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The potential of non-motorised transport for last-mile connectivity in Bengaluru, India

Making urban mobility more inclusive and sustainable

Master thesis

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List of Abbreviations

ADB	Asian Development Bank
BDA	Bengaluru Development Authority
BMRCL	Bengaluru Metro Rail Corporation Ltd.
BMTC	Bengaluru Metropolitan Transport Corporation
BPAC	Bengaluru Political Action Committee
BRTS	Bus Rapid Transit System
BTP	Bengaluru Traffic Police
CMP	Comprehensive Mobility Plan (Bengaluru)
DULT	Directorate of Urban Land Transport, Government of Karnataka
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
IIHS	Indian Institute for Human Settlements
IMT	Individual motorised transport
IPT	Intermediate public transport
ITDP	Institute for Transportation and Development Policy
IRC	Indian Road Congress
LMC	Last-mile connectivity
MaaS	Mobility as a Service
MoHUA	Ministry of Housing and Urban Affairs, Government of India
MoUD	Ministry of Urban Development, Government of India
NIUA	National Institute of Urban Affairs (India)
NMT	Non-motorised transport
NMV	Non-motorised vehicle
NUTP	National Urban Transport Policy (India)
PBS	Public bike sharing
PTS	Public transport station
SUT	Sustainable urban transport
SUTP	Sustainable Urban Transport Project
TERI	The Energy and Resources Institute
TOD	Transit-oriented development
WRI	World Resource Institute

Research ethics

This research has fully been executed and written by the author himself without any external contribution. Academic integrity of information has been followed according to the standards of Utrecht University. Informed consent from the research participants has been asked regarding the recording of interviews, transcribing, and referencing them in this paper. The privacy of personal data has been kept avoiding harm to the participants. Regarding data management, the data collection, handling, and storage is in line with GDPR regulations. The copyright of material has been checked to avoid copyright violations. Sources have been quoted using the regulations of the APA style 6th edition.

The positions and perspectives of the interviewees have been extracted from the interview transcripts with great care to minimise the potential for misunderstandings or wrong interpretation. This thesis will be sent to the interviewees before publication to be checked whether they have been quoted correctly and their perspectives have been reflected accordingly. All other perspectives and positions are the authors own.

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Abstract

Urban mobility in Indian cities is suffering from traffic congestion, air pollution, road safety, land use conflicts and an overburdened transport network due to population growth, urbanisation, increasing transport demand and high motorisation rates. With urban transport planning focusing on building infrastructure for the automobile to resolve congestion, footpaths diminished, cycling was restricted, and public transport underfinanced leading to a decrease of usership. However, many people rely on these modes as cars are unaffordable for people from low-income households but also marginal groups, making them highly exclusive. With limited resources and options available in the city, there is a need for more sustainable and inclusive transport options which have been developing in recent years and gaining momentum during Covid-19.

Based on a mixed methods approach of reviewing literature, interviewing experts, analysing policy documents and collecting best practice cases, this research is aiming at understanding how last mile commute (LMC) to public transport stations can be improved through non-motorised transport (NMT) modes in the southern Indian city of Bengaluru. Following an assessment of the current commuting patterns in the city, an analysis of potential alternative means for commuting, and a reflection on policies and best practice cases, approaches for shifting LMC towards more NMT are reflected. Recommendations from citizen organisations together with results from this research are ought to support this transition towards a more inclusive and sustainable mobility system in Bengaluru.

It was found that the majority of commuters in the city walks to public transit stations, while a smaller share uses intermediate public transport options or personal vehicles, whereas cycling to stations was not observed. Considerable differences between genders have been identified with women preferring shared modes while men used private vehicles more to cover the last mile gap. Challenges have been identified around the accessibility of stations, the availability of LMC mode choices, the affordability of both LMC and public transit but also reliability of services. Thus, there is a high demand for change and a large potential for NMT and other mobility innovations to cover LMC in the city. For the implementation of these changes, it is essential to focus on the preferences of commuters, identify existing barriers, and involve all stakeholders into the development process. This research recommends to further discuss micromobility modes and cycle rickshaws as NMT mode options having a high potential to make urban mobility and particularly LMC more sustainable and inclusive.

1. Introduction

India has witnessed remarkable economic but also population growth in recent decades leading to increased urbanisation, affluence, and a steep increase in transport demand. However, the transport infrastructure has not kept up with the rapid growth and high numbers of individual motorised transport prevalent today. With 210 million personal motor vehicles registered in 2015, numbers were going up from 5 million in 1981, representing a 40-fold increase (NITI Aayog, 2018). This has led to major challenges in Indian cities concerning air pollution, traffic congestion, road safety, and land use but also unequal access to mobility. With an ever-growing popularity of the automobile in the last century, it took centre stage in planning processes for mobility, pushing aside easily accessible and convenient forms of transport which are also healthy and environmentally friendly. The more traditional modes of transport like walking and cycling are hardly possible anymore on streets designed for motorised transport only (MoUD, 2016). However, the problems resulting from increasing motorisation, like congestion, pollution, and accidents, initiated the rethinking of urban spaces and resurrected the potential of non-motorised transport (NMT).

This momentum has created a need for new, more inclusive, and sustainable alternatives for mobility based on the existing infrastructure and adjusted to the needs of the urban population. The COVID-19 pandemic has led to restrictions in mobility but also induced a paradigm shift in urban mobility towards NMT worldwide. Studies on walking and cycling in Indian cities have recently focused on the effects of COVID-19 but also its role in first- and last-mile connectivity (LMC) to public transport. The urgency of finding long-term solutions for sustainable mobility systems is making this a highly relevant topic for further research from a societal and scientific perspective. With new and adjusted policies focusing on active mobility (DULT, 2021a; MoHUA, 2020; MoUD, 2016) a shift in urban transport developments is already happening. A major challenge is however that NMT is not just lacking attention from policymakers and urban planners but also suffers from a social stigma around its captive use (Nagrika, 2021). Therefore, these challenges need to be analysed from a policy, institutional, planning, cultural, and enforcement perspective. This research aims at contributing to this research gap by conducting an analysis on the potential of non-motorised transport for last-mile commute in the Indian city Bengaluru.

1.1 Overview of the study site - Bengaluru

Bengaluru (formerly known as Bangalore) is the capital of the Indian state of Karnataka and one of the fastest growing cities in India (Government of Karnataka, 2021). With an estimated population of more than 13 million in its urban area in 2022 (World Population Review, 2022a), it grew from 8.5 million in 2011 with a rate of 3.35% per year (Census India, 2011) (see Figure 1) making it the third most populous city in the country and the 24th most populous city in the world (Britannica, 2018).

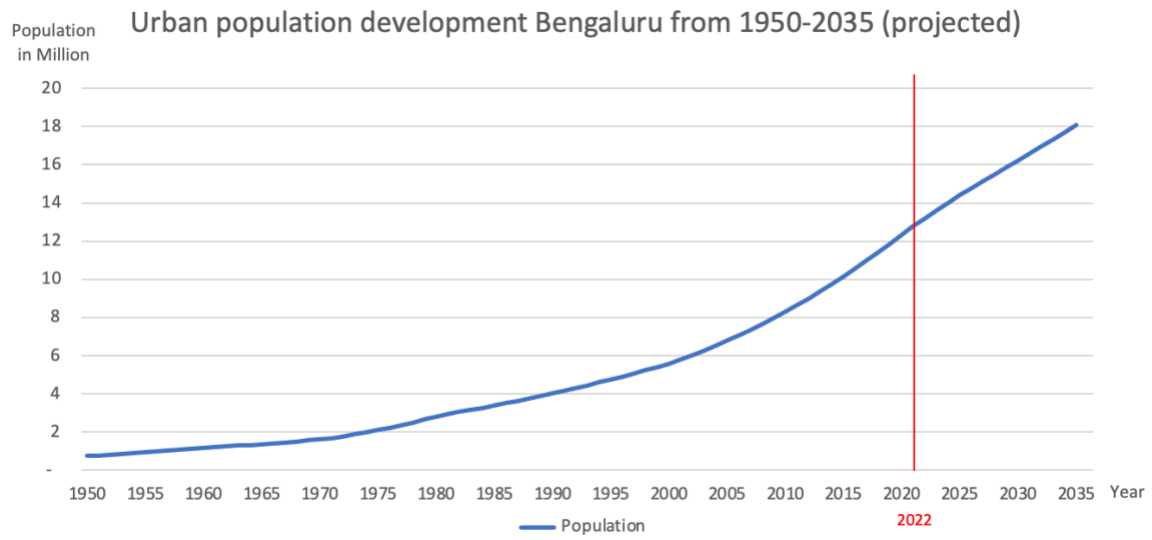

Figure 1: Urban population development Bengaluru from 1950-2035 (projected), own visualisation based on data from (World Population Review, 2022a)

The city is located in the south-eastern region of the state of Karnataka close to the border with Tamil Nadu in the south of the Indian subcontinent. Located on the Deccan plateau with an elevation of 900m above sea-level, the city is known for its pleasant climate throughout the year (Government of Karnataka, 2021). Due to its high elevation, Bengaluru enjoys a very moderate climate with temperatures between 15-35 degrees Celsius. There is a dry and a wet season, with the monsoon season mainly including the months August until October. However, the city experiences only 50-60 rainy days per year and barely any rain between November and April, while the humidity lies around 50% on a yearly average (Indian Meteorological Department, 2015). Due to its high number of lakes and public parks, Bengaluru was once called the 'garden city of India' (Y. Jain, 2021).

Bengaluru is now known as the Silicon Valley or IT capital of India, due to its high density of tech companies and IT-related businesses. It is also home to a number of well-recognised educational and research facilities and institutions (Bengaluru Urban District, 2022). Next to technology, electronics, and services industries, the city is known for its garment production but also has heavy and light industries. Many international and Indian companies are headquartered in the city, making it one of the fastest growing economies in the country. With an average economic growth rate of 8.5%, it is among the top ten fastest growing cities worldwide (Dezan Shira & Associates, 2019).

The average income in the city is greater than the Indian average resulting from the strong urban economy leading to investments into industries, infrastructure, and services, which have also created secondary employment opportunities. There is a large number of migrants from other parts of the country who moved to the city mainly for employment or education and the literacy rate of the population is 75% (Sudhira et al., 2007). With the number of urban poor rising, slum settlements have been growing and facing high land prices and cost of living, they live in inadequate conditions and are being pushed further out of the city. The physical growth of the city has been high, leading to increased travel times and escalating real-estate prices (Sudhira et al., 2007).

1.2 Transport infrastructure and mobility in Bengaluru

Bengaluru has more than 14,000 kilometres of roads including ring-roads, arterial roads and residential streets (RMI India, 2020). There are several large roads crossing through the city, with Mahatma Gandhi (MG) Road being the most important east-west connection. Many former roads and town streets constructed during the colonial rule have been transformed into commercial and residential areas after independence (Britannica, 2018). Since then, the traffic has increased dramatically with 1.6 million vehicles registered in 2015, which is the second highest number recorded in India after New Delhi (BTP, 2019). It has become a challenge for authorities to manage and maintain the infrastructure due to growing traffic in the city. To improve congestion problems, the city has heavily invested into road infrastructure but also public transport projects in the last ten years (Dezan Shira & Associates, 2019). There have been improvements regarding the creation of one-way streets, increasing flow at junctions, and constructing ring roads, bridges, and flyovers where several infrastructures have been reconstructed through public private partnerships funded by private companies (Knight Frank, 2020). These measures have slightly improved the situation temporarily, but with an ever-increasing growth in individual motorised transportation of 7-10% per year (BTP, 2019), the overall traffic situation did not improve. Still, the Bengaluru Development Authority (BDA) is adding lanes to many major roads in the city and tries to divert traffic onto ring roads and peripheral roads. Initially, the roads in the city were not designed for the amount of vehicular traffic that is prevailing today, which is now causing slow traffic and traffic jams all across the city (Y. Jain, 2021).

Busses are operated by the Bengaluru Metropolitan Transport Corporation (BMTC) and provide a reliable and essential mean of public transport across the city. With a fleet of 7000 busses, BMTC is delivering inner-city transport across Bengaluru forming a grid along the twelve major roads through the city centre (DULT, 2020b). For short commute, three-wheeled auto-rickshaws called *autos* are a popular option, running on meters and accommodating up to three people. Additionally, City Taxis are available on call but are generally more expensive than auto-rickshaws (Britannica, 2018). In 2011 a rapid-transit commuter rail system, called *Namma Metro*, was inaugurated in Bengaluru with an extension built in 2015 now covering 41 stations along two stretches of 42 kilometres of an elevated and underground network (BMRC, 2022). Once fully completed, the Namma metro system will connect central locations within the city but also reach outer regions.

For most people in Bengaluru, the main mode of commuting is walking and with 28% of the modal share it is among the highest compared to other major Indian cities. Another 28% use buses as their main mode of transport, 23% take a scooter and only 10% drive a car, while Metro use is rather low with less than 5%. The modal share of cycling went down from 18% to 2% from 1980 to 2011 (Jose et al., 2020). More detailed data on commuting and NMT will be presented in the results section based on governmental data and scientific studies.

1.3 Current research and policies

Research on sustainable (urban) mobility in Indian cities is exhaustive (IIHS, 2015; NITI Aayog, 2018; Soman et al., 2019) as well as on sustainable urban transport (SUT) in the Global South in general (GIZ, 2020; Pojani & Stead, 2015; Uteng & Lucas, 2018). Papers are covering issues of access to mobility (Singh & Sarkar, 2022; Venter et al., 2019) and barriers of accessing transport (Basu & Vasudevan, 2013; Sagaris & Arora, 2016). Focusing on India, multiple previous studies address the opportunities and infrastructure needs for non-motorised mobility modes (Arora, 2013; A. Jain, 2022; D. Jain & Tiwari, 2013), its use (D. Jain & Tiwari, 2016; UN HABITAT, 2013; Yedla, 2015) and the integration of bicyclists and pedestrians with transit (Mohanty et al., 2017). Some research also focused on cycling specifically (TERI, 2018; Tiwari et al., 2008) including literature on the gender perspective (Arora, 2011; GIZ, 2017) and public bike sharing (Dhingra & Kodukula, 2010; GIZ, 2021). There is also a focus on health issues regarding cycling in Indian cities (Apparicio et al., 2021; C40 cities, 2020) and the most recent papers covering the changes of mobility and transport in Indian cities due to the impact of COVID-19 (Cities Forum, 2020; DULT, 2020a; Nagrika, 2022). SUT in Bengaluru has been addressed regarding its benefits for mobility (BPAC & Uber, 2020; Y. Jain, 2021) and policy implications (Jose et al., 2020; RMI India, 2020). However, the theme of last-mile connectivity in Indian cities especially through NMT has not been addressed extensively in research.

In recent years, a number of policies have been developed that include more sustainable and specifically non-motorised and active transport options. On a national level, the *National Urban Transport policy (NUTP)* was set up by the Ministry of Urban Development stating that "people occupy centre-stage in cities and all plans should be for their common benefit and well-being" (MoUD, 2014). With this, a new planning paradigm was implemented not focusing on the improvement of speed for vehicles anymore but instead on safe infrastructures for every road user. Its implementation was ought to be assisted through the *NMT Guidance Document* (MoUD, 2016) and guidelines for planning and implementing cycling and pedestrian infrastructure (DULT, 2014; IRC, 2012). Next to that, the Ministry of Housing and Urban Affairs has created the *National Transit Oriented Development (TOD) Policy* to encourage multimodal transport through strengthening public transport and its integration with NMT (MoHUA, 2016). In the wake of the pandemic, MoHUA has also ordered cities to develop marketplaces where pedestrians can move freely to increase the pedestrianisation in cities immediately (MoHUA, 2020).

On the state level, the Directorate of Urban Land Transport (DULT) of the Government of Karnataka has issued the *Active Mobility Bill Karnataka* at the end of last year – the first of its kind in India – to strengthen active forms of transport including walking and cycling but also penalties for not following the regulations to protect the rights of NMT users (DULT, 2021a). For the city of Bengaluru, the *Comprehensive Mobility Plan Bengaluru* has been developed to coordinate the efforts of improving mobility in Bengaluru on a local level (DULT, 2019).

An extensive review of the scientific and grey literature and the analysis of policies will follow in the results section of this research.

1.4 Research gap

Mobility in cities around the world is dominated by individual motorised transport (IMT), which is leading to problems of traffic congestion, air pollution, and high resource and energy use, thus making it an unsustainable mean of transport. IMT is exclusive due to its high cost of buying and maintaining a vehicle, license requirements and institutional knowledge while also being inefficient due to its large use of space in cities for parking and moving. Especially in densely populated and congested cities, public transport is a more efficient, cheaper, and sustainable option. However, bus, metro, train, or tram networks can only reach certain points within a city, requiring solutions for covering the first and last mile of the trip which is essential for door-to-door transportation. It is assumed that the most inclusive, sustainable, and less space intensive ways of short commute are NMT modes in combination with public transport. Current policy plans address increasing the share of NMT but there are limited clear implementation plans and commitments to the goal of providing infrastructure for walking, cycling and micro-mobility as well as accessibility to public transport. Research on the potential of NMT for covering the last mile in India and implementation approaches in the context of a large Indian city are insufficient. This paper analyses whether NMT is a feasible option for last-mile connectivity in Bengaluru and which strategies are necessary to implement these changes for more inclusive and sustainable urban mobility.

1.5 Research aim and research questions

The goal of this research is to first understand how first- and last-mile but also short distance commute in Bengaluru looks like, including who commutes, how do people commute, and which challenges they face, to get an overview of the current mobility pattern in the city. The findings will be contextualised by analysing existing policies and best practice cases regarding urban mobility. Essentially, the aim is to find out whether NMT can be or is a viable, inclusive, and sustainable solution for short distances and last-mile commute in Bengaluru. The final output will comprise suggestions, potential solutions, and implementation strategies on how to increase the share of NMT and the connection to public transport within the city.

Therefore, the following research question was developed: *How can first- and last-mile commute to public transport stations become more sustainable and inclusive through non-motorised transport in Bengaluru?*

In order to answer this question, a set of sub-questions was added:

- How does the current commute to public transport stations (in Bengaluru) look like? Who is commuting by which means?
- What would be the potential alternative means of commuting and why should there be alternatives provided for the first and last mile?
- What are existing policies and best practices (from other cities and countries) that can guide the transition towards more active mobility?
- How can these changes be implemented and how can the transition towards more inclusive and sustainable transport modes be managed?

2. Theoretical background

This section will introduce the relevant concepts for this thesis and define them to be applied consistently. Together they will form the basis for the theoretical background of this paper and will be applied and analysed to allow for scientific reflection of the data and information used in this research.

2.1 Non-motorised transport (NMT) and Active mobility

NMT refers to all modes of transportation that are not powered by a combustion engine and are providing mobility for people or goods (Yedla, 2015). This includes walking, cycling and other types of non-motorised vehicles (NMVs) with limited speeds often restricted to less than 25km/h (MoUD, 2016). The most common form of NMT is walking but other means include bicycles, tricycles, human porterage, handcarts, animal drawn carts and other human powered vehicles (Yedla, 2015). Advantages comprise health benefits for people and cities, easy accessibility, and useability as well as traffic, pollution, and congestion reduction. "The importance of NMT as an affordable and environmentally friendly transport mode is increasingly being recognised for its great potential in reducing emissions, improving safety, and create more sustainable urban environments." (MoUD, 2016).

Active mobility on the other hand defines these modes of transport from another perspective by describing the energy source of walking and cycling through human-powered movement as an active form of mobility where people have to use their own body strength to move around (UNECE, 2020). This excludes animal-powered vehicles but can otherwise interchangeably be referred to by the term 'non-motorised transport'.

In this paper, the concept of NMT will mainly be used as it is the more established term for looking at transport which is not powered through an engine. However, the term active mobility defines the modes analysed in this research even closer and will therefore also be applied, especially in relation to the research that has been done in the field more recently.

2.2 First and last-mile connectivity (LMC)

First and last-mile connectivity describes the sections of a trip that are undertaken to and from public transport stations via different means. For a journey by public transport such as busses, trams or metros, there is a need to cover the distance from home to a station and from a station to work or another destination. Public transport stations are usually located relatively far apart creating a need to cover the gap by other means such as walking, biking or small motorised transit, depending on the distance and existing options (EEA, 2019). Covering the distance to public transport stations by NMT allows for easy reachability of a station and increases its catchment area. Good first- and last-mile options make the use of public transport, the main part of the journey, much more accessible and therefore effective (Kanuri et al., 2019). Through this multimodal network of combining different means of transport, destinations can be reached in a flexible manner depending on individual choice and preference (EEA, 2019).

