Chapter 3
Disruptive Mobility in Pre- and Post-COVID Times: App-Based Shared Mobility in Indian Cities—The Case of Bengaluru

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Abstract Smart Sustainable city is an emerging concept of a complex long-term vision to overcome the problems arising in the cities with the help of new technologies. Some of such problems in the transport sector include congestion, carbon emissions, and inadequate public transit service supply. One probable solution to these can be through optimum utilization of disruptive mobility, which has hit this sector like a storm. This chapter presents the scenario of App-Based Shared Mobility (ABSM) services in the city of Bengaluru and the consequent impact it is creating on the urban travel trends, travel behavior, and car ownership. These services generate city-level data, which can be utilized to judge various aspects of city-wide traffic to improve the overall mobility. Moreover, the change in consumer desire from ownership to the accessibility of goods and services has penetrated the transport sector in the form of Transport Network Companies (TNCs), which has great potential to impact the public transit ridership as well as private vehicle ownership which is further explored in the chapter.

Keywords Disruptive mobility · Carbon emission · Congestion · Public transport · Shared mobility · Smart mobility · Environment · COVID-19

3.1 Introduction

The emergence of the concept of ‘Sustainability’ can be traced back to 1645–1714 to Hans Carl von [28], the term ‘Smart City’ came into being just a few years back. However, the development of interlinked issues in the past few decades led to their

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convergence under a new heading, i.e., Smart Sustainable Cities. There are five developments which can be said to be the seeds from which this concept has emerged. They include Sustainable Urban Development and Sustainable Cities, Problems and Sustainable Development, Globalization of Environmental Urbanization and Urban Growth, Information and Communication Technologies, and Smart Cities. The definition of smart sustainable city can be written as a rewrite of Brundtland definition of sustainability with a small addition as follows: A Smart Sustainable City is one which meets the needs of its present inhabitants, without compromising the ability for other people or future generations to meet their needs, and thus, does not exceed local or planetary environmental limitations, and where this is supported by Information and Communication Technologies [19].

Mobility forms an integral aspect of a smart city [4, 6] and hence stays as an important factor of a smart sustainable city. Research conclusions and the present state of mobility in most of the urbanized areas are enough proof of the adverse impacts badly managed mobility systems have on the quality of life. One prominent way to achieve sustainable transport systems is through smart mobility. Smart mobility is a set of actions and projects, with different goals, contents, and technological intensity. In conclusion, it can be said that smart mobility is a multidimensional topic, which involves all paradigms of smart city and generates multiple benefits for all stakeholders of a smart city [35]. The organization HERE Mobility defines smart mobility as an integration of different modes of transport and infrastructure to make travel cleaner, safer, and efficient. It facilitates communication between a user and the mode of transport using Internet of Things (IoT) [27]. A smart city cannot possibly exist without smart mobility which integrates automation and smart connectivity into existing infrastructure to help reshape the city’s transport system [16]. Disruptive mobility (ridesourcing, carsharing, bikesharing, ABSM, electric vehicles, autonomous vehicles, etc.) prevalent these days forms an integral part of smart mobility. It focuses on the accessibility of products/services to the consumers rather than its ownership. This study will particularly focus on App-based Shared Mobility.

It has been observed that the markets in the last decade are giving way to networks as a result of which alternative modes of consumption and acquisition have emerged. It has become a popular trend of the market wherein consumers, instead of buying/owning things, are shifting their focus toward having access to goods and experiencing temporary access to them. In short, ownership is no longer the ultimate desire of consumers [6]. Hence, many business models have come up wherein such customer-demands are satisfied by sharing resources, services, and products with the help of peer communities or technology. Examples of such access models include a wide variety across a range of products, like carsharing (Ola, Uber, Zoom, Zipcar), bike-rentals (Hubway, Yulu), fashion (Bag borrow, Rent the Runway, Borrowed bling), etc. Though this idea of shared resources has been prevalent since a long time now, it is gaining much more popularity, all thanks to the Internet and capitalist marketplace trading in cultural resources instead of material objects [7]. Such consumption which is primarily access-based is defined as a market-mediated transaction wherein no transfer of ownership is done and only consumption time of the item is acquired by the customer. In the case of market-mediated cases of access,
for use of the object, the consumer is willing to pay a premium. This way, consumers can access networks and objects without going through the hassles of ownership and the maintenance it might demand.

Similarly, the transport sector underwent a humongous change with the coming of Transport Network Companies (TNCs) in the last decade. The concept of shared resources was applied by these companies, and hence, now a ride in a variety of cars is just a click away from the desiring customers. The car may not belong to the person riding it and the same ride may be shared by many people having the same or close by destinations. Some companies even offer rental services with daily or hourly charges. These TNCs (like Uber, Ola, Yulu, Zoomcar, etc.) have made a major impact on a lot of aspects like travel behavior, mode choice, and even the attitude toward car ownership, as suggested by various studies quoted in later sections of this chapter.

The Indian TNC market is dominated by two companies: Uber Technologies Inc. and ANI Technologies Pvt. Ltd. [43] which are American and Indian originated TNCs, respectively. Customers access their services via apps on their mobile phones, hence they are termed as App-Based Shared Mobility (ABSM). They have a wide variety of mode options to choose from, i.e., from bikes, autos, cars to even limousines. The prices vary according to the mode and timing of the ride. The customers also have varied payment options like cash, coupons, Google Pay, or even through credit cards. As a result of the ease of travel offered by these TNCs, their customers increased, and moreover, a gradual shift was also observed in the mode choice impacting the car ownership and public transit ridership. This study is an attempt to observe the same aspects in India, taking the case study of Bengaluru. In this chapter, an attempt is made to highlight the slow yet significant transportation paradigm shift occurring in major cities of India like Bengaluru. A comparison between public transportation and ABSM is done and factors identified due to which disruptive mobility is gaining popularity. TNCs generate large amount of city-level data on a daily basis, which can be utilized for the betterment of our cities. Hence, the data generated by Uber is utilized to find the annual cost of carbon emissions occurring due to consumption of additional fuel because of congestion.

In this chapter, public transport and ABSM have been compared on two grounds: spatially and considering waiting time, total travel time, and fare. It must be kept in mind that public transport and ABSM translate to buses and Uber in the first case, while in the second both buses and metro have been considered for public transport, and Uber and Ola for ABSM. The Public Transport Accessibility Map was made considering the bus stops and only phase-I of the Bengaluru metro. The 2019 trip generation-attraction maps of Uber rides could not be made given the unavailability of data on Uber movement website, as on January 2020.
3.1.1 Disruptive Mobility

Several innovations have come up with the potential to disrupt mobility, thereby causing major consequences on the transport system, city development, and energy system. The innovations and trends of disrupted mobility which are majorly responsible for it include Electrification, Shared economy, as well as Automation. The trends show that none of these new innovations, as of now, have been able to make any major changes in the existing mobility which is majorly personal vehicle dominated. Some indications showed a decline of motorization in previous years but the current mobility trends showed a recovery, indicating the main reason of decline to be the economic factors. Research of Sweden showed that the attitude of customers toward car-usage and cars, in general, has not changed since the past decade. This fact was further strengthened by the increase in the number of two-car households. However, it is undeniable that niches have been emerging in major cities which have a strong presence of carsharing services, and that they are increasing. The young people in these countries are taking their driving licenses later than the previous generation did and vehicle ownership is decreasing moderately.

