using public transportation (the Karachi Circular Railway, KCR) matched to their stated intentions using a questionnaire survey. For this investigation, a sample size of 385 people was chosen at random. The theory of planned behaviour was used to anticipate Karachi's intentions to utilize KCR after its resurrection based on attitudes, subjective norms, and PBC. The analysis uses SPSS version and ArcGIS. According to these findings, subjective norms were a major factor in KCR adoption for educational purposes. The educational acceptability of the Karachi circular railway is determined by whether or not other people in the participants' immediate neighbourhood think it's appropriate. Government organizations and officials in Pakistan and other similar locations may find the findings useful.

### **Review of Metro Rail's Influence on Land Use, Traffic Congestion and Heritage Structures (Indian Scenario)**

The goal of this research is to learn more about how urban rail can influence land value increases, particularly

in understudied growing cities like Bangalore, India [8]. The Bangalore Metro had a substantial influence in the 'catchment area' and 'across the city,' according to the report. Between 2012 and 2016, the study used a panel data hedonic price model for around 160,000 units and a cross-sectional data hedonic price model for 314,000 flats. The dataset produced a more reliable prediction that indicates significant gains in land value even outside of the typical 500m catchment. A comparison of pricing afterwards when metro rail operations showed a 4.5 percent increase across the city, indicating a significant cluster monetary board that resulted in a considerable readiness to spend USD 306 million for metro rail connectivity. Emerging cities can anticipate metro rail to significantly improve their economies as well as other co-benefits as long as money can be obtained by capturing this value. A study was done to learn more about the influence of the Metro system on urban development in Delhi and the NCR during the previous few decades [9]. Despite the fact that the Delhi metro has been operational for nearly two decades, little research on its impact on real estate has been conducted. Housing is one of society's most basic needs, and its costs are affected by even minor environmental changes. A variety of factors influence the variation. One of the most crucial factors to examine is the property's accessibility, which is vital because one must travel almost every day for individual matters. In India's main cities, the Metro Rail Transit System is the most versatile means of transportation. Road and highway infrastructure upgrades, as well as the introduction of new public transportation, like the Metro Rail System. As a result, the research will look into the impact of the metro rail transit system on the cost of residential properties in the metro region. There are a number of characteristics of residences located near metro stretches that have a positive or negative impact on the cost of property. As a result, the focus of this article is on identifying such characteristics, ranking them, and then using them to create a model that can estimate property prices surrounding a metro stretch depending on the attributes chosen. Hedonic Regression is used to build three unique equations for Low Income Bracket, Mid Income Group, and Elevated Group properties in order to anticipate property prices around a metro stretch. The study discovered that a property's price near a metro stretch is influenced by a variety of characteristics, which are listed and ranked in this report. Second, the metro has a significant impact in low-income

areas while having little impact in high-income areas. As the distance between a home and a metro station increases, so does its value. 5 The primary goal of this study article is to explore commuters' experiences with the metro rail system, as well as the tactics and approaches employed by CMRL to retain existing passengers and recruit new ones in modern Chennai [10]. The Chennai Metro's implementation needs an assessment of the changes it will bring to the economy's transportation sector. For the city's ever-growing population, public transit is a necessity in Chennai, one of India's busiest cities. Chennai has a big population of persons between the ages of 18 and 30, and a large migrant population looking for better lives and jobs. Chennai Metro should continue to innovate and adapt to new technology in order to take advantage of the demographic dividend. The expansion of Metro service in Chennai after hours, which provides a fast service and allows users to recharge Smart cards online, among other things, could be key steps in that direction. Commuters of all ages come from a variety of societal, economic, and educational backgrounds, and they have a variety of transit needs. In Bangalore, India, research was conducted to determine the effects of the metro transport rail system on property use and property values [11]. The impact on land use has occurred after 2005 due to the low impact of the land ownership profile on land use changes. The influence of the metro on residential property conversions to flats, mixed-use property conversions to residential, and residential or combined property conversions to commercial, as well as future developments on unused land. Land lots have been consolidated in order to take advantage of bigger expansion choices in terms of FSI and allowable building heights. Land values in the surrounding area and along the metro track have increased as a result of the metro. Only partial benefits are utilized due to the current land ownership/use profile form. Prices have risen at a pace of around 9% to 11% each year since the metro's creation. The absolute growth in land values is greater in the immediate vicinity. Between 150m and 500m from the buffer, the biggest rise has been seen. Land use densification has emerged as a result of rising building heights. As a result of increased demand for commercial and retail space, site scarcity for horizontal expansion, and favorable construction options, buildings have expanded vertically. The use of FSI is higher in the metro station's immediate vicinity. Figure 2 shows the increase in land value as a function of time.