In this paper, the abbreviation LMC, last-mile connectivity, will be employed to refer to both the commute to and from public transport stations (PTS), thereby also including the first mile of the journey.

2.3 Transit Oriented Development (TOD)

Transit Oriented Development (TOD) integrates transport planning into land use by developing a planned sustainable urban centre around transport stations that is walkable due to a mixed land use and characterized by high density. This allows transit facilities to be used effectively and creates space for greenspaces increasing living quality in the neighbourhood. By planning an urban area around transport stations with short distances, NMT such as walking and cycling is encouraged and serves as the ideal mean of transport for the last mile. Walking distances should be around 500-800m to the nearest transport station along the transit corridor (MoHUA, 2016). TOD advocates pedestrianisation as an essential mean of transit for short distances to reach shopping, entertainment or work while also enabling the use of public transport to bridge further distances. The creation of such compact and walkable communities lowers stress and the dependency on a car for mobility and survival (TOD Institute, n.d.).

The Ministry of Housing and Urban Affairs, Government of India sums up the advantages as: "TOD increases the accessibility of the transit stations by creating pedestrian and Non-Motorised Transport (NMT) friendly infrastructure that benefits large number of people, thereby increasing the ridership of the transit facility and improving the economic and financial viability of the system. Since the transit corridor has mixed land-use, where the transit stations are either origin (housing) or destination (work), the corridor experiencing peak hour traffic in both directions would optimise the use of the transit system." (MoHUA, 2016). The concept of TOD will therefore be discussed as a potential solution to making public transport more efficient and inclusive through NMT for LMC.

2.4 3A framework (availability, accessibility, and affordability)

The 3A framework covers the three dimensions of *availability, accessibility, and affordability* and was initially developed for the health care sector (WHO, 2022). It was used in the field of food security as well but can also be applied for assessing other types of services such as transportation (Singh & Sarkar, 2022). By creating a framework to identify the quality and quantity of the system analysed, it can be identified how and if marginalised groups can use a service (UNICEF, 2019).

Availability refers to the existence of services in sufficient quantity. Accessibility covers five components including physical, financial, administrative, social and information accessibility. Physical accessibility describes whether facilities or services are reachable within a reasonable distance and whether the route to and from the facility is safe to travel or if there are any physical barriers to reach the location. Financial accessibility covers the funding of the service including the fee that applies given the economic circumstances of those who need to access it. Administrative accessibility refers to procedural steps that need to be taken in order to

access the service, for example a registration, as well as a certain level of literacy required to access the service or prerequisites like a mobile phone, internet access or a bank account. Social accessibility means whether certain people are excluded due to safety, discrimination, language barriers, stigma, or the individual's ability to access the services. Lastly, information accessibility asks whether and how information about the service is being provided to the community and if people can access them given different languages or physical disabilities but also limited literacy (UNICEF, 2019). The third A covers the affordability of services including the price to access services but also financial support for people to use a service or loans for buying a mean of transport and funding for regular trips with public transport (ICT4D, 2018).

This framework will be used to analyse the different options that people have to access public transport and helps to understand whether NMT is an adequate option for the last mile in comparison to other modes.

2.5 Transition management and visioning

Transition management is a tool for executing change through long-term planning and was developed by the Dutch government to induce structural change in major societal subsystems (Meadowcroft, 2009). The approach reflects the challenge of bringing together short-term actions and long-term visions. Through an orientation towards a long-term vision for sustainable development, the goals and general direction are set up looking at a time horizon of 25-50 years (Rogge & Reichardt, 2016). This is combined with short-term learnings which evolve through probing in order to find concrete pathways to realise the vision (Voß et al., 2009). Through cycles of redesigning and adjustments, the approach may be adapted based on the evaluation of learnings during the process. Ultimately, substantive goals need to be reached, however transition management envisions a learning process throughout the development and is not just focused on specific initial measures or strategies (Kern & Rogge, 2018). The guiding vision helps to stay on track while creating room for experimenting with options and different pathways. Thereby, a growing development path can be envisioned, rather than exact planning and long-term control (Voß et al., 2009). Initiators, like certain cities or politicians, are important to transition management as they formulate the vision while also initiating new ideas. Innovation and societal learning are key for sustainable development and help to further develop topics like mobility (Meadowcroft, 2011). This concept will help to define recommendations at the end of this paper on how to potentially implement a transition towards more NMT for LMC.

3. Methods

In this research a *mixed methods approach* was applied to collect and analyse the data and information using qualitative and quantitative methods (Clark et al, 2021).

Qualitative research allowed to understand the local context of NMT options for LMC in Bengaluru while quantitative data on mobility patterns complemented the research allowing for an understanding of the status quo. The mixed methods approach can be classified further according to the criteria priority and sequence of data collection, proposed by Clark et al. (2021). In this research, qualitative data was the main form of information gathered, thereby being selected with priority. In terms of sequence, qualitative and quantitative data were gathered simultaneously. Giving priority to qualitative data allowed to understand and analyse the quality of the current situation (Islam & Aldaihani, 2022), including the LMC in Bengaluru and to explore the potential of NMT for improving the quality of LMC through greater sustainability and inclusiveness.

Qualitative data was obtained through purposive sampling, allowing the selection of sources and interview partners that provided valuable insights for the research problem (Clark et al, 2021). For the sampling of literature, this approach allowed selecting insightful and context-specific documents based on the title and information provided in the abstract. To study the research problem, a case study approach was chosen to focus on the unit of analysis, the policies and interventions in the respective cities, allowing to capture the dynamics of the study sites (Eisenhardt, 1989). Following a deductive approach, established concepts like NMT, TOD and the 3A framework were employed and information interpreted with respect to the Bengaluru context (Clark et al, 2021).

Data from literature was collected by using and combining the following key words: *non-motorised transport (NMT), active transport, walking, cycling, first and last-mile connectivity, transit-oriented development (TOD), Bengaluru, India, urban mobility, sustainable transport, and public transport.* These terms were inserted into search engines such as Google Scholar, Web of Science, World Cat, MS Academic and UBU Catalogue. The goal was to find peer-reviewed papers, research articles, scientific reports and publications from university researchers, research institutions and other scientific sources. This helped to understand findings of existing research that has been conducted in the field and formed the basis for this research to further build upon. In order to get a clear picture of current polices and existing plans and strategies related to this topic, a search on the websites of the Indian government, the state of Karnataka and the city of Bengaluru was employed. These governmental sources were also used to obtain statistical data from surveys, censuses, or other data collection methods about urban mobility in Bengaluru, access to transport and demographic and social data. Additionally, grey literature was used to generate an overview of current initiatives and recent developments in the field, specifically focused on the geographical location of this research. Therefore, newspaper articles, initiative websites and social media were searched to complement the scientific dimension and gain up to date information and alternative perspectives.

A central dimension for information collection and gaining insights were expert interviews to add more specific knowledge to the scientific literature review and to answer remaining questions. The interviews were done online and were recorded to be transcribed later. They were conducted in a semi-structured fashion which allows for flexible reaction to new insights and relevant additional information (Verschuren & Doorewaard, 2010). The interviewees included Venugopal from the Institute for Transport Development Policy (ITDP) India, Sobia Rafiq from Sensing local, Sathya Sangkaran from the Centre for Active Mobility (CFAM) and Chris Bruntlett from the Dutch Cycling Embassy (DCE). They were selected based on their expertise regarding NMT but also knowledge on urban mobility in Bengaluru. Their expertise contributed to understand the current situation and to develop potential solutions (see Table 1). Additionally, insights from citizen initiative groups were added to understand processes and issues on the ground, including the Bengaluru Political Action Committee (BPAC), Citizen Matters Bengaluru and Praja RAAG.

Name/Organisation	**Expertise**	**Contribution**
Venugopal, ITDP India	Involved in developing challenges on sustainable transport across the country	Explained how to implement changes, effects of nudges and policy implementation
Sobia Rafiq, Sensing Local	Contributed to recent urban mobility developments in Bengaluru	Helped to understand the potential for change but also the barriers people are facing
Sathya Sangkaran, CFAM	Promoting active mobility in Bengaluru from a citizen's perspective	Critically reflected on current efforts, challenges, and potential solutions
Chris Bruntlett, DCE	Expertise in multimodality, cycling promotion and strategies to improve mobility	Advised on last-mile options, integration of public transit and active modes & inclusivity

Table 1: Selection of stakeholders for expert interviews

In order to understand the current situation and opportunities regarding legislation but also project implementation, a number of policy documents have been analysed. Existing regulations but also drafts from national, state but also city level dealing with urban mobility and including NMT and LMC have been identified. The main points and statements have been extracted to define the potential of future changes regarding urban mobility for Bengaluru.
Lastly, several case studies from comparable cities on their efforts in regard to promoting NMT and last mile solutions were collected. This provided the opportunity to present best practice cases and learnings from cities that have made considerable contributions towards improving their urban mobility system. In line with the purposive sampling strategy, the cities were selected based on their size, geographical distribution and recent activities in the field of sustainable urban mobility and last mile connectivity.
The first part of the data collection, the literature review and statistical data collection from secondary sources as well as the preparation for the expert interviews, was done as desk

research. The second part has been planned to be executed in India but was also done remotely. Interviews with experts were carried out via MS Teams with consent obtained for recording and referencing in this research. For the collection of transport data in India, studies were used that collected data on transport in Bengaluru first hand e.g., through the Bengaluru Political Action Committee (BPAC, 2019), the Institute for Transport and Development Policy (ITDP India, 2020) and Citizen Matters Bengaluru (2020). They were complemented with traffic data from governmental sources and research facilities including the Indian Census (Census India, 2011), Bengaluru Traffic Police (BTP, 2019) and Rocky Mountains Institute India (RMI India, 2020). Existing data on public transport stations and non-motorised transport from reports and surveys was used to get a clearer picture of the current situation at public transport stations and concerning last-mile commute.

After the data collection was finalised, it was analysed based on the sub-research questions in 4 steps (see Figure 2). First, the current situation regarding urban mobility in Bengaluru was set out to draw a full picture of how people commute in the city based on three dimensions:

- modes: which first and last-mile connections to public transport are used?
- user groups: which groups are traveling/need to be considered?
- Inclusivity/barriers: what challenges do people face in accessing these modes?

These categories and questions helped to answer the first two sub-research questions. Secondly, alternative means were identified to get an overview of potential LMC options for commuters including current but also new opportunities. Potential benefits and challenges were identified to later be evaluated in the recommendations. Along with that, polices and best practices were described to reflect on potential learnings in the field of NMT and LMC from other cities. Ultimately, the potential for non-motorised means of transport for covering the last mile was determined based on the findings from the interviews, literature, reports, policies, and insights about Bengaluru. In the end, the research closes with recommendations and potential solutions on how to increase the share of NMT supported through the concept of transition management which will help to create goals and pathways to guide the transition towards more sustainable and inclusive transport (see Figure 2).

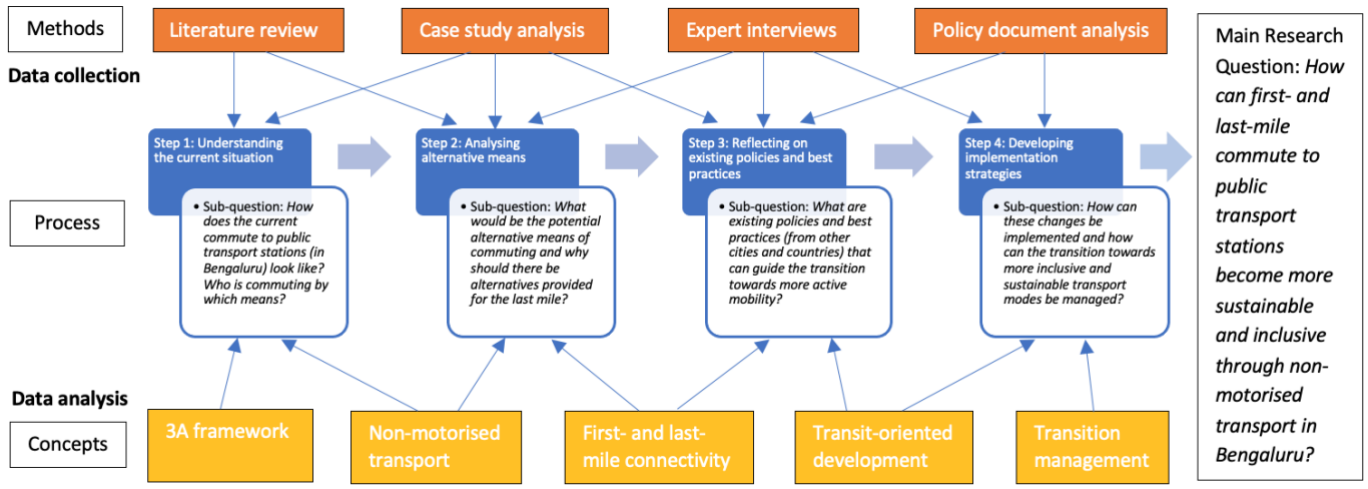

Figure 2: Research design scheme

4. Urban mobility: overview of data, policies, and mode choices

This section will give an overview of the current situation around NMT and LMC in Bengaluru, India and comparable cities by presenting data, mode options, policies and best practice cases to set the scene for the analysis and interpretation. The content is based on secondary data that was collected from literature, databases, reports, and policy documents. It is organised per topic and the structure is oriented along the sub questions. These will be answered in the analysis section and the main research question will be addressed in the conclusion.

4.1 Urban mobility in Bengaluru

"The fastest-growing metropolitan city in the country, Bengaluru, is struggling with the challenges of an overburdened and unsustainable transport network." (BPAC & Uber, 2020). In Bengaluru, the mode share is comprised of 29% on foot and 5% cycling, 23% on scooter or motorcycle, 10% use a car, 28% the bus, 3% autos or taxi and 1% uses the commuter trains (Baindur & Rao, 2016) (see Figure 3). Other data suggests that public transport is 48%, two-wheelers 23%, car/taxi 21%, and auto rickshaws 8% (DULT, 2019). A large share of trips in the city are now done in privately owned vehicles including cars, cabs, and auto-rickshaws. Since 2018, the share of private transport (51%) exceeds the share of public transport (48%) (BPAC, 2019). Bengaluru has one of the lowest shares of public transport compared to other Indian cities like Mumbai or Kolkata which have around 80% (BPAC & Uber, 2020). In the city, 84% of households have a motorised vehicle, 20% own a car, and 60% own at least one scooter or motorbike (DULT, 2019). Private vehicle ownership has been growing by 280% from 2.1 to 8 million between 2007 and 2020 (Y. Jain, 2021). On the other hand, BMTC´s fleet numbers only rose by 7.89% while the city´s population grew by 32% in the same time period (BPAC & Uber, 2020; MoHFW, 2021).

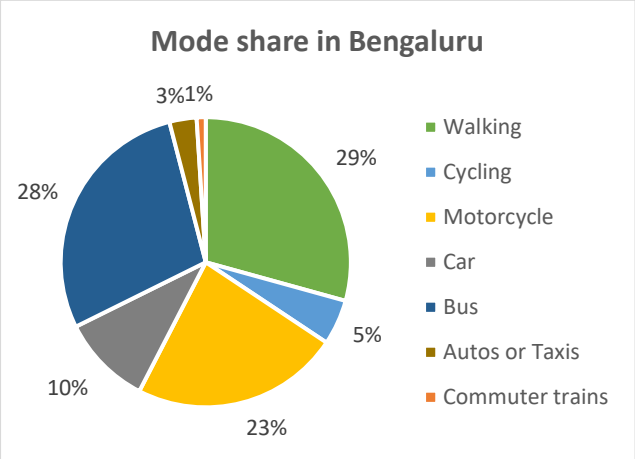

Figure 3: Mode share in Bengaluru, own visualisation based on data from (Baindur & Rao, 2016)

At present, 90% of public transport trips are undertaken by BMTC busses, which is the most dominant mode in the city. Their fleet of 6700 busses carries around 4.5 million commuters every day, however road congestion and a lack of bus priority lanes resulted in lower average speeds and decline in ridership over the last few years (BMRCL, 2019). There are around 180.000 auto-rickshaws and 150.000 taxis in operation in Bengaluru accompanied by an exponential increase of aggregate taxi services (BMRCL, 2019). On a daily average, the city experiences 10 million trips out of which 3-4 million are on BMTC busses, around 400.000 on the metro and less than 200.000 on suburban rail (BPAC & Uber, 2020). A major expansion of the commuter rail network has been agreed on by Indian Railways and the Government of Karnataka with a 160km expansion of the current network (DULT, 2019). In recent years, the

number of suburban rail trips has increased but overall public transport is suffering from underinvestment and inadequate spatial planning (Soman et al., 2019).
The number of car and two-wheeler registrations has increased by 35% and 98% respectively from 2010 to 2018 (MoRTH, 2019). They account for 30% of the trips made but cover 80% of road space (Soman et al., 2019). Traffic at most junctions has already exceeded capacity with major junctions including Central Silk Board, KR Puram or Hebbal, experiencing more than 300.000 vehicles per day (DULT, 2019). The average speed on the city roads is less than 20km/h while in the city centre it is less than 11km/h in peak hours. Trip length averages are 1km for walking, 9.8km for two-wheelers, 10.2km for cars, 13.1km for taxis 12km for busses. For cars and two-wheelers, these distances are expected to rise by 160% while for public transport only marginally by 1km in the coming 20 years (DULT, 2019). The expected mode share in 2031 will shift with a decrease in public transport to 36%, and an increase in two wheelers by 29% and car/taxi to 30% while auto rickshaws might drop to 5%. Based on these assumptions, the CO2 emission are expected to more than double until 2030 (DULT, 2019).
There are two metro lines in the city managed by BMRCL which are now 42km long and were finished in 2016, carrying around 400.000 passengers per day. Another 72km of metro line is being built in the next phase which is under construction and further 55km have been planned (BMRCL, 2019). However, the existing metro network is suffering from a "lack of safe and convenient access to transit stations, last mile connectivity, feeder services, multi-modal integration facilities and common ticketing for seamless mobility of people" (BPAC, 2019). Also, the number of metro riders is lagging behind projections and capabilities with being made for 820.000 passengers per day but currently only carrying around half. A study by WRI found that LMC is a significant hurdle for people to use the metro with 70% of respondents indicating poor connectivity as a major factor (Kanuri et al., 2019).

4.1.1 Non-motorised transport

In Bengaluru 34% of full trips are done by non-motorised modes, with 29% walking and 5% cycling (Baindur & Rao, 2016) (see section 4.1) and the majority of last mile trips to public transit with more than 70% of people walking to the station (BPAC, 2019) (see section 4.1.2). Despite the large share of walking, footpaths are only available on 47% of the roads and are largely in a poor state making it impossible for people with disabilities and older adults to use them (Y. Jain, 2021). In the Comprehensive Mobility Plan (CMP), 548km of footpaths are proposed along a total road length of 14,000km in the city. So far, Bengaluru does not have pedestrian-only streets, but efforts have been made to pedestrianise certain streets with 8 streets being identified in the CMP (DULT, 2019). Nearly half of road deaths in Bengaluru are pedestrians which is the third highest number in India, with 60% of victims crossing the road (Jose et al., 2020). In a study done by WRI, people stated that they would walk more if footpaths were more common (33%), better maintained (28%) and if it was safer to walk (26%) in the city. Other respondents would favour fewer cars, less noise and air pollution but also if peers would walk too and if commuting distances were shorter and the network was better (Sudhakaran et al., 2017).