Shaheen and Christensen [30] defines disruptive technologies as those which have the worst performance at the start with lower prices as compared to the mainstream technologies, but due to the technological improvement as well as convenience, they have the potential to take over the market. This is how disruption might occur from the market’s lower end. Similarly, a disruption from above might occur as well, which might have superior performance than the mainstream but is more costly. These disrupt the market through cost reductions. In terms of transportation, the term ‘disruptive’ is also interpreted as having the ability to create a major impact, thereby interrupting the normal course of the system. This might be a shift from the mobility through a privately owned vehicle, as majorly prevalent today.

Shared mobility describes those transport services, which are shared among the users and contains various options. Car sharing, both traditional station-based and free-floating, bikesharing, car rentals, and public transits fall under the term shared mobility. A public transport company in one of their commercials highlighted that the features which are being praised in the next-generation mobility are actually already present in public transport [33]. Carsharing was first established in Switzerland as early as 1948. During World War II, America ran a government campaign urging its common people to conserve resources and opt for carsharing. Americans, at that time, owned and drove automobiles more than ever before, which prompted an urgent need to save oil and gasoline. The only difference today is the convenience and ease of accessibility to these services, provided by the Internet, GPS, and smartphones. Existing services improved dramatically and new ones were offered due to the convergence of different technological advances. Nevertheless, the marketing strategies of these companies and even some municipalities have played a role in making carsharing services accessible and attractive to the customers. For example, the city council of Paris started an electric carsharing service by the name of Autolib. Municipalities, at times, choose not to support such services if the drawbacks feared
are more than the benefits offered. For example, the municipal corporation of San Francisco decided not to provide any preferential parking to the carsharing services as it was speculated that they will substitute the public transit and bike rides and induce more vehicle use causing environmental issues and loss to the public transit providers.

3.1.2 Worldwide Scenario of Disruptive Mobility

The American Automobile Association reports that the average annual cost of owning and maintaining a motorized four-wheeler to be $8,469 [12]. On the other hand, a member of CityCarshare, a San Francisco based non-profit carshare organization, only needs to pay annually $540 on an average [17]. Several studies showed that these carsharing members either avoided or reduced car purchase. Studies confirm that carsharing can remove 4.6 to 2 cars per shared vehicle [29] which creates a huge benefit both financially for customers and environmentally in general.

It has been observed that ridesourcing has had a negative economic impact on the taxi industry, given the fact that their market share is similar and the ease of accessibility is better than the traditional taxis. Researchers have confirmed that the growth of Uber is primarily due to the substitution of taxi trips. The price of taxi medallion in New York reduced from $1,100,000 in 2013 to $600,000 in 2015 [21]. The entry of ridesharing companies in the market was cited as the cause for this decrease [5]. Many factors collectively fall in favor of Uber, including lower fares, wider service coverage, and lower wait times for the under-served areas and population. For example, a study of New York revealed that Uber services provided the minority and lower income neighborhoods with more transportation services and choice. Also, in Chicago and New York, lesser complaints were received by the taxi services after the introduction of Uber, since the market competition had increased and the taxi service providers were compelled to perform better [42].

When looked at from the environmental perspective, there are studies having both the positive and negative point of view. The University of California Transportation Centre researchers concluded in their study that Ridesourcing users tend to own lesser vehicles which leads to lesser Vehicle Kilometer Travelled (VKT). Though 90% of vehicle-owning survey respondents said they did not change vehicle ownership even after using Uber, 40% of them reported that they drive lesser than earlier. One drawback of TNCs is that cab drivers often deadhead (operating the vehicle without any passenger) either to match passengers or to seek passengers in high-demand areas, which results in higher VKT and increased congestion [25].
3.1.3 Disruptive Mobility in India

On-demand mobility is no longer a foreign concept to India. Uber crossed 500 million rides in Indian cities in August 2017. In four years, the company outreached 29 cities and achieved this mark [38]. Ola cabs, the homegrown competitor of Uber, is growing just as rapidly. World Resources Institute (WRI), India found that impacts of disruptive/new mobility companies can be classified into four categories [41].

The term ‘new mobility’ refers to those companies which utilize technology to provide transportation services in new ways. The disruptions focus on re-inventing delivery, ownership, utilizing connectivity and data in different ways and even decreasing or eliminating the exploitation of non-renewable resources. WRI India, after interviewing representatives from the 60 companies, classified them into 21 categories based on Business models, Target audience, and Services offered. These 21 categories were then grouped on the basis of additional factors like technology employed, potential impact, and area of disruption. This created four major areas of activity and this categorization further helps us to understand the ways in which this new mobility is impacting urban transportation.

Shared mobility describes the transportation models wherein options are shared among its customers. This includes the Transit Network Companies (TNCs) like Uber, Ola, and Lyft. Though all mass transit and public transit modes come under the category of shared modes, the term ‘shared mobility’ is used for those models which accelerate their market presence and accessibility by utilizing mobile technology, especially GPS and smartphone applications. There are further three varieties of shared mobility models:

- **Ridesharing** is the mutual sharing of transportation facilities for passengers moving in the same direction at the same time. It includes carpool, auto-rickshaw sharing, taxi sharing, and bus aggregator.
- **Ridehailing** or drive procurement applies to Internet-based for-hire vehicles used consecutively by travelers, like taxis, road taxis, and auto-rickshaws and are referred to as aggregators and on-demand firms.
- **Vehicle sharing** is a constant usage of properties without possession. Such versions provide riders with exposure to automobiles such as motorcycles, cars, and motorbikes for limited periods of time.

Commuter experience applies to models that often promote increased accessibility environment for commuters, mostly by information exchange that lets consumers make smarter decisions. There are two sectors in India in which private enterprises have emerged:

- **Seamless payments and technology** include models that provide consumers with transit routing/scheduling, trip planning and traffic flow (congestion) details across modes and the opportunity to pay directly for public transport as well as privately provided transportation services.
• Commuter security and safety includes technologies/models that help passengers, car diagnostics, trip tracking, and crowd-sourced health expectations, with an emphasis on women’s safety.

• Product innovation applies to businesses that are seeking to improvise or develop transport vehicles and assets. In India, operation in this segment has been minimal but is expected to expand on the basis of the government’s recent commitment to electric vehicles. Such companies can be mapped into through three major segments:

• Alternate engines and fuels involve advancements in technology across hybrid buses, two-wheelers, electric vehicle charging infrastructure, and electric autos.

• Bicycle innovation involves the increasing advent of early-stage firms making electric bicycles.

• Autonomous technology development is a recent segment creating a buzz in India, powered by the driverless car challenge of the leading car manufacturer, Mahindra.