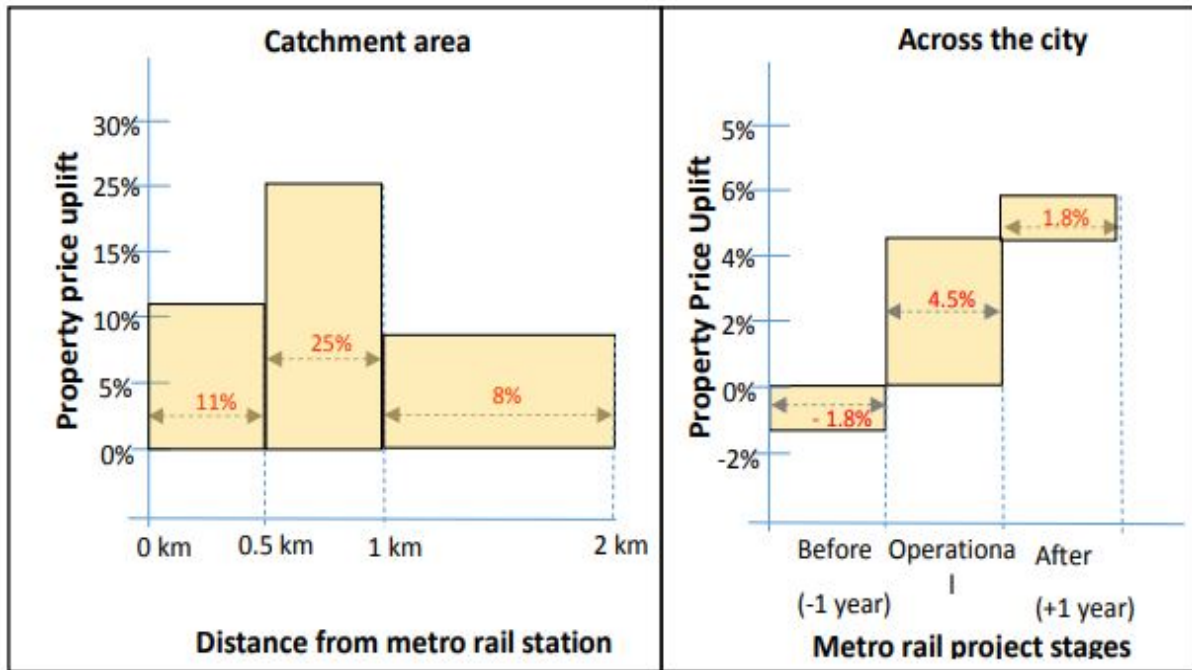


Figure 3. Land value increment due to Metro rail, Bangalore

The influence of metro train construction work zones on the traffic environment in a site located on Swami Dyanand Marg, a six-lane split carriageway in East Delhi, India, and how to quantify these effects were investigated [12]. The impact of a junction in a work zone was investigated in this study. Video graphing was used to conduct speed and delay tests. Traffic component, peak and an off-traffic flow, impact of work area on speed profile, effect of worksite on capacity of the given section off road, and correlation of journey speed, time, and fuel consumption are only a few of the studies conducted. One or more categories of vehicles during peak hours in the work zone region, according to the study, could be one of the transportation planning schemes that can be used in work zones. For each mode, a total of 271 samples were collected, and the average occupancy for each mode was computed. Car journeys account for 52 percent of business trips and 48 percent of non-work trips, respectively. Work journeys account for 53 percent, 28 percent, and 56 percent of two-wheeler, auto, and bus trips, respectively, while non-work excursions account for 47 percent, 52 percent, and 44 percent. The economic losses for elevated metro development in the specified site were expected to be about 20 crores per kilometer per year. The losses are huge, and it becomes imperative to have systematic work zone schedule and an efficient traffic management system to reduce the impacts of metro rail construction. To mitigate the effects of metro rail construction, it is necessary to establish a methodical work zone timetable and an efficient traffic control system. A study was conducted to understand the feeder bus system at metro station, Bangalore, India [13]. Mass Rapid Transit (MRT) is one of