“Considering the conducive weather and the terrain of Bengaluru, cycling should have been an easy go-to for the citizens of the city. But the lack of cycling infrastructure, the constant pressure to move faster than other vehicles and the risk to life that Bengaluru roads pose has reduced bicycling to a leisurely activity.” (Jose et al., 2020). Based on a study performed by Bengaluru moves, the lack of infrastructure for cycling like cycle lanes or bicycle parking limits the number of potential cyclists and is restricting cycling to become a popular mode of everyday commute (Jose et al., 2020). There have been cycling lanes built for example in Jayanagar, but they often can´t be used by cyclists due to vehicles parking on them. Cycling lanes are barely respected by motorised vehicles which creates a dangerous environment for cyclists (Arora, 2013). There is a lack of enforcement for maintaining cycling lanes being used for their purpose and a lack of integrating cycling into larger transport systems like public transport such as busses and metros (BPAC & Uber, 2020). With no public promotion and incentivising of cycling or a strong cyclist movement, cycling remains a minor mode of transport (Jose et al., 2020). Public bike sharing has been initiated but the providers have added motorised vehicles to their fleet adjusting to the demands of the users and challenges connected to cycling. There are currently 4,000 shared bicycles in the city which are spatially limited to central Bengaluru and the IT corridors with another 550 hubs for shared bicycles that are planned (BDA, 2017). Based on the CMP, there are plans to build 174km of cycling tracks in the next 15 years, but compared to the 14,000km of roads in Bengaluru the share is minor. Also, the requirement is higher, as the proposed numbers will only cater to 2-4% of the actual requirement (Sankaran, 2020). Pop-up cycle lanes have been built on 16km of the outer ring road as of mid 2020 and there are efforts by DULT to identify regularly used routes and recommend them for being transformed into cycle lanes (Jose et al., 2020).

The share of bicycle use in Bengaluru has declined by 86% from 1980 to 2005 (D. Jain & Tiwari, 2013). Based on the WRI study, people would cycle more if more cycle lanes were available on roads in and around where they live (18%), but also the safety concern (14%) was among the main reasons. Other reasons included the availability of cycle parking (9%), fewer cars on roads (8%), but also the commuting distance (10%) as well as the ownership of a bicycle (10%). Cycling of peers, time and shower facilities were not among the main concerns of citizens for using a bicycle (Sudhakaran et al., 2017).

4.1.2 Commuting patterns

Commuting preferences differ between population groups, genders and ages but data on last mile commute in Bengaluru is very limited. A study on first and last-mile connectivity to PTS in Bengaluru conducted by the Bengaluru Political Action Committee (BPAC, 2019) gives an overview of how people in Bengaluru reach public transport stations. The survey was conducted by BPAC in late 2019 (pre-Covid) with 1129 participants. It states that 69% of respondents use public transport and that most users are using more than one mode per trip in combination with BMTC busses, Namma metro, and suburban rail (BPAC, 2019). The majority of commuters travel less than 10 km for work or education and the average time spend was 27 minutes (Soman et al., 2019). For reaching the public transport stations, most

people walk to bridge the first and last mile to public transport. The study revealed that 53% of respondents walk both to the station and to their destination while 18% do not walk at all. The difference between the first and last mile is high as 24% walk from home to the station but only 5% walk from the final station to their destination. Next to walking, 51% cover the first mile on shared mobility such as autos, cabs or shared cabs, 44% use personal mobility such as cars or motorbikes and 5% use rental options (see figure 4).

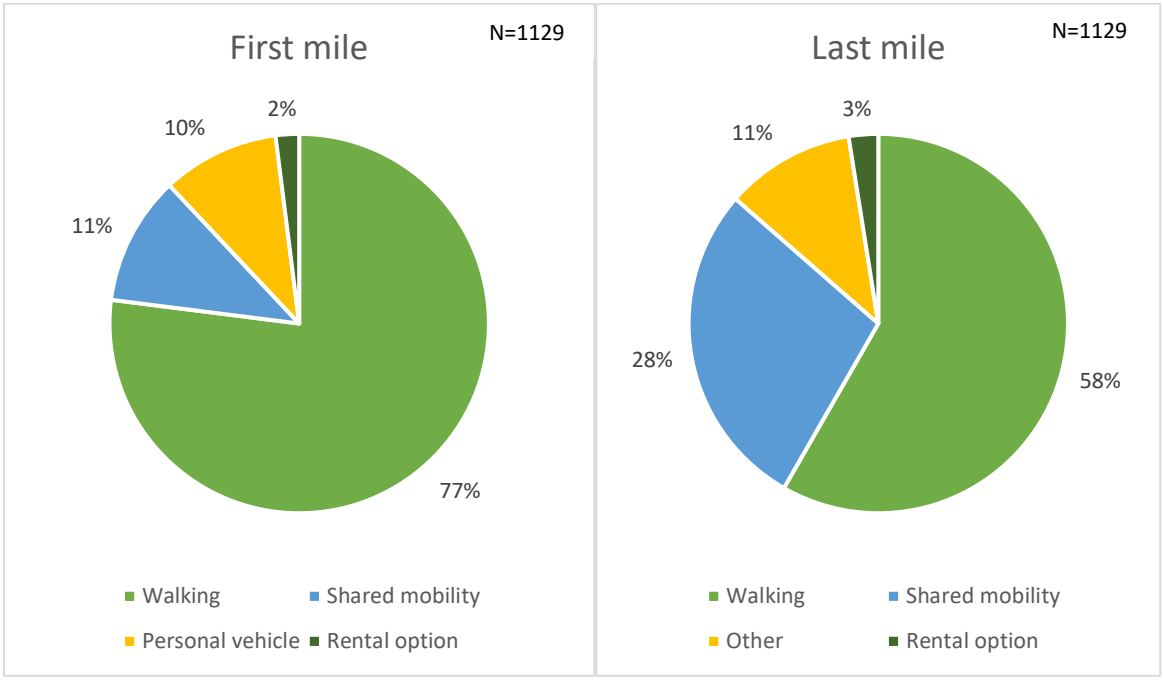

Figure 4: First and last-mile mode use of commuters in Bengaluru; data from (BPAC, 2019)

Differences between the genders have been identified with women preferring shared mobility while men prefer private transport. The share of walking between men and women is similar but walking is considerably lower for last mile commute while rental options are slightly higher. Comparing the first and last mile commute to public transport, shared mobility is used more for the last mile, especially by women. Generally, shared mobility is used more than personal vehicles, except for men on first mile commute (see figure 5).

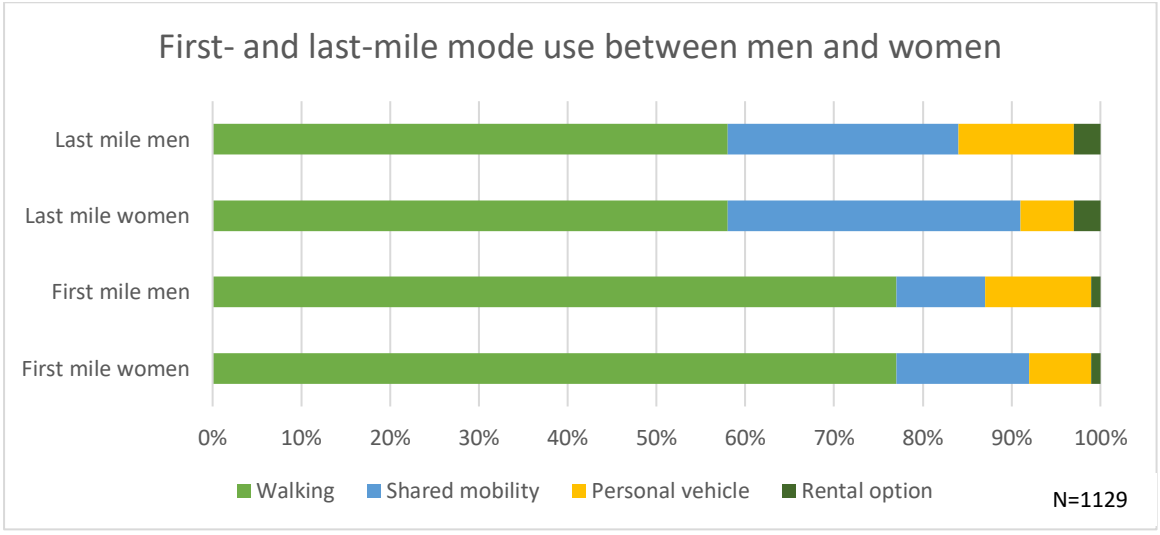

Figure 5: First- and last-mile mode use between men and women in Bengaluru (data from BPAC study 2019)

Looking at people who do not use public transport (31%) the vast majority of 83% uses personal vehicles like motorbikes or cars as an alternative mode of travel. However, 88% of men prefer their own vehicle while only 62% of women responded the same. Other alternative modes of transport for non-users of public transport include shared mobility options (16%) and a marginal share of rental options (1%) (see figure 6).

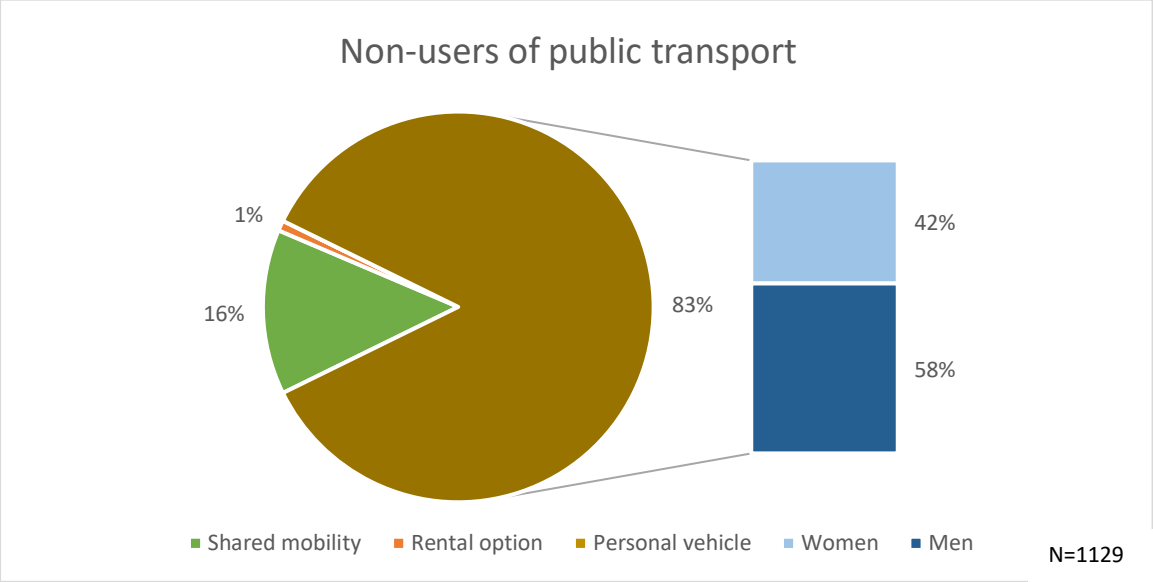

Figure 6: Mobility modes of non-users of public transport in Bengaluru (data from BPAC study 2019)

Reasons for not using public transport include frequency (33%) but also lack of first and last mile connectivity (24%) and accessibility (22%). Convenience was a reason for 19% while affordability of public transport was not an issue (3%) (see figure 7).

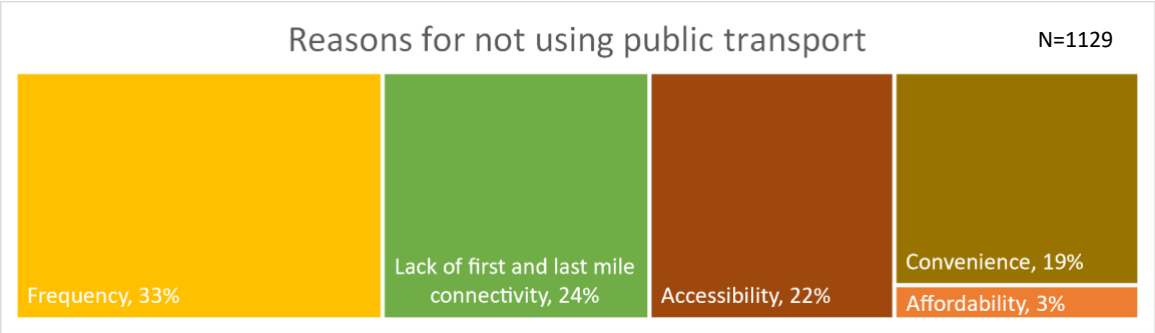

Figure 7: Reasons for not using public transport (data from BPAC study 2019)

The study found that investments into public transport are essential but the ability to reach stations is equally important. A lack of affordable and convenient LMC poses a challenge to commuters and has an impact on the share of public transport compared to other commuting options. The study is not representative since 75% interviewed were men and 85% were employed, however it can give a rough estimation of travel needs of the population in Bengaluru. For further analysis, a study would be necessary that includes more women, but also unemployed, homemakers and students while considering age and the socioeconomic background for generating a more representative picture.

4.1.3 User demographics

"Gender, occupation, and age are highly relevant determinants in distinguishing between the use of different transport modes" (Soman et al., 2019). Mode choice varies between the sexes across India. Women rely more on public transport while men use personal motorbikes more frequently than women. Similarly, men use bicycles twice as much compared to women while women use taxis and shared autos more. Walking has the highest share and is equally often done by both genders (GIZ, 2018). More than half of the employed population walks and uses personal motorbikes, while numbers of public transport users and personal car use are also high. Unemployed and homemakers on the other side are preferring autorickshaws but also walk. Students barely use a car and also few personal motorbikes but rather non-motorised means such as walking and cycling and largely public transport. This is also reflected in the age distribution where younger people use public transport more and barely a car or motorbikes, while older people prefer a personal car or taxis, and the middle-aged generation prefers shared modes (Soman et al., 2019).

Financially, the preference between public and private transport is clear with 90% of respondents stating that public transport was more economical for daily commuting than private vehicles (BPAC & Uber, 2020). Especially poor people are highly dependent on public transport due to the unaffordability of private transport, but often can´t even afford public transport (Arora, 2011). Due to a lack of affordability but also availability, this segment of the urban population has to walk or cycle increasingly long distances, and, consequently, suffer severe pollution (IIHS, 2015). In the end, "the economically weaker sections of the community disproportionally bear the brunt of inefficient public transport" (BPAC & Uber, 2020). This is not just by spending more time and longer distances of traveling to a workplace but also by not having access to potential employment opportunities in the first place due to lack of affordable and efficient transport opportunities. However, public transport in India is usually subsidised with several measures allowing for discounted travel options to make sure low-income groups can use the service and access employment opportunities that are not walkable or cyclable. Still, "as Indian cities continue to spread outward, those residents too poor to afford motorised transport will be increasingly put at a disadvantage, and further cut off from employment, recreational, educational, medical and other activity sites they need to access in the city." (IIHS, 2015).

4.1.4 First and last mile infrastructure

In Bengaluru the connectivity to public transport stations varies across the city, with some areas having metro, bus, or suburban rail connectivity which does not hold for the whole city. The *National Metro Rail Policy of 2017* has stated the need to bridge the first and last mile gap as one of its objectives. Since then, the Ministry of Housing and Urban Affairs (MoHUA), has started focusing on promoting the improvement of services at the metro stations that are sustainable, efficient, and affordable (MoHUA, 2017). Some of the initiatives include feeder busses, electric rickshaws, smart cycles on a rental basis, electric scooter services and a collaboration with cab suppliers to provide last mile connectivity and increase the catchment

area for the metro to at least 5km. A condition in the policy is that the metro must be self-sustaining, connect with other rapid transit systems like busses and provide LMC for commuters to their final destinations (MoHUA, 2017).

Bengaluru´s metro rail corporation, BMRCL has introduced scooter and cycle rental at all metro stations. The feeder bus services however, which were previously operational from metro stations, are currently not running despite a high demand from commuters for this service. It was also announced in 2019 that e-rickshaws would be introduced for last mile commute, but this has not been implemented yet (BPAC & Uber, 2020). A report from WRI highlighted the lack of transport infrastructure to metro and bus stations in Bengaluru, stating that people living further than 5km from a public transport station are unlikely to use public transport (Mani et al., 2012). Additionally, a survey done by Ola Mobility Institute revealed that 70% of citizens in Bengaluru felt that there is a need to improve first and last mile connectivity (OLA Mobility Institute, 2019). The municipal government is planning to install 6,000 shared bicycles with 345 docking stations to promote shared mobility and to improve first and last mile connectivity (BPAC & Uber, 2020).

Concerns of citizens raised regarding first and last mile connectivity, were collected by BPAC in the neighbourhood Malleshwaram (BPAC, 2020). The main points included no connection to metro stations from within the neighbourhood, lack of shared mobility, shared autos, feeder busses and lack of walking and cycling infrastructure in the area. It was mentioned that currently older people rely on private vehicles to get around as they lack alternatives. Additionally, there are no parking spaces for shared mobility at metro stations, BMTC busses only cover the main roads and there is a general lack of integration of public transport in the neighbourhood (BPAC, 2020). Improving first and last mile connectivity will be a challenge considering the existing transport network and diverse demographics. With 42km of metro lines and an insufficient bus network the infrastructure itself but also the connectivity to it needs urgent improvement (BPAC & Uber, 2020).

4.1.5 Recent developments

Most efforts regarding improved NMT and increased intramodality in Bengaluru in recent years have been developed and implemented by the Directorate of Urban Land Transport (DULT). Especially since the outbreak of the Corona pandemic and subsequent lockdowns, several pilots and projects have been developed in the city. Among them was the pedestrianisation of Church Street which was being closed for traffic on weekends, transforming into a popular hangout to walk and cycle for all ages (DULT, 2021b). *Cycle day* is an initiative by DULT together with citizen organisations to promote cycling as a mainstream mode of transport, increase its usage for short to mid commutes and advocating cycling as a preferred mode for last mile connectivity. Several events have been organised in more than 25 neighbourhoods in the city (DULT, 2016). The sustained efforts have encouraged the government to introduce *Open Streets*, an initiative promoting the use of public transport, walking, and cycling by restricting personal motorised vehicles within a given locality. Major roads in the city have been closed thanks to a close collaboration of organisations, institutions

and citizen groups promoting the use of sustainable transport modes. Subsequently, the Smart Cities Mission announced the *Cycles4Change Challenge* in July 2020 to inspire and support Indian cities with the implementation of cycling-friendly initiatives in response to COVID-19. Aiming at connecting citizens and experts to promote cycling, it gave a speedup for the development of NMT infrastructure projects. Several pilots have been developed, funded by DULT, that allowed citizens to participate in the process and promote active mobility (DULT, 2020a). Another pilot project was a *Self-Service Bicycle Repair Kiosk* that was established in Bengaluru (Cities Forum, 2022).

In May 2020, cycle tracks have been added to the Outer Ring Road along a pilot stretch owing to the high number of cycling trips which were collected via the *Cycle to Work* platform created by the Bicycle Major of Bengaluru. With the *#MarkYourCycleRoute* initiative citizens were asked to mark their preferred cycle routes with more than 130 suggestions received by DULT. After analysing the feasibility for cycling tracks, the city announced the stretch to become the country's first pop-up bicycle lane (DULT, 2020a). DULT aims at providing better transport infrastructure in the local areas with neighbourhood improvement plans prioritising NMT users and their safety. Several concrete projects have been implemented or planned and more are in preparation by DULT in consultation with all stakeholders (DULT, 2016).

Together with BMRCL, DULT developed station accessibility plans aiming at creating safe and comfortable movement for people around metro stations. By increasing the use of sustainable and non-motorised modes, the ridership of the metro is ought to be enhanced. Its objective is to "provide safe pedestrian and bicycle access to metro stations and also address safe and easy integration of modes" (DULT, 2016). These safe access plans include proposals for improving the pedestrian and cyclist network around stations but also seamless integration of modes and easy transfers, with the modalities currently being worked out. Concrete schemes have been developed for some stations like KR Market focusing on pedestrian priority and intermodal integration of BMTC busses and metro (DULT, 2020a).

DULT plans to conduct focus group discussions and virtual webinars with cycling clubs, women cyclists, and PBS operators to understand their needs and address them during the pilot and upscaling. Additionally, citizen surveys were conducted to understand the challenges of people to take up cycling and what should be improved. Many initiatives have been established around promoting NMT and plans have been developed, however efforts of bridging the last mile gap to public transit stations though non-motorised modes have not yet been specifically promoted.

4.2 Commuting mode options for the last mile

In Indian cites, as in urban areas around the world, people have different mode options for commuting from origin (e.g. home) to their destination (e.g. work, school, shops, recreation etc.). Based on availability, accessibility and affordability of the service, users from different groups, genders, and backgrounds (have to) make different choices for their (daily) commute depending on safety, reliability, price and existence of the service.