Data-driven decision-making applies to models that utilize technology such as sensors and GPS data that offer unique information to drivers as well as planners. It is a new area of the Indian industry with a few specialized items coming from early-stage firms and customized strategies from major IT corporations. Thus far, two major groups are.

• Insights for businesses which include models utilizing data collected to provide better services including fleet management, routing analytics, vehicle maintenance, and driver safety.

• Insights for city administrators like such kind of models which help city agencies with integrating services, traffic management, and road maintenance [41].

3.2 Problem Statement

The Greater Bangalore Municipal Corporation, i.e., Bruhat Bengaluru Mahanagar Pallike (BBMP) is selected as the study area. Bengaluru is the fifth largest metropolis of India with a population of 6.71 million [8], which is expected to increase to 11.22 million by the year 2025 [24]. Apart from private vehicles, the residents of Bengaluru have a number of transport services to choose from, be it the buses run by the state under Bangalore Metropolitan Transport Corporation (BMTC) or metro services by Bengaluru Metro Rail Corporation Limited (BMRCL), and even a range of App-Based Shared Mobility (ABSM) services including motorized two-, three-, and four-wheeler vehicles. These ABSM services are prevalent all over the city with some providing carpooling services and other on-demand taxi rides. The study area was finalized considering the varying transportation trends observed in the city after the introduction of Uber in the city during the Financial Year (FY) 2013. The BMTC bus service of Bengaluru is one of the best public transit services of India and is the first bus system in India to have the least losses over six years till 2016 among eight metropolitan bus systems of India [22].
Sridhar et al. [34] drew a comparison among eight executing authorities in the transport sector of India on the basis of 20 indicators. BMTC was found to be one of the authorities performing better than the others. However, the corporation has faced a decline in the number of vehicles held, fleet operated, and effective km traveled per day since the FY 2013–14, as per the data collected from BMTC (see Figs. 3.1 and 3.2).

Though not the only one but a major reason for the decline in BMTC services could be the inception of ABSM services in the area. Apparently, the year from which BMTC saw a decline in the fleet operated and the effective km traveled by its buses, is the year when Uber taxi services were first launched in India in Bengaluru. Moreover, there was a spike observed in the registration of the Hiring motorized two-wheeler and Hiring four-wheeler vehicles after FY 2013–14 (See Fig. 3.3).

Hence, this chapter will aim to study the impacts of app-based shared mobility on various aspects of urban travel trends and travel behavior in context of the city Bengaluru, India. The objectives of the study will be as follows:

Objective 1: To find the additional monetary and environmental cost incurred due to congestion through TNC data (Uber).

Objective 2: To study the recent trends of app-based shared mobility and factors which influence their use, along with its impact on car ownership behavior.

Objective 3: To assess the relationship between public transport accessibility and usage of app-based shared mobility.
3.3 Methodology

3.3.1 Data Collection

The data used for the analysis was acquired from the offices of BMTC, BMRCL, and the Transport Commissioner of Bengaluru. Further, the TNC data was collected from the open-source platform of Uber [39]. Uber, one of the largest ridesharing operators has made some of its data available on its website ‘Uber Movement’, which is free for researchers to use. The traffic data hence available has been used for various kinds of research [15]. As per the company, the data may be utilized by urban planners and city officials to address the problems of the city to make decisions based on proper information and actual ground conditions. Uber plans to make the city transportation picture clear so that a proper dataset can explain the why, when, and where of the changes happening across the city. The data is released in an organized manner around traffic analysis zones of cities, which are agreed upon geographic demarcations which makes it easier to work with for the planners. The users are free to control the parameters like time of the day, day of the week and zones and download the specific data as per their use [32]. The hourly aggregate of weekdays for the years 2016 to 2018 was utilized for further analysis. Data for 2019 was available only until February, and hence it was not considered.

A pan-city Revealed Preference Survey was conducted in BBMP. To calculate the sample size, sampling technique adopted by the Bureau of Transportation Statistics, UK was referred [9]. For a population of 12.3 million taking a confidence level of 95% and a confidence interval of 7, the sample size came out to be 223. A total of 23 questions were asked from the residents of Bengaluru regarding their daily travel
behavior and the effect of the influx of ABSM services on their travel. The survey sample consisted of 67% males and 33% females with the majority of them lying in the age group of 20–30 and working as professionals. 51% of survey respondents did not own a vehicle, 41% owned motorized two-wheelers, 4% owned four-wheelers, and another 4% owned more than one vehicle including both motorized two-wheelers and four-wheelers.

3.3.2 Carbon Emission Due to Congestion

For the purpose of the study, 25 routes between the major commercial areas and residential areas were finalized, as per the Comprehensive Mobility Plan of Bengaluru [24]. By calculating the Travel Time Index of these major routes, the issue of extreme congestion is highlighted. Moreover, the TNC–Uber data is utilized to estimate the economic and environmental cost of congestion. By highlighting the economic and environmental loss occurring at these major routes, recommendations are drawn to improve the traffic conditions on them, which will save a huge amount of resources, presently going down the drain on a daily basis.

Five wards each with dominant residential landuse and dominant commercial landuse were selected (See Table 3.1). It has been observed that major commercial and economic activities have clustered in various Central Business Districts (CBDs) and the most important ones include ward numbers 38, 84, 86, 110, and 192. The administrative offices of Bengaluru are located in ward 110, whereas all the others comprise major IT Tech parks which attract most of the crowd from all over the city every day.

To assess the commuting pattern between the wards described, the travel times received from Uber Movement data [39], from each origin to each destination in both AM—peak hour (8–11 a.m.) and PM—peak hour (4:30–7:30 p.m.) were used [37]. The cost incurred due to additional petrol consumed by motorized two-wheeler and four-wheeler vehicles due to congestion was calculated. The steps followed are as given below:

Volume of fuel consumed during free flow = Distance * Fuel consumption

Volume of fuel consumed during peak hours (for each route) = Volume of fuel consumed per route * Route-level Travel Time Index (TTI).

Additional volume of fuel consumed per route owing to congestion = Volume of fuel consumed during peak hours – Volume of fuel consumed during free flow.

Additional fuel cost (for each route) = Additional volume of fuel consumed * Cost of fuel per liter.

