Revert or readjust?
Designing mobility for liveable and social cities

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BENGALURU

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About this series

A lot of money has been spent on transport infrastructure and services worldwide in recent decades. The aim was to enable people to participate in social and economic life and to ensure the functioning of businesses. This has certainly contributed to the economic development visible in many regions. However, since many things necessary for daily life and economic activity were centralised, dependence on the mobility system increased at the same time. The resulting longer journeys place a temporal and economic burden on people, and the increase in passenger and freight transport is a burden on societies through more noise, exhaust fumes, CO_2 emissions, accidents, and more.

In view of its importance and the negative social, ecological and economic consequences, mobility must change, and much more quickly and comprehensively than before. Cities in particular can set good examples in this respect.

Friedrich-Ebert-Stiftung (FES) examined four cities in Asia to see the current state of each city, how they plan to shape mobility in the coming years, how this plan is to be assessed and what leads can be derived from this particular strategy for other cities. The central question is how can a mobility system be designed in such a way that all people can participate in social and economic life, economic development is supported and negative effects for the society and the climate can be eliminated?

CITIES COVERED IN THIS SERIES:
- Bengaluru
- Hanoi
- Jakarta
- Metro Manila

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BENGALURU

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BBMP Bruhat Bengaluru Mahanagara Palike is the administrative body responsible for civic amenities and some infrastructural assets of the Greater Bangalore metropolitan area. It is the fourth-largest municipal corporation in India.

BDA Bangalore Development Authority is a governmental organization (and the principal planning authority for Bengaluru). Its function, under the Karnataka Town and Country Planning Act of 1961, is as a regulatory body required to prepare a comprehensive development plan for the city.

BIAPA Bengaluru International Airport Planning Authority is entrusted with the functions of granting approval for any development on the land within its jurisdiction.

BMLTA Bangalore Metropolitan Land Transport Authority was set up in Bangalore and is classified as a UMTA.

BMRCL Bengaluru Metro Rail Corporation Ltd is a joint venture between the central government and the Karnataka State government. It is the agency responsible for building, operating and expanding the Metro network in Bengaluru, called the Namma Metro.

BMRDA Bangalore Metropolitan Region Development Authority is an autonomous body created by the Karnataka State government under the Bangalore Metropolitan Region Development Authority Act 1985 for planning, coordinating and supervising the proper and orderly development of the areas within the metropolitan region. Unlike the Bangalore Development Authority, the BMRDA does not have the power to acquire land.

BMTC Bengaluru Metropolitan Transport Corporation is a government agency (and state transport undertaking) that operates the public transport bus service in Bengaluru.

BTC Bangalore Transport Company Ltd was founded in 1940 operating buses. It was a state transport undertaking that was later replaced by the BMTC.

DULT Directorate of Urban Land Transport is under the Urban Development Department of Karnataka State. It is responsible for overseeing all the urban land transport initiatives in the urban and local planning areas.

KUIDFC Karnataka Urban Infrastructure Development Finance Corporation is a state government agency under the Urban Development Department. It provides technical, financial, consultancy and other assistance to urban bodies for development schemes, including implementation of master plans. It also acts as the nodal agency of the state for the implementation of various urban infrastructure development projects.

NHAI National Highway Authority of India is an autonomous agency of the Government and is responsible for the development and management of a network of more than 50,000 km of national highways.

NUTP National Urban Transport Policy of the Government of India emphasizes building capabilities at the state and city levels to address problems associated with urban transport. It includes guidelines for developing sustainable urban transport systems.

STU State Transport Undertaking has the responsibility to provide road-based passenger mobility in the state or the municipality because they are the biggest undertakings in the hands of the respective state or municipal government.

UDD Urban Development Department is under the Karnataka state government. It is responsible for overseeing urban development initiatives in the state.

UMTA Unified Metropolitan Transport Authority. The National Urban Transport Policy recommends setting up of unified urban transport authorities in a million-plus cities and that the UMTA should facilitate more coordinated planning and implementation of urban transport programmes and projects and integrated management of urban transport.

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Executive Summary

Bengaluru ranked first in the 2020 Ease of Living Index among all Indian metropolitan cities (with more than a million population). It is a relative measure, however, and does not say much about the absolute situation of mobility in the city. Once a pensioner's paradise and a city of lakes, Bengaluru is now the IT capital of India and one of the largest and most important metropolitan cities in the country. However, the city's mobility situation has not kept pace with its urban development, and there are issues with a dependence on private vehicles; insufficient public transport; the lack of safe, reliable and sustainable mobility options; extremely high air and water pollution levels; and increasing external costs of congestion, like health burdens, accidents and reduced life expectancy.

The silver lining is a shift in focus from "predict and provide" (road infrastructure) to mass transit systems, electric vehicles, sustainable development models and shared (smart) mobility. Also noteworthy for Bengaluru is the active participation of citizen groups in development projects and processes because they want environmentally sustainable development. Karnataka State, where the city is located, is pioneering environmental change: It is the first Indian state to adopt an electric vehicle policy, the benefits of which Bengaluru will share. These policies and plans need to be translated into implemented projects to ensure that citizens have equitable access to safe, reliable and sustainable transport options for their mobility needs.