This section gives an overview of the different mode options for people in India to cover the first and last mile to public transit, its benefits, and potential barriers of using them. Although modes can be divided into several groups, some sections are overlapping, so this overview is supposed to give an idea on the different types of LMC options.

4.2.1 Walking

"Almost every city resident is a pedestrian for some distance" (MoUD, 2016). Walking is the most dominant mode of commute in Indian cities with 70% of trips shorter than 1km being made on foot (Census India, 2011). It is the cheapest, easiest, and most common mode of transport being beneficial for road safety, physical activity, mental health, air quality, placemaking and connection to public transport (MoUD, 2016). The majority of people using public transport are walking either to or from the public transit station and even people using cars have to walk to access their car. Walking benefits everyone but well connected and safe infrastructure is lacking in Indian cities. Even though walking is a fundamental and important mode of travel, pedestrians have been largely ignored by urban planners while private vehicles became the dominant mode of travel (DULT, 2014). Resulting from this, challenges for pedestrians include unsafe pavements, traffic, incomplete or missing infrastructure, land use patterns, air pollution and encroachment (DULT, 2014; MoUD, 2016).

There are differences in the way in which different genders perceive walking facilities, where women are discouraged from walking in certain areas, times, or distances due to a perceived insecurity. Similarly, this holds for differences between the ages, as young children and older adults have shorter walking distances and need barrier free movement (Arora, 2011). For older adults who do not drive anymore but also children who cannot drive, sidewalks are a crucial public resource to remain active and to be able to interact with others (DULT, 2014). Footpaths are not only essential to them but also for people who cannot afford other means of transport they remain their only choice for mobility. NMT users can generally be classified into two categories, people walking and cycling out of choice and "captive users" which are people who do not have another choice for their mobility. Indian cities are dominated by captive users however a growing number of choice users are using NMT modes (Arora, 2011). For persons with special needs, non-motorised vehicles (NMVs) including wheelchairs and hand cycles are essential for their mobility and need to be used on sidewalks. However, pedestrian footpaths are rarely barrier-free, so users often have to walk on the main carriageway, getting into conflict with motorised transport (MoUD, 2016).

4.2.2 Cycling

"Cycling provides personal mobility at minimum cost to a large population" (MoUD, 2016) serving as a mean of mobility for short trips between 3-5km. The cycle and its many variants including passenger cycle rickshaws are an important mode of commuting in Indian cities with high ownership rates. Its low cost and easy usage as well as no licence and fuel requirement make it the preferred mode for students and low wage workers, often being the only affordable mean of transport for low-income households. "A cycle is not only a means of transport to access livelihood, it is a means of livelihood by itself" (Arora, 2011). In Indian cities, a large number of cyclists are captive users who are dependent on cycling for their livelihoods. However, lack of dedicated cycling infrastructure leads to high numbers of road accidents and declining numbers of users (TERI, 2018). The bicycle stands in conflict for space with other modes of transport including pedestrians but especially cars and road infrastructure. Surveys show that perceived traffic danger is a major factor for deterring widespread cycling (Hull & O'Holleran, 2014). Cycling tracks have the lowest injury risk given that no parked cars obstruct the way and that the network is designed based on the principles of coherence, directness, attractiveness, safety, and comfort (Dutch Cycling Embassy, 2021). Especially for female riders, safety, parking facilities and ease of travel are the most important factors for choosing a bike as a mode of travel (Arora, 2011).

Bicycles have the potential to support the mobility of all citizens, not only the urban poor, especially by making commute to public transport cheaper and more accessible. Through an integration of bicycles with public transport, the catchment area of public transit stops can be increased by up to 40 times (das Gupta & Puntambekar, 2016). The combination of cycling and public transport can reduce even more CO2 than promoting the modes alone (D. Jain & Tiwari, 2013). Indian cities offer favourable conditions for cycling due to mixed land use and the high proportion of short distance trips with 70% of trips being less than 5km (das Gupta & Puntambekar, 2016). Even though the bicycle is a mode for short trips, when combined with public transport it can provide an alternative to a car for longer trips as well. It is also an environmentally friendly, cheap, efficient mode, enabling a healthier life by reducing the risk for adverse diseases (UNEP, 2016). It leads to improved road safety, improved network connectivity, better air quality and recreational opportunity (MoUD, 2016). Bicycles consume much less public space than most other vehicles, and due to its low purchase and maintenance costs, it is very accessible to vulnerable groups especially elderly and children (UNEP, 2016). Challenges include weather conditions, safety threats, topography, car-oriented planning, detouring, social stigma and air pollution (MoUD, 2016).

4.2.3 Micromobility

"Micromobility refers to small, lightweight devices operating at speeds typically below 25 km/h and is ideal for trips up to 10km" (ITDP, 2022c). This can include human powered or electric bicycles, scooters, cargo bikes, rickshaws, and skateboards which can either be privately owned or can be part of a shared scheme and are characterised by a low speed. Not

included are internal combustion engine powered vehicles like motorbikes or mopeds which often also reach speeds of more than 45km/h (ITDP, 2022c). Micromobility increases the accessibility of public transport and can replace motorised trips for short commute offering a wide range of people the opportunity to be mobile as most people do not own a personal motorised vehicle. Electric devices make micromobility an even more attractive option as they expand the reach and reduce the effort for the rider. “Electric micromobility devices enable mobility for differently abled people and reduce dependency on two wheelers” (ITDP India, 2019). Due to its various forms available, such devices are suitable for a number of people and different user groups including elderly or people with disabilities. With their low investment and maintenance cost, they are available to a large part of the population while simultaneously reducing the need for private motorised vehicles. Being powered by electric motors, which does not cause any direct emissions, these devices have an advantage over two wheelers when it comes to air pollution, noise and the dependency on oil. The biggest challenges to micromobility in Indian cities are poor and incomplete infrastructure along with rapid and uncontrolled urbanisation where roads are often in a bad state, cars parking on sidewalks and the roadside as well as non-existent parking options (Ubiq, 2019).

One form of micromobility is public bike sharing (PBS) which provides shared bicycles at multiple locations around a city with a fleet of human powered or electrically supported bicycles (GIZ, 2021). PBS has the potential to serve as a last-mile as well as an independent mode of transport catering for trips of 2-4km in India. The first public bicycle sharing scheme of the country was launched in 2017 in Mysuru with 14 cities to follow within 3 years and several being in the planning phase (ITDP India, 2020).

4.2.4 Intermediate public transport (IPT)

Intermediate public transport, also called paratransit or feeder service, is serving short and medium distances especially providing first and last mile connectivity by bridging the gap to the public transit network (Ponodath et al., 2018). The means include auto rickshaws, cycle rickshaws, taxis, minibuses, and e-rickshaws mostly as informal transport modes connecting different areas of a city but also busses, railways, and metros. They are an essential part of every Indian urban mobility system for meeting the daily commute needs of people by offering flexibility and convenience. At the same time, they provide income and livelihoods for their drivers and people from poor and lower middle-class sections in society. (Y. Jain, 2021). However, a restricted number of permits is leading to illegally operated vehicles to meet the demand but also the driver´s expenses. The sector remains largely neglected by political decision-making, leading to an unorganised system and a lack of infrastructure for parking at public transport stops (Mani et al., 2012). The traditional sector is at a disadvantage due to competition from modern technology alternatives including app-based services which mostly rely on cars and have stricter regulations. However, some forms of IPT have been integrated into services of mobility providing companies (BPAC & Uber, 2020).

Intermediate transport modes do not only provide first and last mile commute to public transport but can also provide door-to-door connection for people with restricted mobility opportunities (Chidambara, 2021). Their flexibility, boarding and alighting anywhere along the trip, low fuel consumption and ability to pass through smaller streets make them a preferred mode for commuters. Additionally, they are cheap for the users and provide jobs for weaker but also uneducated/unskilled groups of the population (Ponodath et al., 2018).

Cycle rickshaws are one of the most popular modes of IPT in many Indian cities, operated by the lowest economical sections of society. Their popularity results from their low cost and space requirement which makes them ideal for cities with small streets. While they have similar speeds to bicycles, they require more space which would be important to consider for designing cycling paths (D. Jain & Tiwari, 2013). Some Indian cities have banned cycle rickshaws in certain parts of the city due to their low speed and manual labour required for carrying passengers (Y. Jain, 2021). Cycling rickshaws are affordable, reliable, improve tourist economy, network connectivity and public transit access while creating jobs and saving energy. Barriers include weather conditions, safety threats, topography, car-oriented planning, detouring and air pollution (MoUD, 2016). Even though these modes are serving many short trips and work as last mile connectors to public transport, the sector is treated as informal because of their individual ownership structure as well as lack of regulation and enforcement (Mani et al., 2012).

4.2.5 Private/shared motorised vehicles

Personal motorised vehicles, especially cars, are rarely used for last mile commute to public transit stations in Indian cities (MoUD, 2016). Considering that only 8% of Indian families own a car, the relative importance of the car is low compared to the use of motorbikes or scooters and bicycles which are used by 55% of the population (MoHFW, 2021). In 2018, 79% of all vehicles sold in India were two-wheelers including motorised scooters and motorbikes (Ubiq, 2019). However, the numbers of cars and motorised two-wheelers are increasing by 35% and 98% respectively in 2018 compared to 2010 (MoRTH, 2019).

As a last mile commuting mode, shared vehicles have become more popular in recent years, with a number of different concepts. Ride sourcing links drivers to riders who are using their personal vehicle as a commercial vehicle like cabs or autos. Companies like Uber or OLA offer these services but there is a lack of recognition in policies and regulations, therefore no regulatory guidelines for their operation are in place. So-called app-based taxis are provided through digital intermediaries with a cap on prices to prevent them from becoming too high but also too low (BPAC & Uber, 2020). Another form is ride splitting in shared cabs, shared autos or shuttle busses which allow pick up and drop off at different points which are used as a collector mode for last mile access to public transit. They require carriage permits which are only offered to busses in Karnataka offering seat sharing for more efficient and cheaper travel. Ride sharing, also car or van pooling, where passengers join the driver of a private vehicle for the same destination is becoming more popular with increasing traffic. The cost of a trip is

shared not to make profits but to provide additional capacity in the city and to save rides. With carsharing, users have access to a car for a certain time interval, for example app based rental services. In Karnataka, 28 service providers are serving up to 100.000 trips a day (BPAC & Uber, 2020). Shared motorised vehicles can reduce the number of trips made in personal vehicles used alone. However, they also add up to the traffic on the roads, require parking spaces, add to pollution and lead to car centric planning in Indian cities.

4.3 Urban transport policies including NMT and LMC

In order to make cities more liveable and sustainable, a number of polices and visions are in place on a national, state and city level. Transport is a concurrent subject in India, meaning that the central government together with state institutions are framing regulations, collecting taxes, and deciding on fares together (Jain, 2021). This cooperation is stated in the Motor vehicles act from 1988, which was amended in 2012 (IRC, 2012). Even though Master Plans have been created for decades, planning for sustainable urban transport only started with the National Urban Transport Policy (NUTP) in 2006 (Vaidyanathan and Rathi, 2018).
This section reflects on the major policies around NMT and LMC in India, Karnataka and Bengaluru resulting from the policy document analysis.

4.3.1 India – national level

Prior to the launch of the National Urban Renewal Mission in 2005 and the National Urban Transport policy in 2006, planning for urban transport in India has largely been conducted in an uncoordinated manner. In order to meet the needs of current and future urban populations, a paradigm shift was necessary putting people first and shifting the planning of cities and neighbourhoods away from the dependence on private vehicles towards good public transportation and NMT.

National Urban Transport Policy (NUTP)

One of the first and most relevant polices on promoting sustainable urban transport was the *National Urban Transport Policy* (NUTP) issued by the Ministry of Urban Development (MoUD), Government of India in 2006 to improve urban transport services and infrastructure, focusing on moving people rather than vehicles (MoUD, 2014). The policy set the scene by recognising that “people occupy centre-stage in our cities and all plans would be for their common benefit and well-being” (MoUD, 2014). Its vision was to make Indian cities the most liveable in the world and for them to become engines of India´s power in the 21st century. It stressed that cities should evolve in a way that is best suited for their geography and to support social and economic activities while growing on a low carbon path. Mobility shall be accessible to all citizens to reach their jobs, education, social services, and recreation in an affordable and reasonable manner. Mainly, this shall be achieved through more equitable

allocation of road space for people rather than vehicles to promote city-wide public transport as well as making walking and cycling a safe mode for urban transport. It introduced the 'avoid, shift and improve' approach aiming at avoiding higher travel demand, shifting away from personal motorised vehicles and improving infrastructures and cleaner technologies (MoUD, 2014).

There was a need from the national government for a centralised policy as several agencies are involved in transport planning, creating a number of different acts, rules and programmes next to each other which were ought to be brought together in a state level action plan. In order to realise these policy objectives, a comprehensive approach was developed including urban transport planning, infrastructure design, public transport, NMT, traffic management, financing, governance and capacity building. A central dimension was the integrated land use planning and transport planning, covering a Comprehensive Mobility Plan (CMP), a modal mix, and Transit Oriented Development (TOD). The planning also included equitable allocation of road space and universal accessibility to transport in a multi-modal mobility network. Regarding first and last mile connectivity, the policy states that footpaths and cycle lanes shall be within 500m of stations, feeder services should be covering 5km around stations, drop off and park and ride facilities at stations, and land use should be controlled to avoid congestion. The design principles to improve access of pedestrians to public transport system should include safety, accessibility, reliability, and affordability (MoUD, 2014).

Non-motorised transport is mentioned as an integral part of urban mobility especially for the urban poor but also as a green mode of transport not consuming energy or causing pollution, while providing social equity and providing employment. However, the safety issues for walking and cycling shall be addressed by creating segregated paths for different speeds which shall be designed with experts and the community. The policy also acknowledges the relevance of cycle rickshaws as a public mode for LMC in an integrated citywide multimodal public transport network which has not received much attention from planners so far. Cycle rickshaws shall form an integral part of urban transport and be provided with the necessary infrastructure such as waiting areas. To promote NMT, the government of India wants to give priority to the construction of pedestrian facilities and cycle tracks in all cities to enhance safety to increase the use of NMT. Facilities should be provided city wide and as part of public transit projects where funds should be used to achieve these targets. A separate budget head in the municipalities for planning and implementation is recommended and the possibilities of setting up a bicycle sharing program is encouraged. "The government of India would support the construction of safe pedestrian crossings at busy intersections and high-density traffic corridors, formulations and implementation of specific area plans in congested urban areas that propose appropriate mix of various modes of transport including exclusive zones for NMT and upgrade cycle rickshaws" (MoUD, 2014).

NMT guidelines

For implementing the goals of expanding infrastructures for NMT modes, the *NMT guidance document* (MoUD, 2016) was set up by MoUD and is focusing on TOD, NMT and public bike

sharing (PBS) schemes. Its objective is to apply the NUTP principles for achieving a paradigm shift towards a more sustainable urban transport system. By assisting various government organisations, public authorities and development professionals, sustainable urban transport principles can be integrated into the diverse urban contexts. The document refers to successes and failures of applying NMT globally and in Indian cities and building on these lessons learned from these experiences. It sets out a systematic process for planning and preparation through an implementation manual with checklists rather than defining technical standards or specifications and needs to be adapted based on local conditions by local authorities. By providing a step-by-step planning process, it can be applied to Indian cities serving as a "handbook of ideas and strategies for promoting NMT as the foundation for creating sustainable cities in India" (MoUD, 2016).

The NMT guidance document serves as a compendium of strategies and recommendations for shaping NMT-friendly streets through a five-step planning process for local authorities and for implementing TOD projects. By first addressing the current state and challenges of investing into pedestrian and cycling infrastructure, this document assists cities and transit agencies to assemble the necessary resources and implement a sustainable mobility concept. The NMT guidelines have been translated into the state contexts and for Karnataka the *Guidelines for Planning and Implementation of Pedestrian Infrastructure* (DULT, 2014) have been written by local authorities to emphasize safe and convenient pedestrian facilities to promote walking for people of all ages. Another policy to improve walkability was set up by the Smart Cities Mission, Ministry of Housing and Urban Affairs, Government of India to develop pedestrianised areas called *Marketplaces* (MoHUA, 2020) in cities with more than one million inhabitants.

National Transit Oriented Development (TOD) Policy

In response to rapid urbanisation and urban sprawl in Indian cities, which led to longer trip lengths, higher use of private vehicles and thus pollution, the Ministry of Housing and Urban Affairs of the Government of India (MoHUA) has developed a TOD policy to integrate land use with urban transport infrastructure, making cities liveable, healthy, and smart (MoHUA, 2016). Managing urban spaces is the responsibility of state governments, however the national policy shall serve as a guideline for formulating city level policies, promoting and implementing TOD. The vision of this policy is to enable the transformation from private vehicle dependency to public TOD, promoting the usage of public transport by making it more accessible, promoting green mobility by encouraging people to walk and cycle and curb the negative impacts of motorisation and to create liveable and affordable communities that are compact and walkable (MoHUA, 2016). TOD develops urban centres with an influence zone of 500-800m around public transport stations to increase the use of public transport by enabling residents and workers to walk or cycle for their daily needs and commute. Through a dense road network within the development area, safe and easy movement and connectivity to transit stations via NMT shall lead to a reduction of private vehicle ownership and traffic/parking demand. "The influence area should have high quality integrated

multimodal transport system for the optimum use of the facilities by the residents/users. The system should have seamless physical connectivity, information integration and fare integration across modes so that the first and last mile connectivity does not become a bottleneck in the use of public transit systems by the citizens." (MoHUA, 2016). Facilities should be barrier free and prioritise pedestrians and bicycles including sufficient bicycle parking spaces with expansion potential but also feeder busses, drop-off facilities and P&R spaces. NMT, IPT and feeder busses play an essential role in providing LMC and must therefore be well integrated and stations areas must be kept congestion free. "The streets should be designed for users of all age groups and for all types of commuters including pedestrians, bicyclists, motorists and transit riders. They should be safe and accessible by all." (MoHUA, 2016). Within the development zone, streets shall be designed around small blocks providing for pedestrians, cyclists and other NMT users to ensure accessibility of the transit station. Footpaths must be continuous, unobstructed and of suitable width on both sides of the street protected from parking and encroachment through buffers or bollards. They must allow universal accessibility for people with reduced mobility including visually and hearing-impaired persons. Car speed should be reduced to create a safe and secure environment for pedestrians and NMT users, designed for movement of people rather than vehicles.

4.3.2 Karnataka – state level

For the state of Karnataka, the Directorate for Urban Land Transport (DULT) is responsible for promoting sustainable mobility including NMT in cities across Karnataka. They provide technical guidance, funding and institutional frameworks to initiate sustainable mobility projects across the state. Among them are cycling tracks along the Outer Ring Road, bicycle sharing schemes, pedestrianisations of roads and a cycle day (DULT, 2020a).

In 2019, DULT formed the Karnataka Non-Motorised Transport Authority (KNMTA) for monitoring and financing NMT in Karnataka. Responsibilities include creating safe bicycle and pedestrian transportation networks in the cities, bicycle sharing projects, temporarily transforming roads into free spaces and supporting cycling and other local communities (Jain, 2021).

Active mobility bill Karnataka (Draft)

The *Active Mobility Bill* for the state of Karnataka is the first of its kind in India and was published by the Directorate of Urban Land Transport in 2021 (DULT, 2021a). It is "a bill to protect the rights of pedestrians and cyclists to safe, accessible, and connected pedestrian and cycling networks in urban areas in the State, with a view to promote sustainable urban mobility and build healthy communities" (DULT, 2021a). Resulting from rapid urbanisation, a rising number of private vehicles was causing congestion, pollution, road fatalities while on the other hand "a large section of people of all ages and abilities walk or cycle to commute or for accessing public transport" (DULT, 2021a). Acknowledging that walking and cycling do not only improve personal health but also social wellbeing, it also ensures equity for people from

all income groups. With the current legal framework not covering specific provisions for protecting NMT users, the most vulnerable road users, there is a need for equitable allocation of space and safe accessible infrastructure. This bill shall facilitate the transition to sustainable urban areas with public spaces being designed based on the needs and requirements of all road users in the whole state of Karnataka.