The cost of carbon dioxide emissions due to congestion in environmental terms and monetary terms was calculated signifying the amount of CO₂ emitted during traffic as per the following steps:

1. The steps to calculate the additional amount of fuel consumed are the same as explained in the previous section.
Table 3.1  Major routes between dominant residential and commercial wards of BBMP

| Origin (Residential) | Destination (Commercial) |
|----------------------|--------------------------|
| Ward name            | Ward no | Ward name | Ward no |
| Cottonpete           | 138     | Vidhan Souda | 110 |
|                      | 138     | Yeshwanthpur | 38  |
|                      | 138     | Whitefield  | 84  |
|                      | 138     | Electronic city | 192 |
|                      | 138     | Marathahalli | 86  |
| Hombegowda           | 153     | Vidhan Souda | 110 |
|                      | 153     | Yeshwanthpur | 38  |
|                      | 153     | Whitefield  | 84  |
|                      | 153     | Electronic city | 192 |
|                      | 153     | Marathahalli | 86  |
| Shanthinagar         | 117     | Vidhan Souda | 110 |
|                      | 117     | Yeshwanthpur | 38  |
|                      | 117     | Whitefield  | 84  |
|                      | 117     | Electronic city | 192 |
|                      | 117     | Marathahalli | 86  |
| Malleshwaram         | 45      | Vidhan Souda | 110 |
|                      | 45      | Yeshwanthpur | 38  |
|                      | 45      | Whitefield  | 84  |
|                      | 45      | Electronic city | 192 |
|                      | 45      | Marathahalli | 86  |
| Neelasandra          | 115     | Vidhan Souda | 110 |
|                      | 115     | Yeshwanthpur | 38  |
|                      | 115     | Whitefield  | 84  |
|                      | 115     | Electronic city | 192 |
|                      | 115     | Marathahalli | 86  |

Source Primary Survey

2. Using the additional amount of fuel consumed calculated in the above step, the additional carbon dioxide emitted was calculated by multiplying additional volume of fuel consumed and CO₂ emissions.

Now, to quantify these emissions in economic terms, the calculated additional CO₂ emitted was multiplied with the cost of emissions to find cost of additional fuel emissions. Studies have estimated that in Indian cities, carbon dioxide per kg costs the economy USD 0.086 [26]. The above-mentioned steps were separately performed for 2-wheelers and cars, both petrol only. Finally, the same weights as applied in the previous section were used to arrive at the total cost of additional petrol emissions.
in Indian National Rupees (INR) terms (using the current exchange rate of USD 1 to INR 74.93).

### 3.3.3 Public Transport Accessibility Level (PTAL)

In order to analyze the present public transit infrastructure of BBMP, a Public Transport Accessibility Level (PTAL) map was drawn by measuring the Accessibility Index (AI). The AI is calculated by utilizing the walking distance from Point of Interest (PoI) and Service Access Points (SAP), peak hour frequency of transits (bus-based and rail-based), walk speed, and reliability factor. The procedure followed is the same as that of London PTAL [36], with changes in walking speed and reliability factor as per Surat PTAL methodology [1].

- **Point of Interests (PoI):** In London PTAL methodology, PoIs were considered to build development. However, due to lack of availability of building footprint data, the study area was divided into grids of $500 \times 500 \text{ km}^2$ and their centroids taken as PoIs.
- **Service Access Points (SAPs):** These are the transit stops like bus stops and metro stations. 2,673 bus stops and 24 metro stations were mapped in the study area.
- **Walking speed:** The London methodology followed walk speed of 4.8 kmph. However, as per the Indian NMT infra conditions Surat PTAL considered a walk speed of 3.6 kmph and the same was adopted for this study.
- **Reliability factor (k):** Reliability factor is taken to account for the various unaccounted delays, which may be occurring at the ground level. Following the mixed traffic conditions prevailing in our country, since Surat PTAL methodology considered $k = 0.75$ for Metrorail and $k = 2.5$ for buses (non-BRTS), the same was adopted for this study.
- **Public transit frequency:** The frequency of metro and buses are as per the primary survey conducted.

The PTAL map was formed after calculating AI as per the following steps:

- The whole BBMP area was divided into 3,318 grids of $500 \times 500 \text{ m}^2$ and each of their centroids were marked as PoI.
- The shortest walking distance was calculated from these PoI to the SAPs (bus stops and metro stations).
- The Waiting time (WT) is calculated by dividing the walking distance by the walking speed, considered to be 3.6 kmph.
- The average waiting time (minutes) is calculated by the following formula.

\[
AWT = (0.5 \times (60/\text{frequency})) + k \tag{3.1}
\]

Now the Waiting time (WT) and Average Waiting time (AWT) are added to find the Total Access Time (TAT) in minutes.
Next, weights are assigned to each route for each of the PoI with a weight of 1 for the route of highest frequency and 0.5 for all the others.

Next, Equivalent Doorstep Frequency (EDF) is calculated to treat access time as a notional average waiting time as though the route was available at the ‘doorstep’ of the selected PoI.

\[
EDF = \{0.5 \times (60/TAT)\} = 30/TAT
\]  

Accessibility Index is calculated for each PoI, differently for the different modes, using the formula

\[
AI_m = EDF_{\text{max}} + (0.5 \times \text{Sum of EDF of all other routes})
\]  

\[
AI_{\text{POI}} = \text{Sum of all } AI_m
\]

After calculating AI for each of the POIs, they were grouped into nine levels as explained below and mapped accordingly (Table 3.2).

| PTAL  | Access index range | Map color |
|-------|--------------------|-----------|
| 0 (worst) | 0                   |           |
| 1a    | 0.01–2.5           |           |
| 1b    | 2.51–5.0           |           |
| 2     | 5.01–10.0          |           |
| 3     | 10.01–15.0         |           |
| 4     | 15.01–20.0         |           |
| 5     | 20.01–25.0         |           |
| 6a    | 25.01–40.0         |           |
| 6b (best) | 40.01+           |           |

Source: TfL [36]
3.4  Bengaluru: The Case Study

3.4.1  City Profile and Institutional Structure

Bengaluru, earlier named Bangalore, is the capital city of Karnataka state of India lying almost equidistant from both the western and the eastern coast of South Indian peninsula and lies 920 m above mean sea level. Bengaluru has a flat topography except for the central ridge. Many rivers cross the city including river Vrishabha-vathi, Arkavathi, and South Pennar cross at the Nandi hills. Due to the undulating terrain of the region, a large number of tank formations have occurred in the area, which facilitates traditional uses of irrigation, drinking, washing, and fishing. In 1961, the number of lakes were around 262, but were later seriously affected due to increasing urbanization and their numbers came down to only 33 in the year 2003. The pleasant weather of Bengaluru makes it one of the most preferred cities to settle. The temperature there varies from 39 degrees to 11 degree Celsius, and summer temperature barely exceeds it. The atmosphere neither gets very humid nor very dry and the average rainfall received is 923 mm.