Introduction to Bengaluru

Bengaluru, once called Bangalore, is the capital city of the southern Indian State of Karnataka (figure 1).[1] It is the country's third-most populated and second-fastest growing city (RMI et al., 2020) and the eighteenth-most populous in the world, with an estimated population of 12.5 million (in 2018). The Bengaluru Metropolitan Region spreads across 1,294 sq km (figure 2). Forbes magazine considers it one of the next decade's fastest-growing cities (Dave, 2017). Known as the Silicon Valley of India, it accounts for more than 33 per cent of India's information technology (IT) exports, has a GDP of US$83 billion, which is 1.9 per cent of the country's total GDP (2013–2014) and 36 per cent of the state's GDP (Pandey, 2021; BDA, 2017; C40 Cities, 2017). The city houses many well-recognised educational and research institutions.
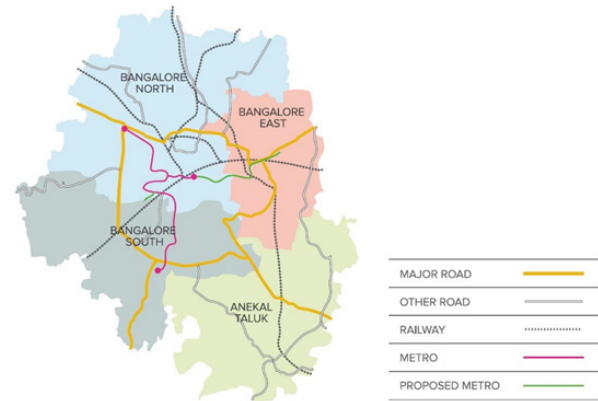
Figure 1: Map of India and the city of Bengaluru

Source: Google Maps

Figure 2: Bengaluru with major routes of transportations systems

Source: RMI et al., 2020.

Geographically, Bengaluru is part of the dusty Deccan Plateau region, distinguished by four seasons—dry, summer, monsoon and post-monsoon. Due to its gentle climate, greenery, many lakes and public parks, it was once known as the Garden City of India. But according to findings from various international surveys over the past decade, Bengaluru has fared poorly on indicators for city living, mobility and congestion (Pandey, 2021; BPAC and Uber, 2020: TomTom, 2020; Ravichandar, 2014).

The city has the second-largest number of registered vehicles in India, at more than 10 million in 2021 (Pandey, 2021), of which nearly 70 per cent are two-wheelers and 20 per cent are cars (Transport Department, 2020; Mukherjee, Toshniwa and Mulukutla, 2017). Nearly half of all vehicles registered in the state are in Bengaluru, which is not surprising due to its threefold increase in private vehicles between 2007 and 2020 (BPAC and Uber, 2020). The city's total road network is 14,000 km (Rocky Mountain Institute, 2020), and it boasts a city bus service, a Metro system, rickshaws and other intermediate public transport and smart or shared mobility options (Mukherjee, Toshniwa and Mulukutla, 2017) (figure 2).

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1 Although the name changed officially, many agencies and services continue to use "Bangalore".

Looking back

The growth of Bengaluru can be traced through three periods: pre-colonial era, colonial era and post-independence era (BDA, 2017). The city began in 1537 as a fortified settlement under the king Kempegowda. By the seventeenth century, it had become the commercial capital of Tipu Sultan who ruled from Mysore. The eighteenth century saw the arrival of the British into the country and into Bengaluru and the start of the colonial era. The post-independence era came in 1947.

Over the past few decades, the city has changed from a "pensioner's paradise" to the country's "IT capital" and "start-up hub" (BDA, 2017), leading to a sea change in its demographics and hence travel needs. There has been a considerable rural to urban migration, and the demand for public transport has increased. The population of Bengaluru has increased annually by 3 per cent since independence (160,000 in 1901 to 9.6 million in 2011). Between 2001 and 2011, population density increased from 2,985 to 4,393 persons per sq km (Baindur and Rao, 2016). Several transport options are available to residents, ranging from the suburban railway, the Metro and city buses to intermediate public transport (160,000 registered auto rickshaws (in 2016), minivans that operate in peri-urban areas and shared or smart mobility services (Mukherjee, Toshniwa and Mulukutla, 2017). Three agencies oversee transport operations: the Bengaluru Metropolitan Transport Corporation (BMTC), the Bengaluru Metro Rail Corporation Ltd (BMRCL) and the South Western Railway.

Suburban rail dates back to 1963, when regular trains ran between Hindustan Aeronautics Ltd[2] and the City Railway Station. It stopped operations and was to be replaced in 2007 by a modern suburban railway station system covering 204 km. But it has not yet been built. In FY2020, the project was re-pitched at a cost of 1,860 billion rupees, to be funded as follows: 20 per cent from the central government, 20 per cent from state funds and 60 per cent through market raising and external funding (BPAC and Uber, 2020).

The BMTC, originally called the Bangalore Transport Company Ltd, started in 1940 with 98 buses. It is the sole public bus provider and serves urban, suburban and rural areas in the Bruhat Bengaluru Mahanagara Palike (BBMP). It is the largest city bus service in the country, with about 6,700 buses, 1.15 million km of service, approximately 2,500 routes, 45 depots and revenue of 50 million rupees a day (Harsha et al., 2019; Baindur and Rao, 2016). There are 10 types of bus services: Red buses, Suvarna, BIG 10, BIG circle, Pushpak, Vajra, Vayu Vajra, Atal Sarige, Metro Feeder Other Ac and regular buses. It is also the first State Transport Undertaking in India to run air-conditioned city buses (Dave, 2017). The BMTC is one of the better-operated bus systems in the country, carrying around 5 million passengers each day— almost half the city population and 90 per cent of public transport ridership (Baindur and Rao, 2016). As a sign of progress, the BMTC launched the country's first e-bus in 2014, and Karnataka became the first state to launch an electric vehicle policy, in 2017 (RMI et al., 2020).