The act defines active mobility as movement or transport by physical activity but including motorised wheelchairs and pedal assisted electric bicycles. Users are described as pedestrians and cyclists, while specifically mentioning persons with disabilities. Moreover, the bill outlines transportation means, covering bicycles, e-bicycles, micro-mobility vehicles, and other supportive devices as well as infrastructures, including cycle tracks, footpaths, shared paths, and slow streets. It also covers public bike sharing and shared micro-mobility and defines traffic calming and management. There is a focus on LMC as well as TOD in connection with public transport systems.

Based on this bill a *Comprehensive Mobility Plan* shall be developed by urban local bodies and incorporated in the *Master Plan* for the local planning area for "enhancing the use of walking and cycling as preferred modes for short trips, and also as first and last mile connectivity to public transport." (DULT, 2021a). The vision is to create complete and connected streets with footpaths and segregated cycle tracks or shared paths and to follow a people-centric design of urban streets. It is therefore necessary to identify and complete missing links to close connectivity gaps and improve access. When redeveloping and building new streets, local authorities have to ensure that footpaths and cycle or shared paths are mandatorily provided in new or existing layouts and that they are connected to the wider network in the area to form a complete and well-connected network. Around transit stations pedestrian and cycling networks are to be designed based on the TOD plans. The document defines the development of footpaths including accessibility by all users, safe and connected access to public transit stations for last-mile connectivity as well as the design of cycle tracks forming a network, cycle stands and public bike sharing hubs for improved connection to public transit. Additionally, the relevance of safe crossings and intersections is mentioned and the design of pedestrianised zones and slow streets. Audits and inspections are planned in to ensure safety and maintenance including removal of obstructions.

Regarding first and last mile connectivity, it is stated that bus infrastructure must be integrated into the NMT network and that active and sustainable modes for LMC shall be promoted. This includes the facilitation of public bike sharing and micro mobility systems at multi-modal hubs and along the street network to encourage NMT for LMC. Another important section covers the rights and responsibilities of pedestrians and cyclists including right to safe passage, right of way and agreements on intersections as well as the responsibilities of motor vehicle drivers towards NMT users and the prohibition of using or blocking NMT infrastructures. Based on this, the section on education, awareness and enforcement states the encouragement of right behaviour on the respective paths, including teaching the code of conduct in schools, communication and outreach as well as voluntary active mobility wardens in the neighbourhood. Enforcement shall be executed through traffic

management agencies, regular inspections, and use of technology. Funding for the construction, operation and maintenance of footpaths, cycle tracks and shared paths shall have priority in the allocation of funds from authorities to assure high quality networks (DULT, 2021a).

4.3.3 Bengaluru – city level

„The city's urban planning has only slowly developed over the years" (Jain, 2021). Current planning for urban infrastructures is based on the Master Plan 2015 which was developed in 2007. The following Master Plan for 2022 was scrapped after it received objections from citizens and is now being updated (Jain, 2021). In Bengaluru, transport planning has been centred around road infrastructure through the predict and provide model in which future car demand was predicted and created accordingly. In the Master Plan 2015 mostly road projects have been proposed including elevated roads and ring roads. The next Master Plan will focus more on transit-oriented developments such as the Bus Rapid Transport (BRT) system, the metro and suburban railway (BDA, 2017). Parking has been free in most of the city until recently, which has been described as being problematic by residents and authorities as it adds to the congestion. The new parking policy is moving towards organised paid parking, slowly creating a mindset shift (DULT, 2019). In the last ten years, investments into busses have been 5-6 billion rupees, while 85 billion have been invested into roadways and 264 billion rupees shall be devoted to the expansion of the metro system (Jain, 2021).

Transport planning in Bengaluru is fragmented and divided across different decision centres (Vaidyanathan & Rathi, 2018). On the state level, DULT is responsible for urban transport, while BMLTA is deciding on the type of investments for transport projects in Bengaluru and is creating visions for the city. BDA, BMTC and BMRCL are executing the land-use planning, maintenance and provision of services as well as the construction of new infrastructure. In the end, multiple agencies and institutions from governmental bodies of all levels of decision-making are involved in the process and create their own laws, acts and bills.

Revised Master Plan for Bengaluru 2031 (Draft)

Bengaluru Development Authority (BDA) is developing a Master Plan for the city that is revised every ten years. The most recent one has been published in 2017 but it has been withdrawn after receiving 14.000 objections from the public. It is being updated based on public suggestions and a revised Master plan is being developed together with experts.

One guiding principle in the current version of the plan for Bengaluru is comprehensive and streamlined mobility (BDA, 2017). BDA has identified a number of challenges in regard to transport due to the fast growth of the city in recent years. Firstly, extreme congestion due to overdependence on private vehicles, restricts bus operations significantly which leads to the share of public transport dropping further. Facilities for NMT are inadequate with respect to the provision of footpaths and cycling facilities while the high car dependency added to increasing levels of air and noise pollution. In a forecast scenario for 2031 BDA estimated that

vehicular trips will increase more than three times and the network will be severely congested. There will be a substantial reduction of public transport share with a reduction of bus frequency to less than half despite doubling the fleet size. Almost all roads would be operating over capacity and speed on roads would drop to 8km/h and less than 5km/h in peak hours and pollution levels would increase threefold. The scenario terminates with: “Doing nothing but believing that the Metro phase-II will solve Bengaluru’s problem is not a solution.” (BDA, 2017).

Their approach is an integration of land use with transport network planning to enhance public transport use significantly. For this, intermodal hubs shall be developed along mass transit corridors creating improved LMC to the mobility stations. The goal is to build mass transit stations within three to four km of any part in the city, equipped with last mile connectivity solutions and road networks to be equipped with proper footpaths and segregated cycle tracks. Small bus terminals shall be set up to create a feeder system to PTS through electric vehicles. Lastly, multi utility zones with IPT stands at mass transit stations shall enable efficient LMC and be equipped with bicycle docking stations “Given that all major roads will compulsorily have a cycle track dedicated, it should be easy to put in place a Public Bicycle Sharing System to help improve end mile connectivity“ (BDA, 2017).

BDA is seeking to address the concerns of all commuters by emphasizing public transport and non-motorised modes of travel in line with the NUTP. The goal is to provide for 70% of trips done by public transport through investment into infrastructure, including a commuter rail system. Following a street design with intrinsic provision of pedestrian and cyclist facilities, the document states: “Consider that the Pedestrian is also a road user – provide comfortable/safe facilities for pedestrians. Re-establish the role of bicycles in Bangalore and encourage/provide for them.“ (BDA, 2017). And finally, to develop 20-25% of the city area based on TOD.

Comprehensive Mobility Plan (CMP) for Bengaluru (Draft)

In late 2019 BMRCL and DULT published a draft of the Comprehensive Mobility Plan (CMP) for Bengaluru to create a vision and strategy for an “efficient and sustainable transport system for all” (DULT, 2019) by building a “multi-modal transport system for equitable mobility access and minimized negative externalities” (DULT, 2019). The main goals include increasing the mode share of public transport to 70% and regaining road infrastructure as a public space as well as reducing emissions from the transport sector. In order to reach these goals, a strategic framework has been developed with a number of strategies and implementation options. The first two strategies discuss the expansion and improvement of public transport while the third one is about the promotion of multimodal mobility options, stating that the increase in personal vehicle use and ownership must be restricted by building a multi-modal transport system with seamless integration. For this, investments into public transport and NMT networks that go beyond road infrastructure are needed. Strategy 4 promotes TOD including the redevelopment of existing areas around transit stations into mixed-use dense and walkable layouts. The next two strategies include the improvement of the road network and

widening of streets, reflecting on the inefficient use of road space through suggesting to prioritise public transport vehicles, pedestrians, and cyclists for equitable allocation of road space. In strategy 7, commuters shall bear the full cost of externalities of mobility modes of low-occupancy transport modes which contribute to congestion and pollution in the city. As the use of inefficient transport modes is not regulated, the costs of the resulting negative externalities are allocated disproportionally onto commuters. A new approach is needed based on fairness and polluter-pays principles to mitigate their impacts and promote more efficient modes.

In the remaining three strategies, fiscal and organisational approaches are addressed (DULT, 2019). Based on the strategies, three options have been defined which include selected approaches and create forecasts for the modal share. Option 3 includes all strategies and envisions future developments and redevelopments guided by TOD, discouraging the use of private vehicles, and regaining road infrastructure as public places. For this, the public transport system needs to be improved and expanded as well as the multi-modal integration. In regard to NMT, 548km of footpaths, 174km of cycle tracks and 103km of Tender Sure Roads have been proposed to be constructed until 2035. Additionally, eight streets are ought to be turned into pedestrian-only streets on weekends and a public bicycle sharing scheme with 550 hubs has been suggested. For intermodal improvement, 30 interchange hubs have been proposed on public transport corridors and ten elevated walkways between public transport stations (DULT, 2019).

Bengaluru Transit Oriented Development Policy

In light of an unsustainable transport system, BMRCL set up a TOD policy in 2019 in order to create a paradigm shift in urban and transport planning (BMRCL, 2019). By promoting compact development and energy/space efficient travel modes, sustainable mobility with optimum utilisation of public investments can be achieved. This shall be realised through TOD, focusing on land-use/transport integration and the promotion of sustainable modes. The policy drafts a vision of Bengaluru becoming a “public transport oriented city that is compact, people friendly, environment friendly and supports economic growth while offering a good quality of life.” (BMRCL, 2019). Bengaluru shall have a ‘world class’ mass transit network and walking and cycling shall become the preferred modes for short and access trips with a combined modal share of 80% (DULT, 2019).

The TOD policy is divided into six components: density, diversity, design, destination accessibility, distance to transit and demand management, which are important to achieve TOD. It shall promote compact development and support walking, cycling and public transport while reducing the use and trip length of private vehicles. Thereby, it lowers the infrastructure costs, curbs urban sprawl, saves energy, enhances convenience, improves quality of life and health as well as reduces emissions by promoting walking and cycling. The goals of the policy are in line with the Master Plan 2031, being 70% share of public transport in motorised trips and 60% of population living in TOD zones by 2031. This will require 600km of mass transit corridors and a development of adequate infrastructure to increase the population density to

250-400 persons per hectare along mass transit corridors. By developing high density centres around public transport stations with mixed land use and walking distances to the hub of five to ten minutes, well integrated pedestrian, bicycle, feeder, and transit networks with mass transit systems, accessible by foot or NMT, the policy is aiming at creating inclusive, accessible, equitable and sustainable transportation for Bengaluru (BMRCL, 2019).

4.4 South-South comparison: Case studies from other cities on NMT and LMC

Next to Bengaluru, several other cities have made considerable contributions to promoting NMT with their policies and will be used as best practice cases which can help as comparisons in the analysis. Therefore, 4 cities have been selected that are comparable in size, having 11-12 million inhabitants, which is equal to Bengaluru: Chennai, Jakarta, and Bogota (World Population Review, 2022b). The selection has also been based on their location to gain a fair spatial representation: one other Indian city, one other Asian city and one other city in the Global South.

4.4.1 Chennai

Chennai was the first city in India that adopted an NMT policy in 2014. It aimed at overcoming the decline in walking and cycling by creating safe and complete footpaths and cycle tracks as well as NMT facilities. The NMT policy in Chennai mandates that at least 60% of the transport budget must be invested to maintain and construct NMT infrastructure (Corporation of Chennai, 2014). Emphasis is put on high-quality footpaths, pedestrian zones, and multimodal street design. Over the last five years, 100km of safe and continuous footpaths were created along streets catering for the needs of pedestrians and especially vulnerable road users such as women, children, elderly, and persons with disabilities (Jose et al., 2020).

The vision of the NMT policy states that: “Chennai will be a city with a general sense of well-being through the development of quality and dignified environment where people are encouraged to walk and cycle; equitable allocation of public space and infrastructure; and access to opportunities and mobility for all residents.“ (Corporation of Chennai, 2014). The Corporation of Chennai aims at increasing the use of cycling and walking by building safe and accessible footpaths, cycle tracks and greenways, to serve all citizens in the city. Based on best practices and consistent design, pedestrian-oriented and multi modal street design will be prioritised and integrated into environmental and urban planning. A focus of the policy is on improving access to mobility for all residents and socio-economic empowerment through providing low-cost mobility. Also gender equity with a focus on safety for women and social inclusion regardless their age, ability and status are incorporated in the goals. An essential dimension is a change in culture of using bicycles and walking as a regular mean of transport and a mean to reduce the environmental impact of transport. For further acceptance, participation of local residents, businesses and stakeholders is aiming at fostering more active use and ownership of the public space (Corporation of Chennai, 2014).

In order to reach these goals, COC is leading the paradigm shift from current urban planning towards focusing on NMT and public transport through prioritising these modes, training engineers and administrators, incentivising their own employees to walk and cycle and encouraging other institution to adopt this behaviour. A priority scheme for different modes will be followed and a street design that does not discriminate any user, allows for safety, convenience, inclusivity, and quality to create open and attractive public spaces with fewer traffic is strived. COC has set out clear goals to be reached until 2018, namely: increasing the mode share of NMT to 40%, establishing footpaths on 80% of streets as well as unobstructed, segregated, and continuous cycle tracks of 2m width, and zero fatalities of NMT users (Corporation of Chennai, 2014). There is no study yet analysing the impact of the policy yet, however it has helped to improve the situation considerably and provided the city a guideline including a vision with goals to be reached (Interview Venugopal, 2022). As a result of the successful policies and infrastructure projects, the Chennai model has been expanded across the state of Tamil Nadu into ten cities including Coimbatore and Madurai (Jose et al., 2020).

4.4.2 Jakarta

Since 2017 Jakarta has started to prioritise pedestrians, cyclists, and transit users within the transport hierarchy. The city shifted from being car-centric to transit oriented by prioritising mass transit and active mobility over private motorised vehicles (ITDP Indonesia, 2021b). With the impact of Covid-19, Jakarta aims at rethinking and redesigning urban mobility by building integrated stations and protected bike lanes. Transforming pop-up bike lanes into permanent structures and creating intermodal integration of modes, the city aims to lower emissions and improve connectivity (ITDP Indonesia, 2021a). The government is promoting active last-mile mobility and prioritises NMT and public transit in connection with a strong public transport system of busses (Transjakarta) and commuter trains (Sutanudjaja, 2022). After the pandemic, the city experienced a 340% increase of cycling and provided new NMT infrastructure in response to the growing numbers of users and a bike sharing program was set up with integrated shared mobility services (ITDP Indonesia, 2021b).

The Jakarta city government has developed a NMT strategy to improve walking and cycling conditions but also to increase accessibility to public transport. It was created in collaboration with key agencies to align roles and funding streams. Clear responsibilities were given for managing the pedestrian and cycling improvement projects, while workshops and collaborative initiatives helped with the public support (ITDP Indonesia, 2022). The main outcomes of the strategy are improving pedestrian infrastructure, creating better connectivity at transit stations and setting up shared streets as well as cycling infrastructure and bike sharing schemes. This has been piloted as a public-private venture with 63 parking locations that will be expanded to another 96 locations, especially located near public transit stations (ITDP Indonesia, 2021b).

In the last three years, pedestrian facilities have been improved by expanding sidewalks and creating pedestrian crossings at grade particularly focusing on areas around transit stations.

Together with placemaking initiatives, the infrastructures have been made into new spaces for cultural, social, and economic activity. Multiple stakeholders collaborated to improve pedestrian safety with interventions focusing on areas around transit stations but also residential neighbourhoods with school children (ITDP Indonesia, 2021b). Together with mobility operators, local government, public works agencies, NGOs and local residents, initiatives were developed including school safety zones, improved pedestrian crossings and wayfinding to navigate in and around public transit stops (ITDP Indonesia, 2021a).

For implementing the NMT strategy and increasing cycling rates in the city, a multi-stakeholder workshop was held that developed an action plan prioritising safe cycling infrastructure, parking facilities and bike sharing. The city piloted 63 km of pop-up cycle lanes and is aiming for 500km of cycling network until 2030. It will be connecting local and regional transport options and mandates transport corporations to build cycle parking facilities at all stations (ITDP Indonesia, 2021a). The existing network has been considered a success, though it remains unclear whether it can withstand interests of car-oriented politicians and groups (Sutanudjaja, 2022). Civil society groups were heavily involved in advocating for a more sustainable and inclusive mobility system in the city. However, there is no set mechanism for developing a collective vision of the cities transport development (Sutanudjaja, 2022). The design and vision guideline developed by ITDP for the city government will help planning authorities in creating new infrastructures and archiving the goals of the city of forming a human mobility network in Jakarta (ITDP Indonesia, 2022).

4.4.3 Bogota

“In recent years Bogotá has experienced a profound transformation towards non-motorized transport (NMT) in its infrastructure planning and policies“ (ICLEI, 2013). In the past two decades, the city has undergone a complete transformation of its public spaces and transport infrastructures, including redevelopment of destroyed or inexistent sidewalks, the creation of parks and open spaces from dusty areas as well as a 350km cycling network across the city (ITDP, 2022a). In the 1990s, new city regulations led to the development of cycle paths and improvement of pedestrian infrastructure. Through the creation of a Land Use Plan, Mobility Master Plan and Public Space Master Plan, the city defined clear goals and policies were prepared, steps of implementation defined, financial requirements set out and indicators for measuring the performance of the operation were created (Cervero et al., 2009). Additionally, a Bike Path Master plan was set up, which was executed by first identifying the current mode uses and the potential of bike use as an alternative mean of transport including its complementarity with existing public transport systems. The identified network was then integrated into the urban plans and after a feasibility study, the most effective network was set up which was designed in a grid covering the whole city (ICLEI, 2013).

The transformation of public spaces and transport infrastructures required a process of feasibility studies, design manuals and construction projects. Aiming at high-quality urban design that offer street furniture, bike parking and landscaping among others, the execution

of public works covered issues of land management, environmental, social, network utilities and technical components. For the upkeep of the network and a smooth operation, public funds were necessary on a regular basis. This was realised through a community service scheme where local residents and vulnerable population groups help to maintain the system though social work (ICLEI, 2013). In response to Covid 19, emergency bike lanes of 84 km have been added, of which many have been made permanent and 45,000 km^2 of road space have been transformed into pedestrian spaces (ITDP, 2022b).

Lessons learned from Bogota include that political will and clear commitments are essential to promote NMT, institutions must collaborate effectively, and regulations and policies need to enhance the potential of NMT. Also, infrastructure is crucial for increased use of bicycles especially by children and women, citizens must be involved in the development process, advocacy is very useful particularly concerning the use of bicycles and lastly, maintenance is often ignored in infrastructure development but fundamental for a successful NMT network (ICLEI, 2013). In addition, various transport projects directed towards public transport like the TransMilenio bus rapid transit system or the improvement of the existing bus fleet with electric busses were integrated into the NMT network of the city (ITDP, 2022b).

The urban renewal campaign and investments into sustainable mobility increased the public´s confidence in its public entities due to covering the transport needs of the majority of people and Bogota is now recognised for its accessible and sustainable transport network. With an ambitious advertising campaign, institutional presence and support, the numbers of NMT increased while they have also provided time and financial savings, increased civic involvement and an overall improvement of the transport infrastructure as well as awareness about individual health and environmental issues. Various stakeholders have been involved in the process which has strengthened the efforts made. Also, political barriers were broken down to allow projects to be continued beyond politicians´ terms on office (Cervero et al., 2009). New projects have been coming up including traffic calming measures, programs for students commuting on foot to school safely, and a bike sharing system with 1,500 bikes connecting with public transport that will start in 2022. It will grant a 20% discount for people from lower income groups and provide bike repair shops free of charge for all users, thereby creating an inclusive system providing sustainable mobility to all citizens regardless of gender, ability, and economic status (ITDP, 2022a).

For comparable cities interested in similar projects, Bogota provides an example of how the transformation of its urban mobility system through improved infrastructure, policies and promotion strategies lead to an adoption of existing regulations to promote NMT: „The model used for work done in terms of urban planning in Bogotá, such as the Bike Path Master Plan can be replicated in cities with similar socio-economic characteristics: it can be realized with low budgets especially when compared with other heavy infrastructure projects.“ (ICLEI, 2013).