The municipal governance of Bengaluru’s history can be traced back to March 27, 1862, when a Municipal Board under the Improvement of Towns Act of 1850 was formed by nine leading citizens of the city. After this, the Cantonment area of the city was also allocated with a similar municipal board. These two boards after being legalized in 1881, functioned as independent bodies by the terms Bangalore City Municipality and the Bangalore Civil and Military Station Municipality. After India’s independence from the British, the two municipal boards were merged as per the Bangalore City Corporation Act to form the Corporation of the City of Bangalore in 1949. This corporation had 70 elected representatives along with 50 electoral divisions. The name of the council also went through changes. It was first named Bangalore City Corporation (BCC), then Bangalore Mahanagar Pallike (BMP), and finally to Bruhat Bangalore Mahanagar Pallike (BBMP) in April 2007. BBMP was formed with 198 wards after a notification issued by the Karnataka Government to form one administrative body by merging the areas under existing BMP with 7 CMCs (City Municipal Council), 1 TMC (Town Municipal Council), and 111 villages around the city. BBMP presently comprises eight zones, i.e., East, West, South, Bommanahalli, Yelahanka, Darasahalli, Mahadevpura, and RajajeshwariNagar zone. BBMP follows decentralized administration at the zonal level. The Joint/ Zonal additional Commissioner drawn from State Administrative Services head the zonal office. All of the eight zonal offices are assigned the following functions and departments within jurisdiction: Welfare department, Education department, Revenue department, Health department, Horticulture department, and General administration (Fig. 3.4 and Table 3.3).
3.4.2 Transportation in BBMP

Bengaluru has a radial pattern of road network which covers 4000 km from which arterial and sub-arterial are about 350 km. The road network in the central part developed organically through the years with inadequate Right-of-Way. An outer ring road cuts across various radial roads and spans a length of 62 km. Also, an intermediate ring road was constructed at the southeast of the city between Old Airport Road and Koramangala. National Highways crossing the city include NH-4, NH-7, and NH-209 and the State Highways include SH-17, SH-17E, SH-19, and SH-86 [24].

Bengaluru has always had the reputation of having more motorized two-wheelers than other modes (See Table 3.4). Out of the 36.8 lakhs of total vehicles registered in 2010, 70% are motorized two-wheelers. Autos and taxis are also a popular form of transport available in the city. The bus services are operated by Bengaluru Metropolitan Transport Corporation (BMTC), which is fully owned by the State Government. The daily ridership crosses a 40-lakh mark with 578 city and 1756 suburban routes per day. To provide direction-oriented services instead of destination-oriented services, a total of 27 high-density corridors were identified and services were started along these ‘grid-routes’. However, they were withdrawn due to poor patronage and instead BIG10 services were launched. In this, 12 major corridors
| Area (km$^2$) | 1991 (millions) | 2001 (million) | CAGR (%) 1991–01 | Decadal growth 1991–01 | CAGR (%) 2001–11 | Decadal growth 2001–11 | 2011 (in millions) | CAGR (%) 2001–11 | Decadal growth 2001–11 | 2016* (million) | 2021* (in million) |
|--------------|----------------|----------------|------------------|------------------------|------------------|------------------------|-------------------|------------------|------------------------|----------------|------------------|
| 800          | 4.3            | 6.17           | 3.68             | 43.49                  | 3.26             | 37.78                  | 8.5               | 2.83             | 32.21                  | 9.77           | 11.24            |

*Source* Verma [40]
Table 3.4 Growth in registration of motorized two-wheeler and hiring vehicles in Bengaluru (2010–2019)

| Year | Motorized two-wheeler vehicles registered | Hiring motorized two-wheeler vehicles registered | Four-wheeler vehicles registered | Hiring four-wheeler vehicles registered |
|------|------------------------------------------|------------------------------------------------|---------------------------------|----------------------------------------|
| 2010 | 1,493,884                                 | 44,438                                         | 347,424                        | 41,052                                 |
| 2011 | 1,921,370                                 | 44,576                                         | 370,334                        | 44,760                                 |
| 2012 | 2,067,302                                 | 34,136                                         | 389,410                        | 49,620                                 |
| 2013 | 2,140,180                                 | 34,418                                         | 358,728                        | 41,112                                 |
| 2014 | 2,433,130                                 | 34,946                                         | 358,728                        | 44,492                                 |
| 2015 | 2,118,974                                 | 38,045                                         | 375,992                        | 80,416                                 |
| 2016 | 2,515,298                                 | 41,480                                         | 409,756                        | 96,072                                 |
| 2017 | 2,438,822                                 | 44,476                                         | 400,824                        | 87,010                                 |
| 2018 | 2,538,370                                 | 52,470                                         | 372,018                        | 57,130                                 |
| 2019 | 2,238,566                                 | 68,138                                         | 357,106                        | 47,400                                 |

Source: RTO Office, Bengaluru

were identified and buses were run on the direction where commuter takes the next bus [24].

### 3.4.3 Bangalore Metropolitan Transport Corporation (BMTC)

BMTC is a renowned public sector transport undertaking owned by Karnataka state and is governed by the Board of Directors appointed by the State. BMTC, founded in 1940, was originally called Bangalore Transport Company. It was catering to the whole city by a fleet of 98 buses. In 1956, the Government of Mysore took over the city transport from the company and named it Bangalore Transport Services. On August 15, 1997, Bangalore Metropolitan Transport Corporation was incorporated. Presently, BMTC is providing services both in the city center and suburban areas of Bengaluru in a radius of about 40.4 km. In view of Greater Bengaluru, the services were expanded from 3527 to 5130 km². During the FY 2018, total 6143 schedules were being operated. BMTC makes it a point to curtail low earning schedules and scrap off aged vehicles from its fleet along with adding better schedules and adding new buses to its fleet. Presently, BBMP is operating a fleet of 6466 buses. The corporation had a staff strength of 34,114 in 2018 consisting of both regular and temporary/trainee employees. The total staff ratio for the FY 2017–18 stood at 5.6. BMTC also has a Control Command Centre at Central Office to increase the efficiency of its depots and schedules using Intelligent Transport System. To carry this out, the operations are supervised in six zones, i.e., North, South, North-east, East,
Table 3.5  Details of infrastructure held by BMTC, as in 2018

| S. No | Factor                                  | Quantity |
|-------|-----------------------------------------|----------|
| 1     | Bus stations                             | 53       |
|       | Permanent (3 major, 40 minor, 10 TTMCs)  |          |
| 2     | Bus shelters in BBMP                     | 2212     |
| 3     | Bus stops with bus shelter               | 992      |
| 4     | Bus stops without shelter                | 1220     |
| 5     | Depots                                   | 44       |
| 6     | Canteens                                 | 24       |
| 7     | Commercial establishments                | 368      |

Source BMTC [3]

West and Central zones. It also has two major workshops situated at Shanthinagar and Krishnarajapuram [3]. Each zone has varied schedules as shown in Table 3.5.

3.4.4 Bengaluru Metro Rail Corporation Limited (BMRCL)

The metro services in Bengaluru are provided by Bangalore Metro Rail Corporation Limited (BMRCL), known as Namma Metro (literally ‘our’ metro). The Phase-1 of Namma metro is currently functional, while Phase-2 is under construction. The Phase-1 was opened for the public in June 2017 and consists of two corridors. The Purple line has 16 stations and spans across 18.1 km and the Green line runs along 24.2 km with 24 stations on it. From the total 42.3 km system, 8.8 km lies underground, while 33.5 km is elevated. Out of the total 40 stations, 7 are underground, 2 are at-grade and 31 are elevated. The Phase-2 of Namma metro includes a total length of 72.095 km of which 13.79 km is planned to be underground, having 61 stations (12 underground) [2].