Figure 3: Geographical area served by the BMTC and the BMRCL

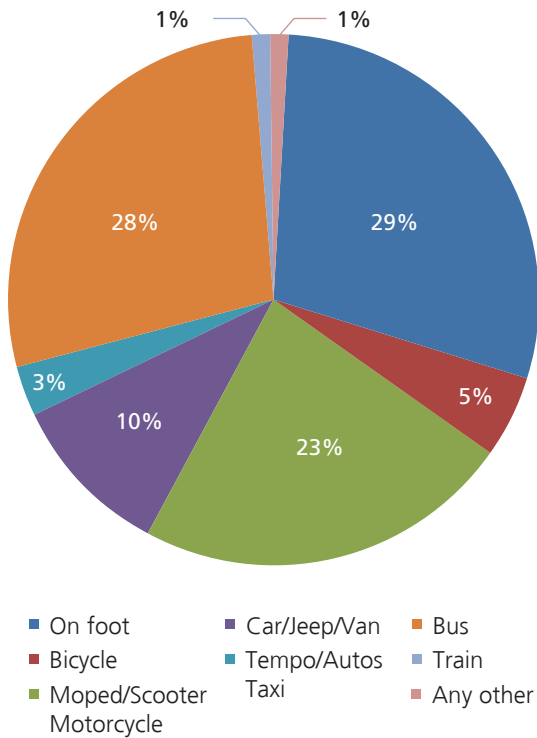*Source: Mukherjee, Toshniwa and Mulukutla, 2017.*

AREAS SERVED BY BMTC AND BMRCL

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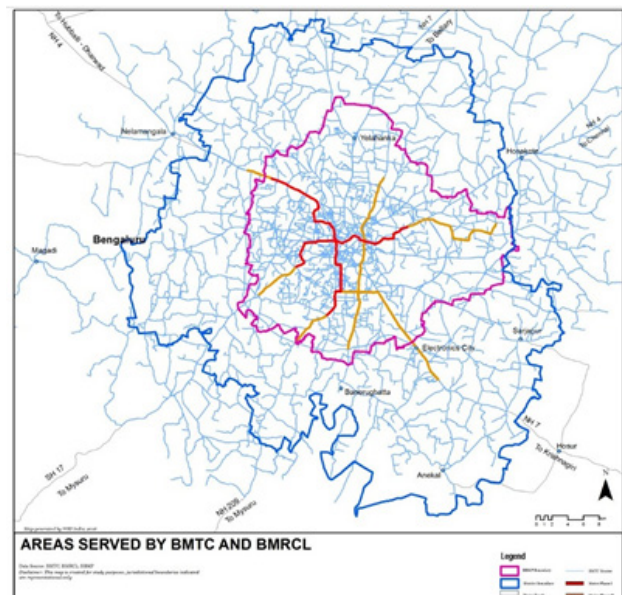
2   Hindustan Aeronautics Ltd was set up in 1950s and was one of the only activity centres near (then) the city, which was considered a pensioner's town at that time.

Figure 4: Breakdown of trips, by modes of transport in Bengaluru

Source: Baindur and Rao, 2016.

- On foot
- Bicycle
- Moped/Scooter Motorcycle
- Car/Jeep/Van
- Tempo/Autos Taxi
- Bus
- Train
- Any other

The BMRCL manages the Metro. In the first phase of its development, 42.3 km of Metro line was to be completed by 2011. Due to delays, it was not finished until 2016. In the Metro Phase II (expected to begin in 2019 but is also delayed), 72 km will be built (Mukherjee, Toshniwa and Mulukutla, 2017). Figure 3 reflects the service area of both the BMTC and the BMRCL and their routes, and figure 4 shows the modal breakdown of trips around the city.

The city's urban planning has only slowly developed over the years (figure 5). The Master Plan 2015, made in 2007, remains the operating framework. The Master Plan 2031 was prepared but scrapped after it received 14,000 objections from residents and is being reworked.

Transport planning has followed the "predict and provide" model and has centred on creation of road infrastructure. The Master Plan 2015 proposed a number of road projects, like elevated roads, additional ring roads and grade separators. The next master plan will focus on the transit-oriented development, the Bus Rapid Transport (BRT) system, the Metro and suburban railway. Until recently, parking has

been free in most areas, and both the authorities and residents have cited it as problematic because it adds to the congestion. The parking policy is moving towards paid parking, organized on-street parking and other approaches (DULT, 2020). This suggests a shift in mindsets, albeit slow.

Between 2011 and 2019, the population increased by 32 per cent, while the bus fleet increased by only 7.9 per cent (BPAC and Uber, 2020). This has fuelled private vehicle ownership. The COVID-19 pandemic has accelerated the purchase of two-wheelers and cars (Pandey, 2021). Lopsided investment priorities have not helped, with only 5–6 billion rupees invested on buses (between 2007 and 2017), while 85 billion rupees has been invested in roadways and 264 billion rupees are earmarked for the Metro Phase II (Mukherjee, Toshniwa and Mulukutla, 2017). Political push for the various budgets is motivated by various politicians' need to create visible infrastructure, such as flyovers, elevated roads, Metros and roads to look productive to residents. Thus, if residents are not properly informed or are not aware of the unsustainable consequences of such development, the good development projects that

Figure 5: Evolution of urban planning as public function in Bengaluru

Source: Baindur and Rao, 2016.

1945	City Improvement Trust formed
1949	Bangalore City Corporation established
1952	Bangalore Development Committee founded
1961-1965	Karnataka Town and Country Planning Act enacted and enforced
1976	Bangalore Development Authority constituted
1984 1995 2007	First, second and third Comprehensive Development Plans (CDPs) or Master Plans were approved

are sustainable will need more than just the support of technical experts.

The dynamics between the government and the market have mostly been one-sided, with the government as the provider of transport, which is a public good. Recently, due to developments in e-mobility and smart mobility services, the private sector has become more involved, making its concerns known to the government—which are being incorporated in the electric vehicle policy and other policies on shared mobility.

Visions for a liveable & social city

Bengaluru was ranked the best Indian city with more than a million population on the Ease of Living Index 2020 (measured by the Indian Government), based on four segments: quality of life, economic ability, sustainability and a Citizen Perception Survey (MOHUA, 2020b). However, on mobility, the city was rated as poorly performing because the transport infrastructure and public transport supply were found to be insufficient for the growing population.