5. Results and Analysis

5.1 Status quo regarding NMT and LMC in Bengaluru

Bengaluru, like many other Indian cities, experienced a steep increase in motorised transport in recent years, leading to a neglect of non-motorised modes such as walking and cycling. More road space has been taken up by a growing number of motorised vehicles while non-motorised options were granted correspondingly lesser space and facilities. At the same time, the public transport system has not kept up with the increasing demand due to the city´s population growth and urban sprawl resulting in a highly inefficient, inadequate, and unsustainable transport system (BPAC & Uber, 2020). The declining share of public transport and non-motorised modes can be explained with low investments but also the sheer neglect of pedestrians, cyclists, and public transport users in the planning process (Chidambara, 2021). Even though large investments have been made into road and rail network expansion, the problems of congestion, pollution, road fatalities and overburdened infrastructure were not solved. Instead, the vehicle ownership rates have increased ten times the population growth, attributing to the aspirations of a growing middle class but also revealing a lack of accessible and reliable public transport options (DULT, 2014).

A key factor is the lack of integrated and reliable first- and last-mile connectivity especially to the metro rail system and the commuter rail network but also to bus stops. Convenient and economical first and last mile connectivity is a neglected theme with most transit infrastructure interventions stopping at major transit hubs not addressing the connectivity to stations (BPAC & Uber, 2020). Together with a lack of adequate NMT infrastructure, the dependency on motorised means for LMC increases. However, commuters see it as an integral component of rapid transit systems with 65% of metro users mentioning problems with LMC and significant time and money spend on reaching the stations. For people not using the metro, issues regarding LMC including inconvenient and unsafe walking and cycling conditions are deterrents while more than half of private mode users would be willing to use the metro if efficient feeder services were provided (Chidambara, 2021). While some feeder services to metro stations exist, the demand is principally met through IPT such as autorickshaws which are sometimes even more expensive than the main section of the trip. Cycle rickshaws are not allowed in Bengaluru due to their lower speed as they have to use the main roads and therefore impact the motorised traffic flow.

The majority of transit commuters relies on walking or para-transit modes while only a small percentage is using private modes for LMC (Chidambara, 2021). Despite this, footpaths are only available on 47% of the roads in the city, thus the majority of roads are without footpaths (DULT, 2014). This makes it especially hard for vulnerable groups such as elderly, women or people with disabilities to access public transit. Motorised modes such as autorickshaws are often expensive, therefore restricting people from lower economic classes from accessing them. Additionally, large areas of land around public transit stations and across the whole city are devoted to private motorised transport, while properly planned designated spaces for

LMC modes including IPT are a rarity (Chidambara, 2021). Instead, these modes find their spaces along the main carriageway or in side streets making it more difficult for pedestrians to access the stations safely.

Next to the lack of efforts to effectively integrate modes physically, there is also no information integration for seamless multimodal transit to inform users about public transport connections or last mile mode options. A common payment system or cross mode ticketing for better multimodal integration is also not in place. Opportunities for reaching public transit stops via bicycle or micromobility modes is limited due to a lack of parking spaces and safe infrastructure but also general lack of consideration. Feeder busses from metro stations are still not implemented with BMTC struggling to set up a viable connectivity network and intermediate paratransit services not always being reliable, accessible or being inconveniently located (Kanuri et al., 2019). With the metro line only connecting a few paces in the city and ridership of BMTC busses declining, the public transport infrastructure is not a viable alternative. The lack of effective land use and transport integration has led to urban sprawl in many cities and as distances became greater, the dependence on personal vehicles for mobility has increased (DULT, 2014).

There have been ambitious policy plans created in recent years addressing the issues of last mile commute but also on promoting NMT. However, with most of the recent plans still being in the draft phase, there is only a limited number of legally binding bills and laws enforcing safety for NMT users and promotion of LMC through NMT. Already 15 years ago, the NUTP has been framing clear goals for more sustainable urban transport, however its implementation remains incomplete. Due to a lack of integration of plans from national, state and city levels, policies and approaches do not align and are again hindering their implementation. With the comprehensive mobility plan for Bengaluru neither prioritising public mobility infrastructure nor the connectivity of mobility services and lack of multimodal integration, commuters shifted away from public transit towards the use of personal vehicles. The three major public transport modes, bus, metro and suburban rail, carry more than 4 million passengers a day which is less than 50% of commuters. These numbers are lagging behind other major Indian cities, adding to congestion, environmental pollution, loss of productivity and reduced quality of life (BPAC & Uber, 2020). Even though transport is a state subject, the improvement and implementation of projects regarding road infrastructure lies with the cities and their urban local bodies. Over the last decades, their main focus has been on relieving congestion by widening roads, building flyovers and enabling uninterrupted flow of motorised vehicles leading to a higher dependency on cars and motorbikes (D. Jain & Tiwari, 2013). On the other hand “city authorities and state governments have not invested in upgrading NMT infrastructure, resulting in a degrading level of service and increasing risk to pedestrians and bicyclists.“ (D. Jain & Tiwari, 2013). However, funds are now becoming available for sustainable projects including mobility projects where footpaths have been widened for making the centre more walkable. Nevertheless, outside the centre and in large parts of the city it is still a struggle to find continuous footpaths (Interview Sobia Rafiq, 2022).

There is a difference in the travel patterns of men and women when using public transport and how they access it to cover the first and last mile gap. The BPAC survey revealed that the majority on women prefers shared mobility including autos and cabs, while men preferred personally owned vehicles like motorbikes to cover the first mile to access public transport. Although the share of walking is similar, the use of bicycles is considerably higher among men. For last mile commute, more shared modes were used, especially by women, while the first mile was covered more by personal vehicles (BPAC 2019). When developing innovations for LMC, gender travel patterns need be taken into account to provide inclusive and accessible first and last mile solutions (Kanuri et al., 2019). Improving LMC is a challenge in Bengaluru considering the varying demographics and issues with public transport connectivity that prevail. With only 42km of metro line serviced covering a limited number of locations, a negligible suburban rail service and a large but often inefficient bus system, the challenges will remain in the short and medium term (BPAC & Uber, 2020). People indicated high willingness to use public transport, but the majority sees a lack in LMC but also frequency of the services, reliability, real-time information, and route planning (Smart Cities Council, 2018). With the start of the global Covid-19 pandemic, NMT usage showed an increase of users, however a widespread adoption of NMT modes was missing. This can be explained by the lack of planned NMT infrastructure, avoiding high crowding levels and uncoordinated movement of pedestrians. On the other side, as many people were shifting to working from home, the total number of commuters declined leading to a general decrease in NMT users (Nagrika, 2022). At the same time, the number of cyclists rose steadily during the pandemic and has doubled between 2017 and 2020 according to the cycle to work platform (Interview Sathya Sangkaran, 2022). Even though the cycling community is growing in the city, there is no space for cyclists or cycle centric infrastructure. The overall number of cycle lanes remains insufficient with some tracks existing but without continuity or a coherent network. Currently routes are being developed by DULT, but the construction remains slow and is only a small share of what could be build (Citizen Matter Bengaluru, 2021).

5.2 Alternative means of transport for Bengaluru

"The ever-compelling need to provide more road space for growing number of vehicles meant that newer infrastructure investments are more focused on personal vehicles than the need for allocating space for other modes like walking, cycling and public transport." (DULT, 2014). This resulted in diminishing sidewalks, neglected walking infrastructure and ill-maintained pedestrian facilities. Even though the need to strengthen NMT modes has been stressed on all levels, little investments have been made to promote these modes. Pedestrians are the most vulnerable traffic participants while being involved in more than 50% of accidents in Bengaluru. Improving the safety of pedestrians should be a main concern of planners, engineers and administrators (DULT, 2014). However, the political support for the various budgets is often impacted by the need for politicians to build visible infrastructure such as flyovers and metros, aiming to appear productive. Sustainable infrastructure is lacking a lobby and citizens are often unaware of the unsustainable consequences of such developments (Y. Jain, 2021).

NMT modes are generally perceived as slow and inhibiting the speed of travel in cities, so their use is often curtailed on main roads or restricted to neighbourhood streets. As a result, many cities have banned cycle rickshaws in certain areas or even the whole city which has seriously affected the livelihoods of poor families depending on this service. Rickshaws are often blamed for creating congestion. However, if NMT is segregated from motorised traffic, the total road capacity can increase (Tiwari 2007). Segregated lanes are possible on larger arterial roads while on smaller streets and in neighbourhoods they can flow within the slower traffic. Cycle rickshaws are an important mode for last mile commute to public transit stations in many Indian cities with high numbers of metro riders depending on them, for example in Delhi. These non-motorised IPT modes could also be used as feeder mode in Bengaluru, given that they regain the permission to ride again accompanied by the required infrastructure for parking and safe riding where necessary. If they get acknowledged as a green, healthy, silent, space efficient, non-polluting and oil independent mode, they could provide jobs to low-income individuals and a cheap last mile mode option for commuters. Even though cycle rickshaws exist in many Indian cities, transport planners, traffic police and policymakers do not recognise their role in the mobility system. There is no discussion about their positive contribution to the mobility system of a city as well as their requirements since their presence is often not taken into consideration in the data (D. Jain & Tiwari, 2013).

"The city's poor are captive users of walking and cycling, but most neighbourhoods have either poorly constructed footpaths or they have been badly maintained, while some have no footpaths at all" (Tiwari 2007). Poor people are affected the most with significant amounts of their household budget spend on transport. This increases further when informal settlements are moved and distances get longer or even more than double, the mobility of people is highly restricted and is often decreasing (Arora, 2011). Especially bicycles are unrecognised modes driven by unconsidered people as government policies still do not provide space for cyclists on the roads. Efforts have been made over the last few years, but the negative image of the bicycle has prevailed as they are still seen as a vehicle of and for the poor (D. Jain & Tiwari,

2013). Even though bicycle ownership is relatively high in most megacities, the share of riders is less than 10% or even 5% because of the barriers that users are facing (IIHS, 2015).
Cyclists do not get the required space on the road and are forced to compete with larger and higher speed motorised vehicles increasing their vulnerability and risk of accidents. Since there is no space for cyclists, bicycles are only used by people who have no other choice especially low-income men, while women find it tougher to undergo this struggle on a regular basis (Arora, 2011). Most infrastructure is designed for young males while more vulnerable traffic participants like women, children or elderly have different requirements regarding space, safety, parking and accessibility. This gender biased infrastructure design together with bicycles designed for men and their needs but also harassment and abuse of women contribute to a hostile street environment for weaker sections of society, disabling their mobility (Arora, 2011). Cycling on badly lit roads with potholes, aggressive driving behaviour of motorised vehicle drivers, social stigma and no provision of rights make the bicycle a highly unattractive mode choice especially for these groups. The fear of unsafety, bicycle theft but particularly the lack of infrastructure including parking spaces and cycle tracks affect the widespread usage of bicycles across all sections of the urban society (IIHS, 2015).
However, it was argued that the traffic is slow in the city, so the actual danger of accidents is lower than on highways, as risk is proportional to speed (Interview Sathya Sangkaran, 2022). Additionally, mental barriers of actually using a bicycle and the initial resistance against taking the bike and the perception towards active modes detains a lot of people from using it (Interview Venugopal, 2022). Cycling has no direct economic benefit and some challenges of comfort compared to a private vehicle, the current infrastructure does also not support this mode and sustainability is only a factor for very few people. “It is difficult to quantify climate change for an individual person if they have to put food on the table, so climate change is seen as an issue that can be fought by the rich.” (Interview Sathya Sangkaran, 2022). Another big challenge is that owning a motor vehicle is considered an aspirational goal which is created though social norms and peer influence ignoring good reasons for using NMT including individual health and pollution reduction. Incentives are necessary including financial incentives for limiting car use, but the government is not acting because there is no majority for this (Interview Sathya Sangkaran, 2022).
Walking and especially cycling is often seen as exclusive or ableist leaving some people with physical disabilities or certain age groups, demographics or gender behind because they might not be able to walk or use a bicycle. However, the opposite is true as building safe sidewalks and cycling lanes allows these people to use them with their mobility devices such as rollators, wheelchairs and electric mobility scooters (Interview Chris Bruntlett, 2022). This has been observed in many places around the world and shown in case studies for example in Bogota (Cervero et al., 2009). If infrastructure is built in an inclusive way, it creates a large opportunity to include people from a diversity of physical abilities, ages, genders but also financial situations. At the same time, it is important to impose speed limits and reduce the number of cars, segregating traffic where possible or necessary, and creating dedicated spaces for these population groups. This should be executed in an inclusive and intuitive way because they are

traveling at slightly different speeds. For many people, using a mobility scooter or a special bicycle might be easier than walking, so by not creating this space, a lot of people are put at a disadvantage (Interview Chris Bruntlett, 2022).

Cycling is one of the most inclusive, sustainable, and efficient modes of transportation especially for shorter commutes and to bridge the last mile gap. It has been highly popular in the country before the large-scale expansion of individual motorised vehicles took over the public space and is still a relevant mode of transport for many. Yet, bicycles are barely used to access public transit stations compared to other NMT modes like walking or cycle rickshaws in some cities. People do not think about the bike as a last-mile mode, leading to the fact that the catchment of stations is low because bicycles are not considered (Interview Sathya Sangkaran, 2022). This is due to a lack of dedicated infrastructure including bike parking at stations, safety and accessibility of transit stops. Similarly, other forms of micromobility, including new mobility developments around e-mobility and smart mobility, need to be considered to create alternatives for reaching public transport stations. Its various forms of electric micro-mobility devices make them suitable for a wide range of users including aiding the mobility of elderly or people with disabilities. With lower investment and maintenance costs they could help many users to reduce the dependence on private vehicles or even allow others to be mobile at all. Micromobility could also reduce the usage of motorised two-wheelers as they cost less than entry-level motorbikes or scooters in India. “Further, with shared usage models for micro-mobility, akin to public bicycle sharing, the residents of a city could be spared the costs of ownership, thus making e-scooters an attractive proposition compared to private two-wheelers.” (ITDP India, 2019).

Often, walking, cycling or micromobility can´t compete with the car or motorbike on distance, while public transport can´t compete on convenience and door to door connection, but combining these modes can create a cohesive door to door mobility service. Convenience and time saving are essential for making micromobility competitive with cars, thus good intermodal integration is key, while time competitiveness and financial competitiveness are making it more attractive (Interview Chris Bruntlett, 2022). When mass transit systems are poorly integrated with other modes and lack accessible infrastructure, large shares of the time and money spend for the trips constitute towards the first and last mile segments of the journey. “The disproportionate time and cost implications of the first and last mile journeys are an indication of sub-optimal efficiencies, associated with unavailability of reliable connections, longer waiting times and high transfer penalties.” (Kanuri et al., 2019). Additionally, the public transport system itself is not very reliable regarding the frequency of busses and the willingness of people to take the bus as the network is not sufficient. Busses are much more affordable than the metro, so most users come from lower economic classes and many walk far distances to catch the bus, especially women (Interview Sobia Rafiq, 2022). The public transport system in the city needs considerable improvements regarding the number of vehicles, and areas covered as well as the frequency but also regarding LMC, integration of NMT and accessibility.

5.3 Potential for change of urban transport in Bengaluru

Indian cities have mixed land use patterns, high residential densities and a large share of low-income workers who live close to their workplace. Therefore, the majority of trips even in very large cities is shorter than 5km which offers a high potential for NMT use. Even though many cities have a high share of NMT users, the amount especially of bicyclists has been reducing, despite high ownership rates of cycles. While the majority of users are captive users, with a rise in income and poor quality of infrastructure the total share of riders is likely to reduce. “There is a need to improve safety and convenience for pedestrians, bicyclists and cycle rickshaws, in order to retain the current modal share and attract potential users from other modes of transport who are using motorised vehicles for short trips” (D. Jain & Tiwari, 2013). Some action plans were taken up to improve infrastructure and encourage NMT use, however, their implementation remains incomplete. In order to retain the modal share of walking and cycling, and to encourage them by choice, it is necessary to shift the focus from providing services for motorised vehicles towards prioritising NMT on urban streets. By creating an environment conducive to their use, it will provide an increase in accessibility and safety for all commuters in the city.

“The appropriate provision of infrastructure for NMT reduces the obstacles for its users and encourages both captive and potential users” (D. Jain & Tiwari, 2013). Reversing the declining trend of NMT use can be achieved through the development of appropriate infrastructure that is well integrated with public transport along with strong societal and political will. However, “improving the environment and attractiveness of NMT in India is going to need much more beyond infrastructural improvements. It will need institutional reform, private sector involvement, interagency collaboration, investment prioritisation framework, and most importantly - cultural change.“ (MoUD, 2016). A mere provision of rapid transit systems is also not sufficient to convince users to refrain from using motorised modes. “Commuters are more likely to shift to public transport if factors such as accessibility, comfort, convenience, journey time and/or cost are not severely compromised upon.“ (Chidambara, 2021). Public transport can provide a mobility alternative, but it is a challenge for transport planners to persuade commuters to shift from cars and two-wheelers to busses, trains and metros. Modal choice is not only influenced by the quality of public transport but its accessibility and connectivity from origin to destination. Private modes offer a variety of advantages such as door-to-door connectivity, comfort, status, speed and convenience so public transport must enhance its accessibility, reliability, convenience and comfort as well as last mile connectivity to be a viable alternative for commuters (Chidambara, 2021).

First and last mile commute remain a concrete issue for the optimisation of transit infrastructure improvements. It has been proven that convenience and increased accessibility through LMC can considerably increase the capacity of transit modes and reduce the motor vehicle dependence (BPAC & Uber, 2020). “The lack of suitable last mile options discourages commuters to shift to public transport, despite being offered a state-of-the-art rapid transit system. At the same time, it compels transit commuters to use private modes such as cars and bikes for last mile connectivity, thereby creating a massive parking demand at metro

stations. Last but not the least, it makes the overall journey expensive, tiring, unsafe and unpleasant for the transit users. In order to make public transit systems more accessible to the commuter, planning for transit systems and LMC needs to be dealt with in a wholistic and integrated manner.“ (Chidambara, 2021).

Current debates focus on infrastructure and its effects for the users but also increasingly address behavioural change. While developed countries are mainly concerned with shifting from private cars to active modes, developing countries still have high shares of walking, cycling and public transport, so improvement of services but also accessibility issues arise. Less attention has been paid to intermodal strategies especially combining cycling with public transport, even though bicycle sharing schemes have been set up around the world and examples for bicycle parking at transit stations such as in Bogota have been around for a while (Sagaris & Arora, 2016). In many Indian cities, cycle rickshaws cover the last mile, but they are restricted in certain areas or even the whole city. They bear, however, a large potential as an LMC option if efforts are made to integrate these ITPs with rapid transit systems (Chidambara, 2021). Additionally, new mobility services and intermediate transit options have the potential to bridge the last mile gap to mass transit infrastructure. Shared mobility services offer commuters to access services on a needs-basis such as car-sharing, bike-sharing and micro-transit. Due to their on-demand nature, they have changed the way of how people are accessing public transport while also connecting to other modes. When integrated with mass transit, they offer a reliable option for LMC, improve accessibility of public transit, reduce vehicle ownership, and promote the reliance on public transit modes (Kanuri et al., 2019). While it is important to invest in public transport services, it is equally important to improve the accessibility to public transport, through excellent first and last mile connectivity facilitated by a strong data sharing framework. Multiple studies that have been conducted in Bengaluru to understand the low ridership on public transport, have also found the lack of first and last mile connectivity as one of the primary reasons for poor usage. (BPAC & Uber, 2020).

“With being one of the most congested cities in the world, it is evident that change needs to happen in order to create a well-functioning mobility system in the city again” (BPAC & Uber, 2020). Evidence from commuters shows that daily commute is time consuming, exhausting, and toxic, while the city is suffering from low usage of public transport and a steady increase in private vehicle ownership. Even though these trends are recognised as unsustainable, the focus of mobility plans lies on expensive big-ticket projects even though other interventions are more financially viable (Y. Jain, 2021). As mass transit infrastructure expansions are long term projects only finished in several years, so solutions need to be developed now to create a shift in the mobility pattern of the city. LMC is an essential factor for the use of public transport and for incentivising the move from private to public transport. In order to provide first and last mile connectivity that is accessible, affordable, sustainable, and efficient, solutions on a micro-level serving the diverse socio-economic groups of society are necessary. There is very little provision for NMT in the Master Plan for Bengaluru but also the budgets allocated to improving its infrastructure. The suggested additions for new footpaths and cycle

tracks are minimal in comparison to the entire street network of the city. Even though a large share of trips is shorter than 5km and already done by walking and cycling, its function for commuters to reach public transit stations is not considered (Nagrika, 2021). Instead, the draft mobility plan includes major investments into the road infrastructure with the controversial elevated corridor plans project for nearly two billion rupees which has been criticised by Citizen Matters Bengaluru (2020). Although the plans for expanding the metro network, setup of a suburban rail network and creation of bus priority lanes have been addressed as well, they will take a long time and cost large amounts of money. Concepts such as TOD, multimodal mobility fare system, and congestion/parking fees only appear in later phases of the proposal, while the goals are to develop a common mobility card for public transport operators, improve intermediate para-transit options, and create parking areas at the stations (BDA, 2017). These interventions have high potential to improve LMC and make public transit systems more effective, however their implementation needs to be awaited.