3.5 Data Analysis and Discussion

3.5.1 Travel Preferences for Work and Recreational Trips

The mode share of Bengaluru, as reported in a study conducted by UMTC 37, showed that maximum share was of public transit (30%), then walking (29%), followed by motorized two-wheelers (26%), then IPT (10%), and least by taxis/shared taxis/motorized four-wheelers (5%). Another study conducted by CLIMATRANS [40] reported the modal split of Bengaluru Metropolitan Region, comprising BBMP and the surrounding sub-regional areas. The share of buses (50%) and motorized
two-wheelers (29%) was observed to be the highest. It was followed by cycle (11%), IPT (4%), and walk (4%).

During the revealed preference survey, residents were inquired about their daily travel mode preference. The metropolis has various travel options to choose from and hence the respondents were asked regarding their mode preference for daily work/education purpose trips and recreational trips separately.

Maximum of the respondents (37%) said they prefer to travel to their workplace/education centers via two-wheeler vehicles. The vehicle registration data also shows that two-wheelers form the major part of the vehicle fleet of Bengaluru (See Table 3.4). The second most popular mode of travel was found to be BMTC buses followed by ABSM services. Though metro services are pretty efficient in Bengaluru, only 7% prefer it as their daily travel mode since it presently covers very few areas of BBMP and is under construction.

The survey respondents usually prefer two-wheelers (34%) for their recreational trips, followed by ABSM services (27%) and BMTC buses (10%). Two-wheelers being a flexible and readily available mode of travel is popular among the users. ABSM services prove to be comfortable and free the users of the responsibility of driving and finding parking places and hence is the second most preferred mode for recreational trips.

During the survey, respondents were also asked to list down the reasons which led them to choose their daily travel mode. All the reasons were further grouped into eight classes as shown below. Though ABSM services did not outperform other modes in any of the ‘Reasons for daily mode preference’, they fared pretty well in terms of comfort, security, and avoiding parking stress. It was observed that users mainly prefer it due to comfort (23%) and lesser travel time (23%), followed by value for money (20%) (See Fig. 3.5). ABSM is also preferred when there is no option of any public transit in certain areas of the city.

![Fig. 3.5 Major reasons for mode choice preference. Source Primary Survey](image-url)
Table 3.6 Routes surveyed to compare ABSM and BMTC services

| Route no | Route length (km) | Origin                  | Destination                                         |
|----------|-------------------|-------------------------|-----------------------------------------------------|
| 1        | 6.3               | Palace Ground           | KR Market                                           |
| 2        | 15.4              | TTMC Shanthinagar       | Indranagar                                          |
| 3        | 8                 | Domlur                  | Chickpete                                           |
| 4        | 2                 | Chamrajpet              | National College                                    |
| 5        | 5                 | Mysore Bank circle      | Jayamahal                                           |
| 6        | 20                | KR Market               | Don Bosco Institute of Technology                   |
| 7        | 17.8              | Brigade Road            | Electronic city                                     |
| 8        | 4                 | Electronic city phase I | Electronic city phase II                             |
| 9        | 21.2              | Electronic city phase II | MG Road                                             |
| 10       | 8.2               | NGO Colony              | Frazer town                                         |

Source Primary Survey

To draw a comparison between Uber and BMTC, ten smaller routes lying within the proximity of the major 25 routes were surveyed. These ten routes covered those places which were found to be the major trip generating and trip attracting areas during the recce survey. The mix of ten Origin–Destination (OD) pairs comprise major commercial areas, educational institutes, bus depots, metro station, IT Park, and dense residential areas to draw conclusions taking reference from almost all the possible type of trips. The Origin and Destination were kept the same and the trip was undertaken at the same time of the day, i.e., during AM peak hour (7–10 a.m.) (Table 3.6).

The Uber drivers followed the shortest or fastest path indicated by Google while buses followed their specific routes, which made a huge difference in the total travel time. On one hand, though the travel time of Uber rides was comparatively lesser, their fares were much higher. A steep difference was also observed in the waiting time for these modes. Given the service of different charges for different modes opted in TNCs, separate comparison of ABSM cabs and BMTC buses was carried out. It was also kept in mind that the cab charging the least is opted from Uber. The comparison of total travel time, waiting time for mode arrival, and fares is presented with the help of graphs (See Figs. 3.6 and 3.7).

The waiting time for BMTC buses was observed to be highest in almost all the places except one, i.e., Mysore Bank Circle. The ABSM IPTs made their customers wait for the least time, followed by ABSM cabs, followed by BMTC buses.

The ABSM modes, be it a cab or IPT, used the shortest path instructed by GPS between the origin and destination. However, the public buses had to halt at the designated bus stops and given their size were more prone to being stuck in the frequent traffic-jams the city faces. Hence, ABSM provides faster services than BMTC buses. Lesser waiting time and travel time further depends on the availability and distance of Cab/IPT from the user at the time of booking, if the service is demanded immediately.
Figure 3.6 Comparing waiting time and travel time of ABSM and BMTC. Source Primary Survey

Figure 3.7 Comparing fares of ABSM and BMTC. Source Primary Survey

Figure 3.7 clearly shows the wide variation which occurs in the fare charged by ABSM services (be it Cab or IPT) in comparison to that of BMTC buses. Hence, it was established that ABSM provides better services in terms of waiting time and travel time, but BMTC buses are cost-friendly.
3.5.2 Cost of Additional Carbon Emissions Due to Congestion

Travel Time Index (TTI) is the ratio between how long it would take to complete a trip during peak hours as compared to that during free-flow hours. Suppose TTI of a certain route comes out to be 3, it indicates that the traffic would be moving three times slower than that at free-flow speeds. TTI is measured as the ratio of travel time between peak hour speed and speed limits as decided by the government; however, given the weak implementation of speed limits across India, travel time in free-flow conditions was used [10]. The TTI for all the 25 major routes (See Table 3.7) was calculated for both AM and PM peak hours and found to be 2.75 and 2.46, respectively. This signifies that a 30-min trip with no traffic takes 82.5 min during AM peak hours and 73.8 min during PM peak hours. Further, the cost of additional petrol consumed and hence the cost of carbon emissions due to the additional petrol consumed was calculated for the 25 routes. The route from Malleshwaram to Whitefield was observed to have the maximum cost of additional petrol consumed during both AM and PM peak hours, i.e., 419.2 INR and 400 INR, respectively (Table 3.8).

This additional petrol being consumed by vehicles further leads to additional carbon emissions, which were calculated for each of the 25 routes. The cost was found to be highest on the route where the maximum additional petrol was being consumed, i.e., Malleshwaram to Whitefield. During the AM peak hour, the additional carbon emissions cost 99.9 INR and that during PM peak hour 95.3 INR (See Tables 3.9 and 3.10).