Figure 6: Ease of Living Index 2020, India

Source: Ministry of Housing and Urban Affairs (MoHUA), India, 2020a.
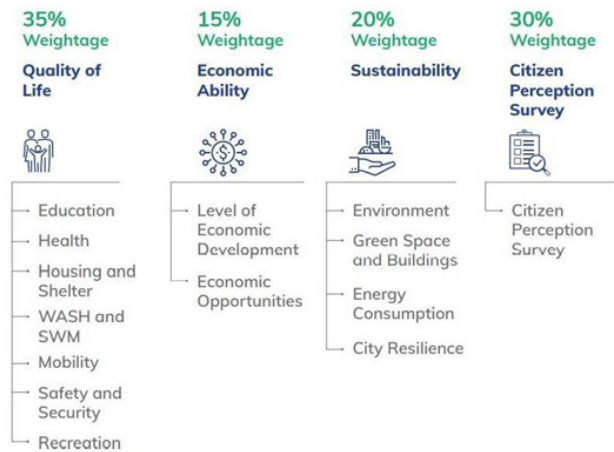
To make the city more liveable and sustainable, a variety of visions exist at the national, state and city levels. Transport is a concurrent subject in India, meaning that both the central and state governments jointly frame regulations, implement them, impose taxes, issue permits, decide fares, etc. Their cooperation is outlined in the Motor Vehicles Act, 1988 (amended in 2019) (BPAC and Uber, 2020). Although master planning has been around for decades, sustainable urban transport planning only started in 2006 with the National Urban Transport Policy (Vaidyanathan and Rathi, 2018).

Increasing motorization and low-quality public transport are chiefly recognized as unsustainable. A broader vision to create mass transit projects exists in theory, but given the bias towards big-ticket projects like the Metro that may be financially unviable, there is increased emphasis on bus rapid transit systems with lower costs but comparable impact. The central government realizes the benefits of shared mobility and aims to give flexibility to states to make local regulations that support smart mobility by way of promoting the sharing of vehicles, creating a fair regulatory system to include all taxis, shared mobility and aggregators and others (BPAC and Uber, 2020). The Beckn protocol, designed by the Open Shared Mobility Foundation (a not-for-profit organization) and co-founded by Indian visionaries, promotes and encourages open-data infrastructure that induces trust and scales up open-data efforts around mobility (BPAC and Uber, 2020).

Various state organizations have presented their vision of sustainable and equitable mobility. The draft Comprehensive Mobility Plan, for instance, talks of creating efficient, sustainable, multimodal transportation for equitable mobility access. The goal is to increase each mode's share of public transport and to reduce emissions from the transport sector. The parking policy (DULT, 2020) aims to reduce the parking demand and on-street parking by replacing free parking with paid parking and to promote public–private partnerships in the provision of parking. The Guidelines for Planning and Implementation of Pedestrian Infrastructure (2014) emphasize safe and convenient pedestrian facilities to promote walking for people of all ages. The state electric vehicle policy promotes e-mobility in public transport, goods transport and personal vehicles (CID, 2017). The BMTC aims to completely go electric and triple its fleet size (Habitat, 2020). The private sector has helped in creating the vision of e-mobility by providing inputs, concerns and views to the government on practical issues relating to the uptake of electric vehicles, battery and charging infrastructure, financial roadblocks and legal issues affecting shared mobility services (BPAC and Uber, 2020; RMI, 2020).

In short, sustainable mobility in the form of mass transit systems, e-mobility, smart and shared mobility and increased modal share of public transport appears to be the vision for the liveable and social city of the future.

Building a future pathway from the status quo

Transport planning in Bengaluru is characterized by institutional fragmentation and multiple decision centres (Vaidyanathan and Rathi, 2018). At the top are the Urban Development Department, the Directorate of Urban Land Transport and the Bangalore Metropolitan Land Transport Authority (BMLTA). They decide the nature of investments in transport projects and thus create visions for the city.

At the next level are the government-funded city bodies (like the BBMP, the Bangalore Development Authority, the BMTC and the BMRCL), which are responsible for land-use planning and construction, maintenance of road infrastructure and providing bus and Metro services. On the third, or bottom, tier are those organizations that are tangentially or indirectly part of decision-making processes, like the Infrastructure Development Department, the Karnataka Urban Infrastructure Development Finance Corporation, the Bengaluru International Airport Planning Authority, the National Highway Authority of India and consultants. Multiple agencies handling urban transport functions often have overlapping responsibilities, and urban transport interventions are often decided on political motivations rather than on scientific-based judgement (Pandey, 2021).

There are also different laws for different subjects. For example, the Motor Vehicles Act (1988) looks at rules regarding vehicles but has nothing to do with urban transport planning. Pollution boards and traffic police have different mandates. The National Urban Transport Policy (2006) is considered the only single set of rules that focuses on planned urban transport, integrated land use, non-motorized transport and financing mechanisms, but it needs appropriate legal and financial backing. Lack of a unified metropolitan transport authority means that agencies are unable to resolve disputes around payment mechanisms, changing fare structures or common mobility cards (Mukherjee, Toshniwa and Mulukutla, 2017). In 2007, the Karnataka government established two unified authorities: the Directorate of Urban Land Transport and the BMLTA. However, they lack the necessary legal backing and independent control. Actual decisions are made by authorities with financial control over projects. For example, the BMRCL is controlled equally by the state and central governments and hence needs approvals from both. For most other agencies, the state government is the final

sanctioning authority for transport projects because it controls the finances.

The Town and Country Planning Act (1961) states that public consultations should be conducted before development projects are undertaken. However, they seldom take place, and no legal obligation exists to respond to the objections or concerns made by the public. Planning body officials believe that public consultations are merely a function of informing, not consulting. Getting information regarding projects is difficult because different departments work in isolation and are not willing to share information with "outsiders" (Vaidyanathan and Rathi, 2018).