the key transportation systems suggested in metropolitan cities such as Bangalore in order to alleviate numerous traffic problems and reduce travel time, among other things. A good Integrated Transport System can boost the efficiency of this system by attracting a larger number of trip makers. The Feeder system, which includes Feeder, buses (Mini-buses) operating across the radial areas of Metro stations, is one of the techniques planned for Namma Metro in Bangalore. The current 7 study examines the need for these buses in comparison to public transportation buses now running in these locations in terms of commuter willingness, frequency, and frequency of service and travel time. The study examines the primary design features of two EPB TBM machines that pass through Jaipur's Chandpole Gate[14]. The UG1B is the first underground Train Line under construction in Jaipur, Rajasthan's capital (India). The dual bore tube goes through Jaipur's ancient city, dubbed "Pink City," in its historic center. World-famous historical buildings such as the Hawa Mahal, Jantar Mantar, Isarlat Tower, Tripolia Gate (city palace's main entrance), and Chandpole Gate are included in the project's broader effect zone. The double-hole TBM tunnel penetrated 4.5 meters beneath the base of Chandpole Gate, one of the city's most important historical gates and nearly 300 years old. Settlement and vibrations at heritage structures in Kolkata, India are being assessed in this study [15]. Kolkata, India, is one of the most densely populated cities on the planet. It has an underground metro train system that predominantly travels north-south through the city. Another subsurface metro train link between the city's center and the railway terminals and the airport is being proposed. Under the

Ganges and across the city's most congested sector, twin tunnels with diameters of 6.1 m and 15 m are now being developed. The tunnels are located between 17 and 24 meters below ground level. In Kolkata's soil layers, light clay minerals (clay soils silt to silty clay) created more by river are intermingled with stacks of heavy sand at quite a deeper depth. Several historic heritage structures have been unearthed along the E-W metro route. These structures are 19 to 33 meters from the tunnel's centerline. During tunnel building, excessive settlement and/or vibration may cause damage to these historic structures. Both dynamic and static finite element simulations were used to estimate the movement and resonance at those historical buildings. The analysis' conclusions are compared to case studies of tunnel building on soft soils published across the world, as well as empirical approaches proposed by Mair et al. and the FHWA to estimate ground settlement due to proposed tunnel construction. This research explored how Visually Challenged People (VCPs) interact in terms of cognitive traits such as attention, memory, and perception when commuting by Metro, taking into account the facilities already accessible for VCPs in the Bangalore Metro station [16]. The majority of (VCPs) use public transportation because they cannot afford to acquire a car with a driver and because they are unable to drive it themselves. The key motivation for the study would be that the Bangalore Metro was just recently established as a mass transportation system in Bangalore, and it currently provides certain facilities for VCPs. By examining the status of VCP facilities supplied in existing Metro stations, the findings of the research can be beneficially incorporated at the time of building of new Metro stations, which are sprouting up at a faster rate. The research assessed the platform's capability to provide train-related information and services. This covers ideas for improvements to Metro station facilities and possible proposals and engagement strategies.

### 3. Discussions and Results

From the above literature studies, the following observations were made:

#### The Impact of Metro Rails on Land Use

Land values are boosted by access to train infrastructure. People with a middle-to-high income appear to be more optimistic about the new metro station bringing markable development. Metro parking facilities are a prerequisite for a successful Metro facility installation. The Analytic Hierarchy Process (AHP) and the Clustering Weight Method (CWM) models can be used to provide decision-making help for risk control on comparable projects.

#### The Impact of Metro Rails on Socio-Economic Characteristics

Developing cities can anticipate large economic and other co-benefits from the metro rail. The metro has a large influence on low-income neighborhoods and a low impact on high-income neighborhoods. The value of the property varies as the distance between it and the metro station grows. The highest rise in land value has been observed between 150m and 500m from the buffer. In terms of increased building heights, land use densification has emerged due to the Metro rail system.

#### The Impact of Metro Rails on Traffic Congestion

Because the losses are so significant, it's critical to have a well-organized work zone timetable and an effective traffic management system in place to mitigate the effects of metro rail construction. A well-integrated transportation system can increase the efficiency of a metro rail system by attracting more passengers and reducing traffic congestion on the road.

## 4. Conclusions

More research is needed to see how the impact of metro rails may be 'quantified' using simple, user-friendly ways. Significant improvements in journey times compared to the baseline are required for users to view the system to be more appealing than other public transportation systems. Measures to increase total trip duration, service frequency, comfort, and guidance are also to be included. Furthermore, good access to the station regions is necessary to achieve beneficial strategic outcomes such as urban growth and higher property prices. The evaluation of Metro rail systems after every 5 years from the operations are very much essential to understand and improve the rail systems to make them more attractive to people to shift towards public transport systems.

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