Table 3.7 Cost of additional petrol consumed (INR) during AM peak hours

| Ward name       | Ward no | Cost of additional petrol consumed (INR) AM peak hour |
|-----------------|---------|-------------------------------------------------------|
| Cottonpete      | 138     | 0.2 53.4 25.1 34.9                                     |
| Hembegowda      | 153     | 6.1 32.1 25.1 203.4 2.1                                |
| Shanthinagar    | 117     | 3.4 82.3 7.2 11.6 0                                   |
| Malleshwaram    | 45      | 0 0 419.2 31.7 105.3                                  |
| Neelasandra     | 115     | 199 75.6 13.8 6.4 3.4                                 |
| Vidhan Souda    | 110     | 38 84 192 86                                         |
| Yeshwanthpur    | Whitefield | Electronic City  Marathahalli |

Source UberMovement [39]
Table 3.8 Cost of additional petrol (INR) consumed during PM peak hours

| Ward name      | Ward no | Cost of additional petrol consumed (INR) |
|----------------|---------|----------------------------------------|
|                |         | PM peak hour                            |
| Cottonpete     | 138     | 0                                      |
|                |         | 0                                      |
|                |         | 37.8                                   |
|                |         | 1.2                                    |
|                |         | 25.8                                   |
| Hembegowda     | 153     | 1.0                                    |
|                |         | 24.2                                   |
|                |         | 2.0                                    |
|                |         | 197.7                                  |
|                |         | 0.2                                    |
| Shanthinagar   | 117     | 2.3                                    |
|                |         | 67.2                                   |
|                |         | 4.6                                    |
|                |         | 8.5                                    |
|                |         | 0                                      |
| Malleshwaram   | 45      | 0                                      |
|                |         | 0                                      |
|                |         | 400                                    |
|                |         | 18.0                                   |
|                |         | 103.5                                  |
| Neelasandra    | 115     | 15                                     |
|                |         | 59.2                                   |
|                |         | 11.5                                   |
|                |         | 3.7                                    |
|                |         | 3.4                                    |
|                | 110     | 38                                     |
|                |         | 84                                     |
|                |         | 192                                    |
|                |         | 86                                     |
|                | VidhanSouda | Yeshwanthpur  |
|                |         | Whitefield                             |
|                |         | Electronic City                       |
|                |         | Marathahalli                           |

Source: UberMovement [39]

Table 3.9 Cost of carbon emissions due to additional petrol consumed (INR) during AM peak hour

| Ward name      | Ward no | Cost of carbon emissions due to additional petrol consumed (INR) |
|----------------|---------|------------------------------------------------------------------|
|                |         | PM peak hour                                                      |
| Cottonpete     | 138     | 0                                                                 |
|                |         | 0                                                                 |
|                |         | 9                                                                 |
|                |         | 4.3                                                               |
|                |         | 6.2                                                               |
| Hembegowda     | 153     | 0.2                                                               |
|                |         | 5.8                                                               |
|                |         | 0.5                                                               |
|                |         | 47.1                                                              |
|                |         | 0.1                                                               |
| Shanthinagar   | 117     | 0.5                                                               |
|                |         | 16                                                                |
|                |         | 1.1                                                               |
|                |         | 2.0                                                               |
|                |         | 0                                                                 |
| Malleshwaram   | 45      | 0                                                                 |
|                |         | 0                                                                 |
|                |         | 95.3                                                              |
|                |         | 4.3                                                               |
|                |         | 24.7                                                              |
| Neelasandra    | 115     | 3.6                                                               |
|                |         | 14.1                                                              |
|                |         | 2.7                                                               |
|                |         | 0.9                                                               |
|                |         | 0.8                                                               |
|                | 110     | 38                                                                |
|                |         | 84                                                                |
|                |         | 192                                                               |
|                |         | 86                                                                |
|                | VidhanSouda | Yeshwanthpur  |
|                |         | Whitefield             |
|                |         | Electronic City       |
|                |         | Marathahalli           |

Source: UberMovement [39]

3.5.3 Relation Between Yearly Uber Rides and PTAL Map

3.5.3.1 Yearly Trend Uber-Trips in BBMP (2016–18)

The weekly aggregate Uber trip data was utilized to make ward-wise Uber trip generation and trip attraction maps. The ward-wise trip generation map of BBMP shows that the number of trips generated increased from 2016–17 and remained almost equal in 2018 as compared to the previous year. Maximum of the trips are observed to generate from the central wards, which have the highest population density and the wards lying toward the west of BBMP. Maximum of trip attraction was observed again in the central wards with highest population density and wards
Table 3.10  Cost of carbon emissions due to additional petrol consumed (INR) during PM peak hour

| Ward name     | Ward No | Cost of carbon emissions due to additional petrol consumed (INR) AM peak hour |
|---------------|---------|--------------------------------------------------------------------------------|
| Cottonpete    | 138     | 0 0 12.7 6 8.3                                                                |
| Hembegowda    | 153     | 1.5 7.6 6 48.5 0.5                                                            |
| Shanthinagar  | 117     | 0.8 19.6 1.7 2.8 0                                                           |
| Malleshwaram  | 45      | 0 0 99.9 7.5 25.1                                                            |
| Neelasandra   | 115     | 4.7 18 3.3 1.5 0.8                                                          |
| Ward no       | 110     | 38 84 192 86                                                             |
| Ward name     | Vidhan Souda | Yeshwanthpur | Whitefield | Electronic City | Marathahalli |

Source UberMovement [39]

Lying south of BBMP. During 2018, an increase in trip attraction was observed in wards lying toward the south (Figs. 3.8, 3.9, 3.10, 3.11, 3.12 and 3.13).

3.5.3.2 Public Transport Accessibility of BBMP

The PTAL map of Bengaluru (Fig. 3.14) clearly shows that the ease of accessibility is still concentrated in the central wards lying in the southwest of BBMP. The areas housing the major IT parks, like Electronic City toward the south, Marathahalli, and major residential area like Whitefield lying eastwards of BBMP have extremely low public transport accessibility, indicated by AI ranging from 1a to 3 (See Table 3.2).

On comparing the Uber trip generation and attraction map with the PTAL map, it can be seen that though core areas have high AI, the Uber trip generation is highest in them. Further, the Uber trip attraction has been the maximum in eastward wards, which have the least AI. This emboldens the fact that the lack of public transport services in that area is being compensated for by Uber and similar ABSM services.

3.5.4 Car, a Status Symbol?

Culturally, the normative ideal of the mode of consumption had always been ownership. This idea was based on the perceived advantages that ownership provides including it as a means of capital accumulation, sense of independence, security, and flexibility of use including reselling the commodity. However, some studies report that in recent times, ownership has become more precarious owing to various factors, which include increased costs of maintaining and acquiring the ownership of the commodity over time, unstable social relations, and uncertain labor markets.
Nevertheless, access has especially been popular in the urbanized areas that have limited space, be it for parking or storage even after being stigmatized and seen as an inferior consumption mode. Afterall, renters could not acquire investment, sense of security, pride of ownership, and depreciation benefits as offered by ownership; and hence were always looked down upon as people with lower financial status and power [11].