Bengaluru is fortunate to have various citizen groups and advocacy groups for human rights that try to keep a close watch on development projects and their implications for the environment. These groups have spoken up about road-widening projects, the felling of trees, a suburban rail project, the Metro, the revival of lakes and more (Aras, 2018; Ravichandar, 2014). For example, Bengaluru Bus Prayanikara Vedike, a bus rights group that works on improving urban mobility in the city, released a series of proposals in 2020 to improve the public transport system. Their proposals included improved bus service, free bus travel for women, bus-priority lanes, waivers on heavy taxes on the BMTC, congestion charges and thinking beyond big-ticket projects like the Metro (Rao, 2021). Sometimes, the objections made by citizens or citizen groups have made an impact, like rejection of the draft Master Plan 2031 in view of 14,000 objections, but other times, their objections on Metro project, or elevated roads, or even increase in bus fares, were ignored.

The active work of Bangalore's citizen groups has particularly paid off with the rejuvenation of the city's lakes. Almost 500 years ago, when Kempegowda founded Bengaluru, he dotted it with numerous lakes, earning it the name City of Lakes. From the 262 water bodies that existed in 1960, there are only 81 surviving today, of which only 34 are alive (Barua, 2019). Unplanned urbanization, uncontrolled discharge of sewage and industrial waste turned many of the lakes into inflammable, frothy, foamy and dangerous reservoirs of deterioration. Citizen awareness of this decline of the once-lush natural bodies, the dying biodiversity and the lack of any government action encouraged them to

take matters into their hands. The lakes are being revived one at a time, with local leadership and community efforts funded by socially responsible corporations and voluntary contributions. Revival efforts include the sledging of the lakes, desilting, setting up smaller islands for birds to nest, afforestation, stopping the inflow of untreated sewage and industrial waste, oxygenation of lake water and creation of thriving biodiverse environments.

When the state government recently announced plans to revive some lakes (Menezes, 2021; IANS, 2020), a large outpouring of activists, officials and residents insisted on being active partners in the process. They believe that the only way ahead for the rejuvenation of Bengaluru's water bodies is through collaborative efforts between agencies, residents' welfare associations and the public (IANS, 2020; K.R., 2020; N., 2020; Wangchuk, 2020). This is an example of the strong resolve of the public to not be spectators but partners in development, thus creating truly sustainable development.

In the foreseeable future, planned traffic minimization will be targeted with a mix of transit-oriented development plans, bus and Metro expansions and shared mobility services. The transit-oriented development policy (BMRCL, 2019) aims to develop concentrated nodes of moderate to highly mixed land-use density within 5–10 minutes of walking distance from mass transit stations, which are well integrated with pedestrian, bicycle, feeder and transit networks. Within the transit-oriented development zones, physical and social infrastructure will be augmented and made accessible by foot or non-motorized transport.

Table 1: Plans for public transport supply

Mode of public transport	Length of network
Buses	1,321 road km
Metro (Phase I and II)	114 km
Commuter rail (proposed)	161 km
BRT (proposed)	280 km

Source: Mukherjee, Toshniwa and Mulukutla, 2017.

Mixed-use development around stations and terminals will mandatorily incorporate affordable housing and open space areas. The Metro Phase I and II, when completed, are expected to improve public transport ridership by up to 70 per cent, even though it is forecasted that buses will continue to serve 75 per cent of the public transport demand (Mukherjee, Toshniwa and Mulukutla, 2017). Thus, investment in buses is planned to increase the fleet size and use e-buses by 2031 (C40 Cities, 2020 and 2017). Table 1 shows the expansion plans for all of public transport in Bengaluru.

The parking policy (DULT, 2020) also plans to discourage traffic by regularising and restricting parking in specific areas by lowering the minimum standards for parking in transit-oriented development zones—although numerous reports suggest that transit-oriented development zones should work with parking maximums, not minimums (see, for example, Singh, 2021). There are also suggestions to reserve parking for electric vehicles and shared mobility like bikes (BPAC and Uber, 2020).

Affordability, availability & inclusivity

Public transport in India is typically subsidized to allow low-income groups to use the service to access employment opportunities that are beyond a cyclable or walking distance. Thus, affordability is a critical component of public transport, just as much as availability and inclusivity. There are several measures in place to offer safe and discounted travel options to users, even though there is room for improvement in all these areas, including route rationalization, fare restructuring, removing corruption, increasing the supply of public transport, land-use transport integration and more.

The BMTC is the most expensive bus service in the country, having changed fares 11 times between 2002 and 2011, increasing fares by 75 per cent—leading to strong public reactions, despite which, the decisions were not reversed (Baindur and Rao, 2016). This has impacted low-income groups who have modified their travel behaviour and travel patterns and shifted their choice of transport. The BMTC is funded and taxed by the government, and one way to reduce fares is to either increase funds or reduce taxes.

The current fare structure is telescopic or logarithmic in nature, which charges more for short journeys and penalizes passengers for changing buses during a trip (it can cost 65 per cent more than a single bus journey) (Mukherjee, Toshniwa and Mulukutla, 2017). There are suggestions to charge less for shorter trips because the bus also acts as a feeder line to the Metro. Fare pilferage by bus conductors, who issue the tickets, is also an issue reported by many users; suggestions to prevent this include fixing fares in multiples of five to make cash transactions easier.

A study by Deloitte (2017) assessed the BMTC service and found that less than one fifth of buses are low to the ground and are not user-friendly. Although there are plans to improve last-mile connectivity by shared bikes, many challenges thwart its uptake. Atal Sarige buses provide low-cost connectivity between major bus stations for low- income communities, but affordability is still an issue.

BMTC performance has been consistently deteriorating. In 2020, the bus fleet reduced by 3 per cent from 2019, and buses covered fewer kilometres than previous years. Ridership also fell, by nearly one third between 2014 and 2019 (BPAC and Uber, 2020). The most common reasons for not using buses are: infrequent service, poor accessibility,

inconvenient and poor connectivity (figure 7). There are plans to augment the fleet size, from 6,600 buses to 15,000 buses by 2031 (90 per cent e-buses). In addition, the Metro Phase II is expected to increase the availability of public transport for citizens.