Based on the draft of the Active Mobility Bill by DULT, footpaths should be built along all urban roads to create a continuous network of obstruction-free pavements that are accessible for all users, in particular children, elderly, and people with disabilities. They shall be well-connected to public transit stations especially bus stops to provide LMC and make it more pedestrian friendly. LMC to bus stops and metro stations shall be ensured through active and sustainable mobility modes such as walking, cycling, public bike sharing and micro-mobility (DULT, 2021a). This would drastically improve the accessibility of transit stops and encourage LMC through NMT modes. Once this bill is approved it will have considerable impact on the mobility system in Bengaluru and allow for safer, more sustainable, and inclusive accessibility of public transit stations.

When Covid-19 started to impact India, commuters tried to avoid public transport and turned to individual motorised transport but also NMT modes to get around. The pandemic has been an opportunity to rethink urban mobility as a public service and to reimagine streets for people (Zuev et al., 2021). Cities shifted their focus towards providing safe, affordable, and equitable modes of transport through walking and cycling friendly cities in efforts of closing roads to vehicles, adding bicycle lanes and widening footpaths as well as proving public spaces (Scroll.in, 2022). The momentum for more walking and cycling due to campaigns reached many cities with city leaders starting to promote walking and cycling and scaling it up, creating a chain reaction. With an increasing demand, many cities have made the interventions like tactical urbanism permanent while others are still figuring out how to best apply these approaches. Concepts like complete streets or ‘tender sure’ roads accompanied by nudging people to use other modes, behavioural change, gamification, as well as shifting recreational cyclists to cycle for commute proved effective (Interview Venugopal, 2022).

“Studies have shown that in the long term, the mobility pattern during COVID signal positive signs for NMT, with an increase in preference for walking and cycling as compared to pre-covid times” (Roychowdhury, 2020). People from different age groups, backgrounds and ages have demonstrated the willingness to use NMT, displaying the large scope for it to become an important mode of transport especially for short and middle distances. (TERI 2020). Even

though Indian cities are not very cycling friendly, there has been a boom in bicycle sales during Covid-19 and a large number of inhabitants saw this as an opportunity to include more activity in their lives. It has also been observed that the perception of the bicycle being a poor person's vehicle is changing, reflecting an increasing acceptance and usage (Nagrika, 2022).

In Bengaluru this was done by closing certain streets to motorised traffic to promote other means of travel, expanding the space for NMT through creating priority zones for cyclists and pedestrians and by setting up temporary pop-up cycle lanes through low-cost interventions including concrete barriers and signage (DULT, 2020a). Additionally, several challenges have been launched to promote walking and cycling including the Streets4people challenge and the India Cycles4Change challenge organised by MoHUA and ITDP (ITDP India, 2020). "After the corona lockdowns, many Indian cities are planning on making their streets more pedestrian and cyclist friendly adding more bike lanes and pedestrianisation of marketplaces."(MoHUA, 2020). Several NMT interventions have been proven to be successful including Complete Streets, Bicycle Plans and Public Bike Sharing for prioritising streets for pedestrians and cyclists (Nagrika, 2021). The pedestrianisation of marketplaces is not only feasible but the only option to restore safe, vibrant, and liveable communities. For the last decades, pedestrian and cycling infrastructure have been the lowest priority despite offering large social, economic, and environmental benefits and having the potential to reconnect the city again (Scroll.in, 2022).

New innovations, especially through digital advancements including app-based taxis, bike rental, e-scooters or carpooling, have the potential to improve the connectivity of public transit more effectively. As the infrastructure for these modes is limited, it is necessary to provide walking and cycling infrastructure as well as cycle parking at metro stations. Additionally, feeder busses are a desirable option to close the first and last mile gab and need to be included as well. "The innovation in the mobility space to close the first and last mile gap such as bike taxis, e- rickshaw, e-scooters should be encouraged as they offer better first and last mile connectivity. Further, a multi modal integration of all public transit modes in the city would enable service providers to build solutions to close the first and last mile gap" (BPAC, 2019). Policy measures to provide this infrastructure along with regulations on the use of private motorised vehicles should be implemented. Additionally, subsidies, tax remittances and microfinancing options to support low-income households in accessing mobility need to be provided (TERI, 2018).

5.4 Implementation strategies for more sustainable and inclusive transport

Most cities are designed around the car and prioritise car traffic, while people on foot, bicycle or other micromobility modes are left in a very vulnerable and uncomfortable position when crossing streets which are very wide with fast moving cars, a lot of traffic, lack of traffic lights, and insufficient NMT infrastructure. When addressing multimodality, it must be focused on these barriers to provide infrastructure enabling people to reach their destination. Dealing with the way how customers are arriving to the public transport system is essential to attract more customers by setting these conditions right and improving them (Interview Chris Bruntlett, 2022). In order to identify strategies to encourage the use of other mobility modes next to personal vehicles, it is essential to focus on the factors that motivate or hinder people to choose a certain mode. Most individual preferences come down to the individual assessment of time, cost, and convenience of the available modes but also comfort, safety, and accessibility factor into the decision. Many residents do not walk, cycle, or take public transit due to a lack of these factors but also a personal preference for a private vehicle. Due to a lack of safety, adequate facilities such as footpaths and cycle lanes as well as public transit quality and connectivity, but also the absence of feeder services and last mile connectivity hamper residents to use or consider public transit or NMT (Sudhakaran et al., 2017).

Feeder bus services have largely been unsuccessful in Indian cities due to a lack of collaboration between transit operators, public agencies, local businesses and citizen groups together with limited funding for innovative ideas, concepts and technology. LMC services need to be dynamic and are dependent on the feasibility of these modes, land uses and population densities. “The role of cycle-rickshaws, shared autos, low capacity-short distance feeder bus service as LMC options needs to be recognized and implemented in a coordinated manner.” (Chidambara, 2021). Oftentimes, LMC is regarded as similar to feeder services, however it includes much more covering easy availability of modes and options, ease of changing between modes and accessibility of walking or cycling to stations at reasonable cost and time (Chidambara, 2021). In Indian cities, cycle rickshaws have the potential to provide inclusive, accessible, and sustainable mobility for short trips and to public transport systems. Recognising their role as a LMC opportunity requires the adoption of favourable policies that integrate them into the overall transport planning. With many cities planning metro and BRT systems, there is an opportunity to integrate NMT as well as rickshaw-friendly infrastructure while planning these systems (D. Jain & Tiwari, 2013).

So far, NMT users have the highest share of traffic accidents so there is a need to plan and provide safe and comfortable facilities for both pedestrians and bicyclists. Various policies have been developed to provide safe, secure, and comfortable movement of pedestrians and cyclists, however their implementation is lacking due to prioritising funds for congestion reduction (D. Jain & Tiwari, 2013). Even though the NUTP from 2006 emphasises safe walking and cycling infrastructure across the country, the same is yet to be realised (TERI, 2018). It is essential to provide equitable allocation of space for all transport participants, focusing on more vulnerable modes. NMT movement needs to be prioritised and users must be legally protected, while motorised vehicle use should be restricted. Bicyclists and pedestrians require

a complete network that is socially safe, well-lit and seamless where the segregation of modes depends on the speed of motorised vehicles. Fully segregated pavements and cycle lanes are suitable along roads with higher speeds while a mixed use of the road is recommended on slow streets within neighbourhoods. Indian style bicycle lanes must also be wide enough to accommodate for cycle rickshaws and should include other facilities like bike repair shops, drinking water and spaces for street vendors. Attention needs to be paid to intersections which are major points of conflict between pedestrians or cyclists with motorised traffic, so traffic signals are necessary, and the integration of cycle paths needs to be carefully considered especially at crossings (D. Jain & Tiwari, 2013).

"People expect that a cycling path must start at their doorstep and end at their destination, separate cycling paths only make sense on larger roads of more than 15m, otherwise slow streets might be more efficient in neighbourhoods where cycling is possible on the roads." (Interview Sathya Sangkaran, 2022). The perception that roads are designed for cars only needs to be overcome towards streets that are shared equally by all users. Bad road conditions and insecurity are main deterrents for people to use NMT, especially for women. Small interventions can already make a big difference, for example small audits to understand the local conditions and act upon them. Improvements can be achieved though simple changes like *"cleaning up an area which has dead elements or parking, improving lighting, small street design elements that do not even cost much to make places safer, more accessible and pleasant"* (Interview Venugopal, 2022). In relation to risk perception between genders, female commuter cyclists prefer routes with maximum separation from motorised traffic. It is therefore important to consider gender preferences as well as age and different backgrounds in the implementation to provide inclusive mobility options that consider underrepresented groups (Garrard et al., 2008).

Additionally, cycling training camps, especially for people from low-income neighbourhoods and women, are very impactful tools to creating independence and opportunities. Giving out free bicycles and teaching children how to bike have been very successful campaigns along with handing out second-hand cycles from the government for people who do not have access to shared bikes or can´t afford their own bike (Interview Venugopal, 2022). "To increase bicycle access among low-income households, the provision of microfinancing options and implementation of cycle-distribution schemes should be undertaken" (TERI, 2018), making bicycles more affordable. Bicycles are barely seen on urban roads as they are taking side roads and not standing in traffic, therefore not being considered. Increasing the visibility of the bicycle can be a measure to improve its acceptability and when people can use them to carry items, they are not solely perceived as a means for exercising but provide a substitute to cars (Interview Sathya Sangkaran, 2022).

"Thus, in order to promote the widespread use of bicycles, a combination of hard and soft measures should be adopted." (TERI, 2018). Hard measures include safe cycling infrastructure across the city, easy financing options for basic bicycles laws and regulations while soft measures cover awareness campaigns around the benefits of cycling and a change in the perception of it being a poor person's vehicle. Through these measures the existing share of

cyclists can be retained and more people could be motivated to shift from private vehicles for short distances but also LMC (TERI, 2018). In order to increase the share of choice users, cities need to consider building bicycle sharing system across the city instead of individual locations and enforce regulations regarding the use of motorised vehicles. This would also lead to financial benefits as "it is estimated that if bicycles were to substitute the two- and four-wheelers used for short-distance trips, it can result in an annual benefit of INR 1.8 trillion, which is equivalent to 1.6% of India's annual GDP for 2015–16." (TERI, 2018).

At present, the proportion of public transit users arriving to a station by bike is very low. However, the bicycle has a very high potential as a feeder service to expand the catchment area of public transport. For the majority of users the most important consideration is time, meaning how long a mode of transport is going to take to reach the destination. Cycling has a time competitiveness to walking but it needs to be safe, comfortable, convenient, seamless and less stressful. Therefore, the "provision of walking and cycling friendly infrastructure and environment on all major and minor roads leading to transit stops is paramount for enhancing accessibility of rapid transit systems." (Chidambara, 2021). To increase accessibility of bicycles at stations, the factors which were found most likely to aid cycling are bicycle lanes, bicycle parking and a cycle sharing system (Mohanty et al., 2017). "By providing appropriate parking facilities for bicycles at or near bus stops, and safe bicycle paths, it is likely that more commuters will be added to the bus service, with an increase to the catchment area. The provision of appropriate infrastructure for NMT provides equal access to all and is a major factor in determining use of public transport in the city. Thus, a complete network plan must be in place for promoting use of NMT that is also well integrated with the existing and proposed public transport system of the city." (D. Jain & Tiwari, 2013).

Next to safe parking for personal bikes, reliable and affordable bike sharing increases the catchment area of a station and allows access for people who are not owning a bike or for last mile commute to be more mobile. Bike sharing also requires infrastructure including parking at stations which is often not provided due to privatisation and commercialisation of land. When transport companies invest more in NMT modes, the number of passengers would increase, creating financial incentives for using land around stations. Discounted fares for public transit when using bikes, free bicycles for the last mile and a single payment model would make it more attractive (Interview Sathya Sangkaran, 2022). „Innovations in the mobility space to close the first and last mile gap such as bike taxis, e-rickshaw, e-scooters should be encouraged as they offer better first and last mile connectivity. Further, a multi modal integration of all public transit modes in the city would enable service providers to build solutions to close the first and last mile gap." (BPAC & Uber, 2020).

Transport integration across modes is essential for seamless connectivity. Integrated ticketing through a smart card would allow metro and BMTC users to use shared micromobility modes and easily switch between modes to execute their multimodal journey. Information integration between the modes would help to better plan journeys and find the ideal mode for a door-to-door trip. An integrated fare system with timetables and clear indication of arrival and destination of modes including suggestions for last mile commute would increase

the comfort for commuters (Interview Venugopal, 2022). BMRCL and BMTC need to integrate their data with paratransit services to offer seamless LMC and a smooth door-to-door journey (BPAC & Uber, 2020). However, these technical solutions rise the question around the accessibility of such services in particular for people from low-income households but also elderly or people with disabilities, further excluding marginalised groups. Especially in Indian cities, the discourse on the Smart City has been highly popular, coupled with ambitious goals to improve cities and its transport systems. Its agenda tends to shift the policy focus away from the mobility needs of people towards a need for more intelligent systems like smart parking and transit tracking or other technical responses, ignoring issues of social exclusion and the 'city for all'. In these corporate-driven smart city agendas citizens will be reduced to consumers while issues on affordability, social justice and access to opportunities are oftentimes left out of the algorithms of such interventions (Zuev et al., 2021).

"Development-related projects may be robust in their technical details but equally ignorant of the nexus between enforced mobility and immobility, and with an alarming regularity, fail to make explicit the linkages between gender, livelihoods, mobilities and empowerment/ disempowerment. Another common shortfall is the lack of context-specific and socio-economically sensitive planning, favouring a direct transfer of, often inappropriate, design and delivery standards from the West." (Zuev et al., 2021). It's not about taking concepts from the west but "probably it's time to relook entirely to some extent of how mobility can be done in Indian cities" (Interview Venugopal, 2022). The focus should not be on replicating 'best practices' but to understand concepts and operationalise learning that can help to understand the potential of solutions triggered by experiences from other contexts. Policy learning activities should incorporate capacity building mechanisms to be used as a continuous long-term strategic change process (Glaser et al., 2019). Even though best practise cases from other countries can be useful, the main learning can be to avoid making mistakes that other countries have done and learn from their failures.

The challenges of the urban transport system in Bengaluru need urgent attention. Pilots must be conducted in high traffic corridors to provide the necessary infrastructure and connectivity services. Such pilots would help to generate learnings used for the upscale across the city and enhance connectivity (BPAC, 2019). Giving due attention to LMC will not only attract more users to shift from private modes to public transport but also help to retain existing riders. LMC is an integral component of rapid transit systems and the whole urban mobility system which needs to be considered in the transport plan preparation process (Chidambara, 2021). It is important to bring together planning agencies so decisions can be streamlined, and budget can be allocated more efficiently. Existing policies are setting larger ambitions and visions some include targets, objectives or roadmaps, but they are not a bill so not binding. "The active mobility bill for the state of Karnataka is one of its kind and comes with a statuary power and mandates. It is not yet approved, so for the time being action plans might be a good first step" (Interview Venugopal, 2022).

The implementation of projects for change in cities is often not taking place due to a lack of political will but also an increasing power of car users. There have been ongoing debates

regarding road space allocation, but it must be accepted that an equitable distribution of space and the needs of all users must be respected. By first allocating space to pedestrians, cyclists and public transit and then to personal vehicles, sustainable transport systems in a city can be promoted. For this, the existing infrastructure needs to be redesigned to create a comprehensive network in the city for both pedestrians and cyclists. Additionally, legal protection is important as well as enforcement against encroachment of NMT infrastructure (D. Jain & Tiwari, 2013). “Studies across a host of countries in the developing world are consistent in their findings that the current transport policies that are being adopted do not place an appropriate level of importance on the lived realities of daily mobilities. Rather, they are mainly concerned with the design and operations of transport systems as purely infrastructure systems, and much less involved with issues of daily mobilities in terms of access to livelihoods, education and health.“ (Zuev et al., 2021).

Covid-19 has changed the way streets are used and highlighted the importance for inclusive mobility. A number of challenges have led to cities wanting to create safe, healthy and happy streets through quick, innovative and cheap interventions. “Cities can create pedestrian-friendly or pedestrian-only streets, convert parking spaces to pop-up parks, revitalise dead spaces, and create walking links between large urban blocks.” (ITDP India, 2020). Even though NMT and public transport have been accepted as the most sustainable modes of transport, the power dynamics in policy and decision-making are based on corrupt routines which are hindering the transformation. With the majority of women, children, elderly and disabled already using sustainable forms of mobility. “Instead of creating an environment where these groups can continue with their sustainable mobility practices, they are increasingly forced into unaffordable, unsafe, and unregulated (or partially regulated, informal) motorised modes.” (Zuev et al., 2021). Policy design should aim at promoting public transport, cycling and walking by improving the conditions and infrastructures for these modes. It has been recommended to apply a people- and needs-based approach within transport planning to create socially sustainable mobility futures (Kern et al., 2019).

In order to implement a mobility transition, starting points need to be identified. Rebuilding the entire infrastructure overnight is impossible so it is recommended to start with the small trips within a neighbourhood including the last mile to public transit stations. When drafting a plan, weak links and barriers must be identified that stop people from using a certain mode. It is essential to involve the citizens in the local design and setup of the mobility infrastructure to cater to their needs. Public engagement processes help to increase the acceptance of the intervention compared to decisions being made disconnected from reality by people with power and influence catering to their own needs. *“It´s about giving each mode of transportation its appropriate budget and space so that people can choose between the right mode for their journey instead of putting all the money into a space inefficient, expensive and dangerous mode of transportation”* (Interview Chris Bruntlett, 2022). Covid-19 created a unique opportunity to change the mobility paradigm in cities towards active transport, multi-modality, and human-centric cities instead of moving vehicles (DULT, 2020a).

In the end, the implementation comes down to political commitment, including financial commitment, to actually allocate money in proportion to the goals and aspirations in respect to how people are currently and are willing to move around in a city. With the vast majority of transport budgets going into car infrastructure, despite the vast majority of the population not having the financial means to drive a car, it creates a tremendous imbalance between the spendings of the government and the way people actually move. *"If this would be looked at from a more balanced way, then there should automatically be more budget freed up for walking, cycling and public transport"* (Interview Chris Bruntlett, 2022). There is a need to stop investing into car infrastructure expansion and start investing into more space efficient, sustainable and inclusive modes to prevent making the same mistakes the western countries made (Interview Sathya Sangkaran, 2022). It is important to communicate the quality-of-life improvements, equity arguments and the idea that congestion can be tackled by taking away space from cars and giving it to alternative means. Also, the financial returns from active travel are higher and society saves money in terms of public health, reduced pollution, congestion, accidents and economic activity, so society is receiving more money back than was invested (Interview Chris Bruntlett, 2022).

Urban transport developments in India are currently focusing on large projects of road or metro construction ignoring questions on accessibility, affordability, and equity. The focus on these technically driven solutions shifts away the focus on why certain people are mobile while others are not. It is not simply a matter of choice or failed policies but the question of who benefits from spatial decisions about allocations of space being made. The way in which different groups of people are moving based on gender, age, social class, employment, or other social aspects is often not considered. Questions of how livelihoods are affected by being mobile and issues around transport poverty need to be dealt with as well. As the modal share is switching from walking, cycling and public transport towards personal motorised vehicles, discussions on sustainable mobility solutions and their implementation will increase. Local decision-makers and urban transport planners need the capacity and knowledge about the variety of methods and opportunities to answer the relevant questions of how to provide socially sustainable transport systems (Zuev et al., 2021).