Hence, on the same lines, people were asked about their opinion on car ownership being a status symbol and their plans to buy one. Surprisingly, 68% of survey respondents no longer consider a car to be a status symbol and hence 9% from among them had decided not to buy one. Another 16% of people are unsure regarding their car ownership given that they do not consider it to be a status symbol and their transportation needs are being well satisfied without owning one. However, there is another factor in the play here which cannot be ignored. Bengaluru being a metropolis attracts a large number of migrants from other states of India who are in search of jobs. Primary survey revealed that many are unsure of their future in the city and
hence refrain from indulging in long-term assets like vehicles and rely on public transit and ABSM services (Fig. 3.15).

3.6 Post-Covid Scenario of ABSM

App-Based Shared Mobility is one of the worst affected sectors due to the hostile conditions created by Covid-19. It is estimated that the carsharing market will lose 50–60% of its shares during 2020 but hopefully bounce back to gain its market by 70–80% in the year 2021 [18]. Ipsos recently conducted a study in China and found that 66% of respondents are thinking of buying a car. These numbers were a mere 34% before the outbreak of worldwide pandemic. Similarly, as opposed to 21% before, now only 15% survey respondents plan to opt for cab services of any kind. 77% of respondents who now plan to buy a car reached this conclusion in the impression that this will help reduce the chances of infection. The consumer behavior
of Indians varies from Chinese due to various reasons; however, industry experts still believe that those who had been availing cab-service but have the ability to buy a car, will be inclined toward it. Hence, some changes in consumer psyche are expected in the country [13]. Companies are adopting various measures to win the confidence of people. Uber distributed disinfectants to drivers, reduced fares during pandemic, facilitated disinfection for bikes and scooters in depots and also developed an app to help drivers find alternative jobs. Ola also responded by reducing its fares, providing sanitizers free of cost, and pausing its Ola-share services to help contain the spread of the virus and maintain social distancing [18].

The Google Covid-19 Community Report provides a comprehensive view of the category-wise trip changes in various cities of the world. It compares the change in trips of six categories with a baseline, which is the median value during January 3 to February 6, 2020. For ‘Bangalore Urban’ the following changes were observed [14]:

Retail and recreation: $-51\%$
Supermarket and pharmacy: $-19\%$
Parks: $-74\%$

Fig. 3.10  Ward-wise trips generated by Uber in 2017. Source UberMovement [39]
Public transport: −43%
Workplaces: −22%
Residential: +9%.

Both the public as well as disruptive mobility have been bearing the heat of the pandemic. The fear has led to suspicion of getting infected by using any kind of shared mobility. Though Namma metro was stopped after a nationwide lockdown in April 2020, BMTC buses resumed services for medical staff and migrant laborers after a short while. In July 2020, the buses started plying at 50% ridership to ensure social distancing. However, around 171 employees contracted the virus while one succumbed to it. Though optimum measures have been taken to keep both the commuters and staffers safe, plying buses at low ridership and high frequency is proving to be a tough task [23].
ABSM resumed their services in May 2020 after closing down due to the nationwide lockdown followed by frequent closures and regulations from time to time. Their drivers are daily wage earners, and hence were the most affected. In June, 2020, Karnataka Transport Department imposed a ban on all the carpooling services to contain the spread of virus. This was a major financial setback for the regular users of these services since they were cheaper than other mobility options in the city. This move was, however, welcomed by the service providers because carpooling, though popular, had yet not proved profitable to them [20]. Uber grabbed the opportunity of providing last-mile delivery for online retailers like Flipkart and Bigbasket while Ola joined hands with the State government to provide services to non-covid patients [31]. In the present conditions too, the cities will keep evolving toward becoming smart sustainable cities. And the way forward is not much different from what it would have been in the pre-covid times, i.e., for all the stakeholders to work in conjunction with each other, share the data generated, analyze it, and reach the best possible solutions for the cities intended.
3.7 Conclusion

The areas having high population density, lying in the southwestern part of BBMP have quite a high AI, ranging from 6a to 6b (very good to best public transport accessibility). Interestingly, the Uber trip generation maps of 2016–18 establish the fact that the wards comprising these areas itself have the maximum number of Uber trip generation. Since these wards house the maximum number of app-based shared mobility users, this potential must be utilized to integrate ABSM with public transit to provide the residents with Mobility as a Service (MaaS). Any such kind of pilot project has more chances of succeeding in these wards as compared to others since its residents are already well versed with the technological requirements to access these services.

Moreover, it was observed during the recce survey that BMTC bus stops were not at a walkable distance in the IT hub-Electronic City. However, the dock-stations of Yulu bike services were close by to both the commercial and residential areas, and
Fig. 3.14 Public transport accessibility level map of BBMP. *Source* Primary Survey

Fig. 3.15 Perception on private car ownership of the survey respondents. *Source* Primary Survey
pretty popular among the residents. This again provides an opportunity for integration of public transit and app-based shared mobility wherein the Yulu bike services can be utilized for first- or last-mile connectivity. The same can be utilized to improve the metro ridership as well.

On an average, a 30 min trip in Bengaluru during the off-peak hours is now covered in 82.5 min during the AM peak hours and 73.8 min during the PM peak hours due to congestion. As a result, the maximum cost (INR) of additional petrol consumed during daily trips, AM and PM peak hours ranged unto Rs. 420 per day in the major routes analyzed. The cost of additional fuel emissions per day in terms of carbon dioxide was also recorded to be Rs. 99 per day during AM peak hours and Rs. 95 during PM peak hours. The maximum cost incurred has been observed on the route connecting Malleshwaram to Whitefield. Hence, it is recommended to form such rules for the workforce of companies present in these areas that they are compelled to use carpooling services if not the public transit. It is recommended that carsharing services and industry/office specific shuttle services be encouraged for these areas to reduce congestion.

It is very clear from the PTAL map of BBMP that the public transit services are not equally accessible for the residents. The areas having lower Accessibility Index are observed to have higher numbers of Uber trip generation and attraction. This case is observed specifically in the eastern wards of BBMP which recorded an Accessibility Index ranging from 1a to 3 (very poor public transit accessibility). It confirms the fact that people living in the eastern wards of BBMP rely on either their personal vehicles or ABSM for their transportation. This is again the reason why the route toward Whitefield was found to be the most congested in Sect. 3.5.2. To combat these issues, it is recommended that the focus of mode integration be accessibility and equity of services in the whole of BBMP.

Covid-19 has taken a toll on ABSM services with more people fearing sanitation issues in the shared vehicles and hence opting for either no travel or personalized vehicles. This will further lead to increase in carbon emissions in the cities, which is why immediate steps need to be taken to improve the confidence of customers in the services.

3.8 Future Work

The methodology of this chapter can be adopted for the study of other cities. The Travel Time Index of various areas can be analyzed with respect to the landuse to conclude which areas are best suited for residential purpose. Hence, commuting data of a city can be utilized to assess the labor market efficiencies [10]. Further, the long-term effect of these changing priorities from ownership to accessibility can be forecasted to see the change it will have on mode-share of the city. Also, the revealed preference survey can be conducted in a much more organized manner to gain insights on travel behavior of city-residents. For example, separate surveys can be conducted for peripheral and central business district or else for the employees
of government sector and private sector. This is so because various research papers have concluded that their travel behavior are significantly different and impact the traffic in different ways.

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