Other issues with the bus service are route planning, which must change from the current inefficient "destination-based" routing to the hub-spoke model. Parallel routes

Figure 7: Reasons for not using public transport in Bengaluru
Source: BPAC and Uber, 2020.
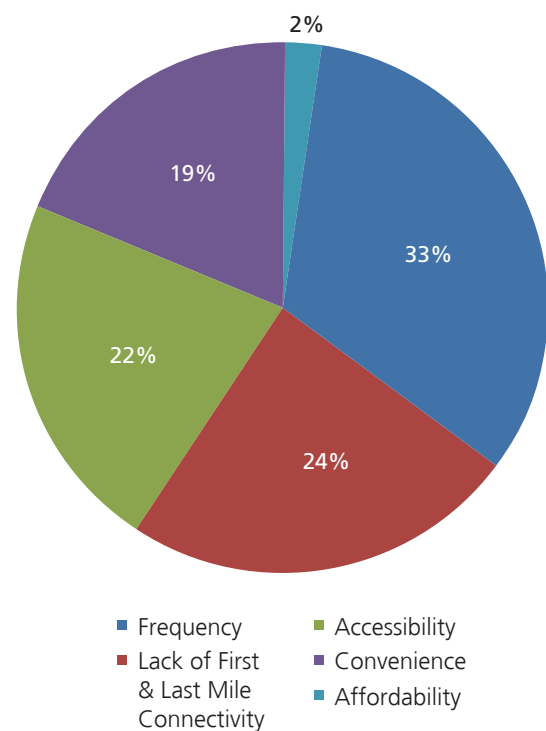
between the Metro and the buses need to be rationalized. Bus boards in local languages are not all-user-friendly, given the cosmopolitan nature of the city; they should be more inclusive (Harsha, Karmarkar and Verma, 2019; Ravichandar, 2014).

The buses offer reserved seats for women in the ordinary buses and have CCTV cameras inside the buses. There are 22 "ladies special" bus services that can be used only by women. A recent user perception survey revealed that 83 per cent of female users were satisfied with the BMTC

services during the day, but only 68 per cent felt satisfied with the night services (HEAT, 2020a). Major user concerns include the high travel cost, the lengthy travel time and low levels of safety, security and comfort. Buses, terminals and stations should be more accessible, safe, efficient, user-friendly and digitalized; and women staff should be increased (HEAT, 2020a). Students and persons aged 60 and older can avail of a highly discounted monthly pass for bus services, and sometimes there are reserved seats for older persons or people with a disability.

The transit-oriented development policy of Bengaluru aims to create inclusive, accessible, equitable and sustainable access to transportation. The transit-oriented development policy (BMRCL, 2019) looks to achieve a 70 per cent modal share for public transport by targeting 60 per cent of the population who live within the intense transit-oriented development zone and achieving gross density of 250–400 persons per hectare along the mass transit corridors by 2031. Mixed-use development around stations and terminals is required to incorporate affordable housing and open spaces, or "circulation areas". Curiously, the policy defines three zones along the transit corridor and not the stations: intense transit-oriented development zones (a 500 m buffer along the transit corridor), standard transit-oriented development zones (a 500 m to 1 km buffer) and transition transit-oriented development zone (a 1–2 km buffer). Financing instruments, such as land value capture, higher charges for building premium floor space a betterment levy, transfer of development rights, cess on stamp duty, advertising space and station branding, are to be used to fund the transit-oriented development projects.

There are clear plans for increasing the public transport supply that should reduce or stagnate private vehicle ownership. Two-wheelers account for 70 per cent of traffic, and they can be more fuel-efficient, less space-consuming, faster, flexible and cheaper to use than cars. Their conversion to e-scooters can make them comparable to e-bikes and hence more sustainable.

Safety & reliability

The BMTC buses were involved in 206 fatal accidents between 2012 and 2015, amounting to almost 11 per cent of all fatal accidents in the city (Mukherjee, Toshniwa and Mulukutla, 2017). Fatalities were primarily caused by passengers falling when boarding and alighting and driver negligence. Working women find public transport safer than autos, non-motorized transport, private taxis or even private vehicles at night or when they are alone (Baindur and Rao, 2016). Verma et al. (2019) reported that only 62.3 per cent of women in Bengaluru feel safe when travelling by bus, yet they continue to use buses because they cannot afford to any other option. They use precautionary measures and strategies that affect their travel patterns and decisions about which mode of transport to use, route and time of commute. CCTVs improve their feeling of safety, but there is demand for increased police patrolling. Destination displays, audio announcements and women helpline numbers are recommended in buses and at bus stops. Drivers and conductors should have a thorough background check, and more female staff should be employed.

The BMTC service is not known for its reliability (accessibility and frequency). As figure 7 indicates, affordability is the least of its problems. The BMTC buses do not have a published timetable, buses do not run on time, routes are indirect or overlap, first-mile and last-mile connectivity are lacking, waiting periods are long, and often buses are full (Aras, 2018). Typically, buses have conductors for ticketing, and many users, especially women, have complained of fare pilferage by conductors (Baindur and Rao, 2016).

The BMTC implemented an intelligent transportation system in 2016 to improve reliability and user experience of the bus service (Rakesh et al., 2018). It has three components: automated vehicle tracking system, electronic ticketing machines and a linked passenger information system through a mobile device app. The project involved implementation of more than 10,000 internet-enabled electronic ticketing machines and 6,400 online vehicle GPS units. Earlier efforts to use GPS on buses (in 1999 and 2004) or using electronic ticketing machines (in 2008) were abandoned due to technical problems. However, the Bangalore Transport Information System, launched in

2007, provides comprehensive urban traffic information that continues to work well.

The new intelligent transportation system also has problems. The electronic ticketing machines have a short battery life, the system crashes, there are connectivity issues, the mobile device application has interface and usability issues and is not helpful for those who do not know the bus network and routes. The app is reported to be buggy, slow and unable to cope with a multi-bus journey, lacks accuracy and is generally not user-friendly.