6. Discussion, Conclusions and Recommendations

This section will embed the research into the larger picture of mobility in India and discuss challenges and opportunities of commuting in Bengaluru to ultimately answer the research questions. By reflecting upon the research execution, limitations will be addressed and critically examined, followed by propositions for further research. The paper will close with recommendations from citizen groups and learnings resulting from this research for promoting the sustainable urban mobility transition in India and Bengaluru.

The urban mobility landscape in India is rapidly changing due to population growth, rising income levels, increasing motorisation and changing preferences, impacting the way in which people are mobile. Indian cities are compact and have a mixed land use, yet the demand for mobility is increasing, as are the travel distances. Car-centric planning, road expansion and urban sprawl led to rising motorisation rates with cities facing challenges of pollution, congestion, accidents, and land distribution, putting a strain on the limited resources available. At the same time, the share of non-motorised modes like walking and cycling but also public transport declined considerably in the last decades, making the urban mobility system more exclusive, inaccessible, unequal and unaffordable especially for marginal groups. Due to a lack of dedicated infrastructure, poor upkeep of facilities and maintenance along with inadequate safety measures for cyclists and pedestrians they have the highest share of fatalities. Through an increased affordability of motorised vehicles, especially two-wheelers, short distance trips that could be taken using NMT are now being made by motorbikes, scooters and cars instead. The negative externalities resulting from this include air pollution and congestion, the dependence on fossil fuels, greenhouse gas emissions and ultimately health implications which all result in high costs for society (TERI, 2018).

In order to minimise these negative impacts, current and future transport demand needs to be increasingly covered by more sustainable modes like NMT and public transport. Walking and public transport are still the most dominant modes of travel in Indian cities with multimodal transport being the norm to reach destinations. There is a large potential to increase the use of public transport with better first and last mile connectivity, requiring a need for multimodal transport planning (Soman et al., 2019). In Bengaluru, many people rely on public transport to be mobile and on non-motorised transport for short distances and LMC. Using NMT modes for LMC has mainly been attempted by setting up public bicycle sharing systems in some cities which were not very successful despite PBS systems being a viable feeder service and positively impacting numbers of transit riders. NMT has a high potential as a sustainable and inclusive solution for LMC, however infrastructure is mainly limited to planned public transit corridors or individual road redevelopments and parking at stations is lacking. Even though walking is the most preferred mode of commute, peoples´ willingness to shift to cycling if it would become more convenient is high. Together with the fact that most commuting trips are shorter than 5km, there is a high demand for more active and green mobility modes having the potential to solve a number of India´s urban mobility challenges (Nagrika, 2021).

In Bengaluru, the share of NMT has decreased most compared to other Indian cities with less than half of streets having pavements and a steep decrease in cycling in the city. Additionally, public transport use amounts less than 50% of the mobility share and is considerably lower than in other Indian metro cities, while motorisation has increased dramatically over the last years. Whereas the urban population in the city grew exponentially, the number of busses decreased, and the number of metro users remains low, similar to the number of commuter train users. Commuters have switched to cars and motorbikes for daily commute due to higher comfort and a lack of reliable alternatives, leading to an overburdened road network reaching its capacity. The metro network on the other hand is not reaching its capabilities as it is only carrying half of the projected passengers while the bus system is already reaching maximum capacities. The way in which people access public transit systems in Bengaluru differs between population groups, genders, and ages. Generally walking is the preferred mode of LMC, while more people walk the first mile to stations than walking the last mile from stations to destinations. It was found that shared modes are preferred by women while men use private vehicles more. Especially people from low-income households but also other marginalised groups are dependent on public transport and rely on NMT for LMC.

Linking back to the concepts guiding this research, the challenges and barriers commuters are facing regarding LMC and NMT in Bengaluru can be identified based on the 3A framework. The *accessibility* of stations varies across the city with some stations being connected better with other means and more accessible in terms of good reachability. However, many stations lack accessibility for marginal groups, such as people with disabilities, elderly or women, due to a lack of facilities catering to their needs. Furthermore, the *availability* of LMC modes is limited due to a low number of options available for commuters to choose from. The transit network is insufficient due to low coverage of certain areas in the city with limited public transit options available. Reaching the station is often more expensive than the mode itself, lowering the *affordability* of public transport with expensive IPT options for LMC. For people from low-income households, even the public transit is too expensive, leaving them with no affordable mode except walking or NMT. Another challenge that emerged during the interviews extending the 3A framework is the dimension of *reliability*. Due to a low number of vehicles, especially busses, the service is low and often unreliable, resulting and an insufficient public transit network. Similarly, LMC options are often not reliable, especially some of the existing mode options like IPT services.

The reasons for these challenges and barriers include lack of shared mobility and feeder busses, absence of dedicated parking spaces for intermodal mobility at stations and incomplete walking and cycling facilities leading to a lack of integrated, economic and reliable LMC. Regarding the transit network itself, a lack of multimodal integration and poor connectivity, insufficient coverage and a lack of information integration posed challenges to commuters suffering from poor investments into multimodal transit. Especially the existing metro network is insufficiently integrated with other modes, lacking safe and convenient access to stations, feeder services, multimodal integration like common ticketing or seamless mobility, leading to low usage. The main barriers of public transport adoption are in relation

to infrastructure, reliability, and safety. For women in particular, the quality of infrastructure and safety are important while men are more worried about distance and travel time. With women relying more on public transit and NMT, a gender sensitive planning is required. There is an urgent need to invest into NMT and LMC for improving seamless travel, affordability, and safety of commuters to cover the distance to public transit and increase urban mobility. The public support for such polices is strong, however implementation is often lacking. “City planning strategies in the past did not focus to the required extent on promoting sustainable modes of urban transport. As a result, usage of sustainable modes like cycling have come down drastically in metropolitan cities like Bengaluru” (DULT, 2020a).

In the city, transport projects often focus on providing more road space for vehicles instead of allocating space fairly among modes including NMT. Sidewalks are diminishing and poorly maintained despite the majority of people walking, reflected by more than half of traffic accidents involving pedestrians. Transport planning and overall governmental policies cater to the needs of the middle and upper class ignoring the interests and needs of poorer segments of the population. With a large share of people not able to afford a car and some even struggling to pay for public transport, they are forced to walk and cycle. With no rights and protection in traffic they are further disadvantaged and cut off from opportunities. Not only are poor people excluded from the benefit from increased motorisation, they also have to bear the highest disadvantages from road expansions with their needs being ignored. There is no lobby for sustainable and inclusive modes, while the political support for building visible and large infrastructure led to the fact that 80% of road space is taken up by motorised traffic.

In recent years and especially during Covid-19, cities in India including Bengaluru have geared up to promote more sustainable transportation to change the prevailing commuting schemes. Current efforts in the city include pop-up cycle lanes and pedestrianisation of streets but also campaigns like Cycles4Change and open streets, however no initiatives that are promoting NMT for LMC. Multiple ambitious polices have been developed to promote more sustainable transport in the city and the country. The Karnataka Active Mobility Bill is the first of its kind in India protecting the rights of NMT users for safe, accessible, and connected networks to promote sustainable urban mobility. It is still in the draft phase but has the potential to transform the mobility in the city and improve the conditions for NMT.

Nevertheless, non-motorised modes face a number of challenges in cities stemming from a lack of infrastructure including cycle lanes, slow streets and bicycle parking but also a negative image around bicycles. They are perceived as slow and inhibiting the speed of travel in cities and are also regarded as poor people’s vehicles. Other factors influencing its use are physical conditions like weather, topography, safety threats and air pollution. By contrast, NMT provided numerous benefits, such as no air and noise pollution, oil independency, space efficiency, greater affordability than other modes, personal health through movement, inclusivity through different modes available for different needs and capabilities. Overall, they are more sustainable and greener compared to motorised modes and can provide jobs and even livelihoods to people especially from lower economic classes.

There is a large potential for NMT to cover the last mile which can also be discussed along the lines of the 3A framework. It increases the catchment area of the PT system and increases *accessibility* by allowing marginal groups to use them to reach stations based on their needs and abilities. The *availability* of different modes is higher, allowing people from diverse backgrounds to be mobile and increases the choices for the appropriate mode from different locations across the city. NMT is much more *affordable,* therefore allowing people from low-income neighbourhoods to use them and also provide a cheaper alternative to existing LMC options like IPT. They increase the *reliability* of LMC by providing more options, allowing for flexibility and choice of personal or shared opportunities, thereby enhancing independence. Indian cities provide favourable conditions for NMT including mixed land use, high residential densities, a large share of workers who live close to work and a high proportion of short distance trips while facing limited space, requiring effective usage of available space. There is also a high willingness of people to use bicycles and micromobility for LMC if safe infrastructure is provided. Especially Covid-19 created a momentum for change and awareness about alternative modes of travel including cycling.

There is a tremendous desire for change in Indian cities for safer streets, traffic calming and cycling infrastructure which does not necessarily involve high monetary cost or much time, "it just costs our imagination" (Interview Venugopal, 2022). "Getting over that inertia that our streets are not set in stone and we somehow can´t touch them or change them in a very light and creative way" (Interview Chris Bruntlett, 2022) can help to make streets incredibly vibrant, safe and enhance social connections. Many cities have used the Corona pandemic to build their cities around walking and cycling with a diversity of ideas and concepts responding to the respective local conditions and by using that momentum for change, with many projects being made permanent. What is needed to implement these objectives is a paradigm shift in urban planning of putting people first and providing mobility choices for the needs of the users allowing them to choose the most suitable mode for their journey in respect to the whole urban mobility system of a city. This can only be achieved if appropriate infrastructure and an urban environment for pedestrians and bicyclists is developed. It will require a close collaboration of transport engineers, planners and urban designers, making sure that these processes are not carried out independently anymore. By designing processes that ensure transport investments are in line with land use, environmental plans and needs of people, urban sprawl and automobile dependence could be prevented. There is a need to develop a comprehensive network in which the security and safety of all users is taken into account to realise the full benefits of the system. With many people being transportation disadvantaged, often relying on walking and cycling to access transit and an increased demand for NMT, there is a need to provide proper infrastructure and facilities for all users. Improving NMT in urban areas must be considered as a way to reduce air pollution, traffic congestion, and health issues, making mobility more sustainable and increasing social inclusion.

In order to answer the main research question on how LMC can become more sustainable and inclusive through NMT, a number of dimensions should be considered to implement a mobility transition. It is essential to focus on the preferences of the commuters to provide

opportunities that people need and can use. By identifying barriers regarding accessibility, availability, affordability and reliability, safe and comfortable options can be created. It is important that all stakeholders collaborate in the development of customised plans to be able to build a complete network. Policies can set larger visions and ambitions, but concrete targets, objectives and roadmaps are necessary for effective implementation. It is suggested to start with short trips and LMC to initiate the transition towards more active modes and a comprehensive network in the city.

To help guide the transition towards more sustainable modes of transport, the concept of transition management could be applied. It is based on goals and visions which are ought to be reached but allows for trials and experimenting to adjust the output flexibly based on learnings and failures. Existing polices in India which have been developed in recent years can provide the necessary vision to create more concrete goals to work towards. Initiatives and nudges offer the possibilities to find the best solution for the respective local context. Additionally, best practices from other contexts and cities that have achieved similar goals can help to avoid making the same mistakes again and guide the transition through a process of learning. Concepts such as TOD or the 15-minute city which have been successful in other comparable contexts might have the potential to transform the mobility of Bengaluru as well. Initiatives and challenges have already been very successful in the country by inspiring NMT friendly initiatives to connect citizens and experts in developing a unified vision to promote active modes. By creating a participatory process of visioning, learning, and experimenting, multiple viewpoints can be included to develop an inclusive and shared vision for long-term change of urban mobility in India.

This research was limited by the fact that data on LMC in Bengaluru is very limited and that several secondary data sources were not fully representative. As there was no primary data collection possible on-site, challenges remain regarding understanding the local context and conditions, so this research aims to provide an external perspective onto urban mobility in Bengaluru. Further research would be necessary with respect to the assessment of gender, age, and background of commuters to provide a more nuanced picture of mobility and give more specific recommendations. This would require data collection in Bengaluru, to include challenges of transport poverty and needs of marginal groups into the context of the research. This analysis should not only be done for full trips but also multimodal journeys, to identify the share of NMT for last mile commute. With new innovations in the field of mobility, the concept of NMT needs to be adjusted and expanded to take human powered but electrically supported modes into consideration as well. NMT has the potential to support all people's mobility and can provide viable options to cover the last mile gap.

The NMT guidance document suggests expanding the definition of NMT in the Indian context to cycle rickshaws, handcarts, vending carts, handicap tricycles and bullock carts to include all modes that are currently in conflict with motorised modes. Based on global best practices on designing and planning NMT, their guiding principles for Indian urban conditions include an interconnected network, complete streets, bicycle friendliness, walkability, safety, comfort, universal accessibility, security, wayfinding, and protection from encroachment. Supportive

principles comprise the informal sector, mixed use, transit priority, parking management, bicycle industry support and building a cycling culture. A clear process for implementing NMT infrastructure has been developed, starting with assessing the current situation by identifying existing initiatives and their impact and potential opportunities to then create a vision with targets and barriers. The planning and designing should be based on existing demand and infrastructure together with stakeholders while gaps in the network need to be identified to expand or reconstruct the NMT network and pilots identified to create an implementation strategy. When investing into NMT, city budget allocations need to prioritise these modes, incentives and disincentives developed and budget for maintenance and repair should be allocated. When implementing the strategy, clear roles and responsibilities for development and maintenance need to be defined, awareness campaigns conducted, and high-quality delivery and monitoring ensured.

The recommendations for Bengaluru are based on suggestions from citizen initiatives working in the city and on insights from the expert interviews. Bengaluru has a strong structure of citizen and advocacy groups, who keep a close eye on developments and implications of projects and speak up on road-widening, the suburban rail project and the metro or bus prices (Y. Jain, 2021). Citizen groups and initiatives include Bengaluru Political Action Committee (BPAC), Praja Raag, Bengaluru Matters, Young Leaders for Active Citizenship (YLAC) and the Centre for Active Mobility (CFAM).

BPAC is suggesting to provide walking and cycling infrastructure and to create bicycle parking near metro stations to improve NMT for LMC. Introducing cycle rentals and other forms of shared mobility would increase options and cater to the existing demand of users. The first and last mile gap should also be closed through shuttle or feeder busses into residential areas. Innovations in mobility space such as bike taxis, e-rickshaws and e-scooters should be encouraged as multimodal integration of all public transport modes would help to build solutions for closing the first and last mile gap. Public transit should not be seen as a standalone infrastructure but requires physical integration including parking for shared modes like bicycles and micromobility with different transit modes complementing each other and being reachable through LMC. Through pilots and data collection suitable physical infrastructure could be provided to support the integration across shared and public mobility modes. It is recommended that operators of mass transit services should invest in improving the infrastructure for pedestrians for better LMC by maintaining footpaths around 1km from the stations. Feeder busses should be reintroduced to help connect interior parts of neighbourhoods to cover the last mile. The solutions should be location specific and be planned on a micro-level taking into consideration the purpose of travel while involving all stakeholders (BPAC, 2019).

To improve pedestrianisation, YLAC suggests increasing coverage of streets with footpaths from the current 47% to higher and use this percentage as an indicator for the development of pedestrianisation. In high foot traffic areas, paths should be increased, and street furniture added to make walking more pleasant, and bins added to keep it clean. Creating inclusive and accessible walking environments and public spaces should be achieved by adding streetlights,

lowering traffic speed, adding ramps and conducting awareness trainings for the police. Motorists should give way to pedestrians and cyclists and the construction of footover bridges should be restricted and pedestrian crossing should be built instead. Walking to public transit could be made more efficient by creating passenger information systems like real-time info on busses. YLAC suggests pushing for TOD including walking facilities, pedestrianise commercial areas, introduce traffic calming measures and add trees to NMT corridors.
For improving cycling infrastructure, they suggest developing dedicated cycling lanes next to major roads, incentivise bicycle parking for employees and customers at local businesses and set up locking systems at metro stations. The availability of bicycles at transit hubs like bus and metro stations should be increased and likewise the availability of community cycles for self-organised sharing. Using urban design and traffic calming measures for colouring cycle paths with different colours and building structures between the lane and the street are simple but effective measures. Transport data gathering should be conducted inclusively to also respect captive users including the urban poor in decision-making processes. Behavioural change of citizens should be induced through nudges to cycle, awareness on personal health and environmental benefits, reduction of CO2 footprints and cost saving and by partnering with aspirational figures and leaders to make NMT usage more popular.
Pedestrianisation and introduction of bicycle lanes would help to reclaim the streets and benefit from reduced numbers of vehicles on the road. Next to constructing cycle lanes, a well spreading out a bicycle sharing network with enough cycles would help to encourage more cyclists. By making streets and footpaths safer, people get the opportunity to ditch their motorised transport vehicle for a cycle or walking to further spreading NMT. “Through this campaign and policy recommendations, we hope to build momentum towards a collective vision of cycling and walking in Bengaluru. We hope that the stakeholders see the value in improving non-motorized transport and the increased gender inclusivity in our public spaces, improved public transit usage, increased safety on our streets, a reduction in carbon emissions and most importantly, healthier and happier people.” (Jose et al., 2020).
For Bengaluru, it might be interesting to focus on the various forms of micromobility including bicycle sharing, electric scooters but also other electrically supported mobility devices. They can expand the catchment area of public transit systems and increase reachability with ease. Due to low investment and maintenance costs compared to motorbikes, but also their various forms make them an inclusive and flexible mode option especially for LMC to public transit. Another mode option that could be considered in Bengaluru are cycling rickshaws. They have been banned in the city due to their low speed and being blamed for creating congestion. However, if provided separate lanes and permission on slow streets in neighbourhoods, they could offer a cheap and flexible but also non-polluting, silent, sustainable, oil independent, space efficient and healthy last mile mode that can provide livelihoods to the drivers and allow all people to be more mobile in the city. Their role in the mobility system has not been recognised, offering the opportunity for a discussion on their potential contribution for more inclusive and sustainable urban mobility in Bengaluru.

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Annex

Interview guides

Sathya Sangkaran (Bicycle Mayor Bengaluru)

- What are you doing, what are your roles?
- What is the current situation regarding cycling and walking in Bengaluru?
- Who is using NMT and what is the commuting pattern in Bengaluru?
- What challenges, barriers for more NMT are there?
- Is cycling for LMC realistic? Which other modes could be useful? Micro Mobility?
- Bike sharing in Bengaluru feasible/make sense? How to implement it?
- What are your recommendations? What should be the next/first steps?

Sobia Rafiq (sensing local)

- What are you doing? What projects do you work on?
- What has happened in Bengaluru recently regarding NMT?
- What are commuting patterns, who is using NMT? What LMC infrastructure is there?
- What is important to consider when building NMT infrastructure?
- How can this be applied to focus on last-mile commute?
- How can this infrastructure be implemented? Challenges
- What else is needed for people to prefer NMT?
- Which policies are hindering/helping to expand NMT? How can these policies be implemented? Challenges, positive examples
- How should an Indian city look like? How to archive this? Your vision

Venugopal (ITDP India)

- Recent activities of ITDP. What has been done in Bengaluru?
- Current situation. What has changed in regard to mobility in Indian cities since Corona?
- Cycling for commute. Is it a realistic mode to cover the last mile to public transit?
- What is needed to improve walking and cycling numbers to public transit stations?
- Policies are existing. How can policies effectively be implemented into action? Are they implemented? Why not? Sufficient?
- How to promote NMT use in cities? Role of challenges to archive higher rates in walking and cycling – tool to promote change?
- What learnings did you get from promoting NMT? What challenges do you face?
- Learnings from other cities/cases. Strategy of Chennai, goals reached? Info on Jakarta or Paris?
- Your wish for the future of active mobility in India. What needs to happen next?

Chris Bruntlett (DCE)

- Commute mode choice. Why do people choose certain modes over others? What barriers do they face in accessing modes?
- Closing the last mile gap. What is important to consider when connecting NMT and public transport?
- Building a comprehensive network, where to start? How to start? First steps?
- How can walking and cycling be inclusive for all people in a city?
- how can policies (and this whole transition) be successfully implemented and managed?
- which learnings (from other countries) could be useful to improve last-mile commute through NMT? For Bengaluru?
- Learnings from NL useful for India? Adapted?