The BMTC is reported to be heavily politicized and dogged by claims of corruption across all levels. On the bright side, the ticketing machines have made audits and cash reconciliation easier, reduced fare pilfering and, due to the vehicle tracking system, fake fines (produced by drivers) have been significantly reduced. The intelligent transportation system measured the bus service performance and found that in the first year, 14 per cent of services were cancelled instead of 6.5 per cent in previous years, passenger journey numbers were down, passenger revenue had fallen by 8 per cent, compared with the 10 per cent growth in previous years, and fleet utilization had fallen below 90 per cent for the first time while costs per kilometre were the highest ever. The reasons for the declines were not made clear. Figures 8–10 give a glimpse of the system and its architecture.

To improve first and last mile connectivity, shared mobility is being promoted. According to (BPAC and Uber 2020), many people use shared mobility for either the first mile or the last mile, while walking remains most desirable: 53 per cent of users walk both the first and last mile, and 36 per cent of them use intermediate public transport service. The municipal government (BBMP) is planning to install 345 bicycle-docking stations with 6,000 shared bicycles. However, the absence of cycling infrastructure and narrow roads are going to be problematic (Deloitte, 2017).

Traffic congestion makes the bus service slower and less reliable. In 2011, it was found that buses cannot achieve a speed of more than 10 kph on around 40 per cent of the city's roads (Harsha, Karmarkar and Verma, 2019). The Deloitte report (2017) noted that more than 80 per cent of roads in the BBMP are narrow roads with two lanes, and

on-street parking creates problems and unsafe conditions for emergency vehicles and non-motorized transport. The parking policy outlines different strategies to reduce the parking demand, relieve the congestion on roads and promote safe off-street parking in Bengaluru.

Figure 8: Architecture of Bengaluru's intelligent transportation system

Source: designed based on Rakesh et al., 2018.
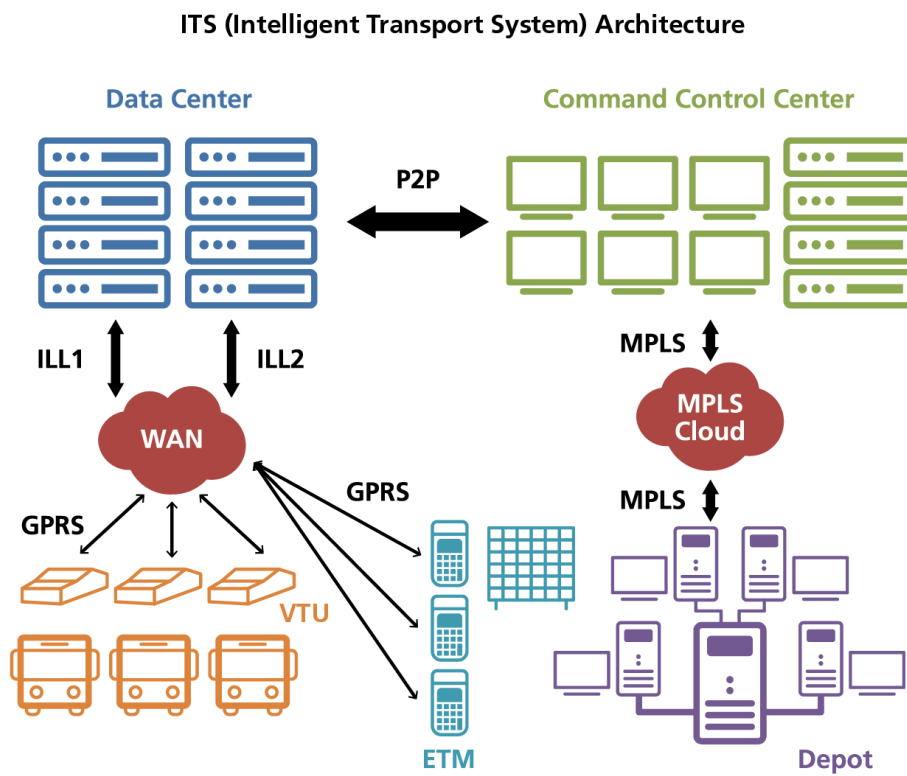
Ecological sustainability, internalization of external costs & traffic avoidance

The external costs of transport have been recognized in a number of ways in Bengaluru. Economic losses due to congestion for two of the city's IT corridors (Whitefield and Outer Ring Road) are estimated at 227.7 billion rupees annually—which excludes the health costs of air pollution. The high vehicular emissions cause nearly 40,000 premature deaths in the country annually. The IBM Commuter Pain Index 2011 ranked Bengaluru sixth on the emotional and economic toll of commuting (Mukherjee, Toshniwa and Mulukutla, 2017).

Bengaluru's air had an estimated 31,300 tons of PM2.5 emissions in 2015, 67,100 tons of PM10 and 10.4 million tons of CO2 (2018). Vehicle exhaust and on-road dust suspension caused 44 per cent of the city's greenhouse gas emissions, 56 per cent of PM2.5 and 70 per cent of PM10 concentrations. While buses account for only 6 per cent of vehicles in the city, they contribute 25 per cent of the PM2.5 emissions (figure 11) (C40 Cities, 2020). Filthy air is causing immense health issues, premature deaths and, as usual, the most vulnerable people bear the brunt of these costs. Residents want more greenery and to revive their lost lakes, which is why the Bengaluru draft Master Plan 2031 was so heavily criticized—it lacked measures to increase green spaces (Deloitte, 2017).

There is a realization that congestion leads to lower travel speeds, longer commuting time, more road fatalities, vehicular pollution, economic costs and adverse quality of life. Hence, a transit-oriented development policy has been developed for the city (BMRCL, 2019). There is growing recognition that for ecological as well as economic reasons, the country must move away from fossil fuel use, especially because India imports most of its oil. In 2015, India paid 4.16 trillion rupees to buy 202.85 million tonnes of crude oil (80 per cent of its demand) (BPAC and Uber, 2020; CID,

Figure 9: Source breakdown of PM2.5 concentrations in Bengaluru, 2015
Source: Urban Emissions Info, 2018.
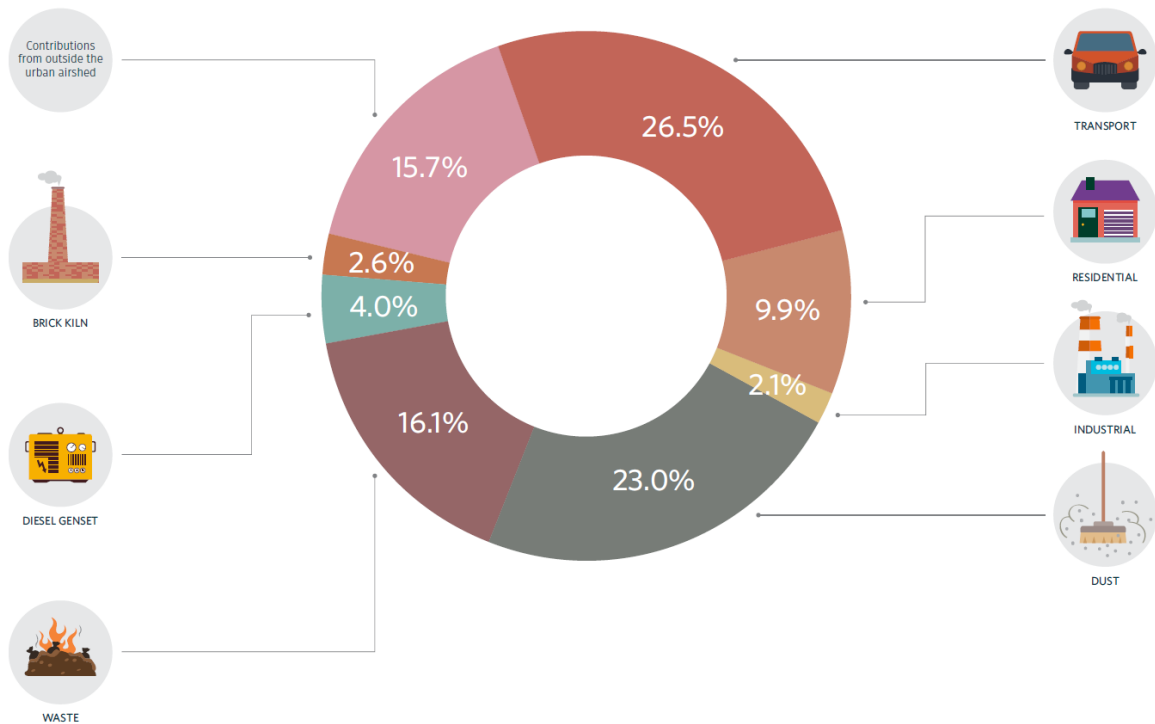
2017). Of this, the transportation sector alone accounted for about a third of the total crude oil consumption and road transportation accounted for more than 80 per cent of the consumption (CID, 2017). There have been steps around promotion of cleaner fuel standards (like compressed natural gas) and tighter standards to reduce overall emissions (2018). Vehicles older than 15 years have been banned.

The draft comprehensive mobility plan (2020) aims to build a multimodal transport system for equitable mobility access, increase the share of public and intermediate public transport by up to 70 per cent, reduce transport emissions and minimize negative externalities. This requires significant augmentation of public transport capacity, e-buses, service quality improvements and incentivizing the modal shifts (Mukherjee, Toshniwa and Mulukutla, 2017). The BMTC is working with C40 Cities to achieve these targets (HEAT, 2020b), starting with 15,000 buses (90 per cent e-buses) with the highest vehicle emissions standards by 2031. With this, C40 (2017) has said that emissions will reduce (more than 51 k Mt of CO2 will be eliminated, provided electricity is green), that public transport use will increase to 60 per cent and that pollution levels will reduce by 50 per cent.

The state's electric vehicle policy aims to achieve 100 per cent electrification of fleet vehicles and three- and four-wheelers for goods transport by 2030 and introduce 1,000 electric buses by the BMTC (CID, 2017). Policy incentives include numerous subsidies, exemptions and land acquisition benefits for manufacturing. As Deloitte reported (2017), the state electric vehicle policy encompasses plans to launch electric auto rickshaws, set up new electric vehicle manufacturing zones and charging infrastructure across the city by 2031, raise US$470 million and create 55,000 jobs. Currently, the electric vehicle market has only 1 per cent share in India, of which most are two-wheelers. For Bengaluru, too, the electric vehicle share is less than 1 per cent, of which 75 per cent are two-wheelers. For developing countries, electric vehicles have been found to be economically more feasible for commercial fleets, like buses, ride-hailing, employers' transport, auto and cycle rickshaws, than personal vehicles due to the high capital costs.

Shared mobility services face a legal roadblock because they are not allowed to work with stage carriages[3] permit and must work with contract carriages permit, which does not allow them to legally pick up and drop off from different locations and imposes fare caps. Private vehicles also cannot be legally used for commercial purposes, like Uber and Ola. Some law amendments and adjustments are needed.

The city is not aiming to reduce trips but rather to either create a modal shift or make mobility sustainable by adopting e-mobility. With India's electricity still generated through fossil fuels, it is hard to call e-mobility green or sustainable. At least not yet.

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3   Stage carriage: According to Motor Vehicles Act 1988, stage carriage means a motor vehicle constructed or adapted to carry more than six passengers excluding the driver for hire or reward at separate fares paid by or for individual passengers, either for the whole journey or for stages of the journey. Contract carriage: According to Motor Vehicles Act 1988, contract carriage means a motor vehicle which carries a passenger or passengers for hire or reward, from one point to another, and without stopping to pick up or set down passengers on the way.

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