ITDP Institute for Transportation & Development Policy

Final Report
High Volume Transport:
Urban Transport Theme 2

iMC worldwide

HIGH VOLUME TRANSPORT
APPLIED RESEARCH

UKaid
from the British people

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Acknowledgements

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First we would like to give our deepest thanks to Holger Dalkmann for his oversight and guidance to develop the work presented here. Bernard Obika and Louise Cathro from IMC Worldwide were a pleasure to work with and helped with this report. We would like to thank Jeff Turner for his review and feedback on the early drafts of this report. Finally, we would like to thank Professor Harry Dimitriou, Peter Jones, and Ed Simpson for their invaluable reviews and constructive criticism of early drafts.

We consulted the following global experts to identify literature sources and key concepts: Peter Adriaens (Center for Smart Infrastructure Finance, University of Michigan); Chris Ballinger (Mobi Open Blockchain Initiative), Bruce Belzowski (Automotive Futures Group); Jeb Brugmann (100 Resilient Cities); Ceit Butler (George Brown College Blockchain Program); Adam Cohen (UC Berkeley); Benjamin de la Pena (Seattle Department of Transportation); Claire Enslin (Where Is My Transport); Efon Epanty (Fairfax County, VA); Danielle Guillen (Ateneo de Manila University); Bern Grush (Harmonize Mobility); Ralph Hall (Virginia Tech); Jackie Klopp (Columbia University); Holly Krambeck (the World Bank); Alan McKinnon (Kuehne Logistics University); Apiwat Ratanawaraha (Chulalongkorn University); Lauren Reid (Sidewalk Labs); Lake Sagaris (Pontificia Universidad Católica de Chile); Mimi Scheller (New Mobilities Research and Policy Center, Drexel University); Kristin Schondorf Slanina (Thirdware Solution INC); and Eduardo Vasconcellos (SSATP).

In addition, the **Improve** section drew upon information from over 60 global public and private sector thought leader interviews summarised in the report, *MaaS: Understanding and Accelerating the Demonstration-Learning-Deployment Cycle of Mobility-as-a-Service Globally,* A University of Michigan SMART University Research Project (URP) supported by Ford Motor Company, 2016–2018.[1]

1. Executive Summary

The Department for International Development (DFID), the United Kingdom's international aid agency, has begun a five-year research programme on high-volume transport (HVT), a term closely related to sustainable transport. The first phase of that programme is to assess the existing state of knowledge of HVT, which will inform the second phase of research in the programme. This report details the work conducted by the urban transport theme of the HVT programme. The first objective of this work is to develop a better understanding of what we know about HVT measures within urban transport, including the structures and capacities that enable HVT measures to be implemented. The second objective is to better understand the existing

[1] http://mobi-platform.com/wp-content/uploads/2019/03/18.12.10-SMART-MaaS-Report-PDF-Version-1.pdf

capacities in two lower-income regions, Africa and South Asia, and identify measures and capacity improvements useful for HVT measure implementation in these places. The final products for this work are a report, capacity-building guidance, and two papers submitted to peer-reviewed academic journals.[2]

The State of Knowledge review is based on a normative vision of transport developed by a coalition of institutions involved in the Sustainable Mobility for All effort. We adapt that framework to focus first on increasing access in cities, the primary purpose of urban transportation. For this review, we define high-volume transport (HVT) as **"regulations, infrastructure, and services that improve access to destinations in a way that enhances safety, addresses inequity, minimises environmental impact, and uses resources efficiently".** (We expand this definition in **Table 1**.)

THE GOALS OF HIGH-VOLUME TRANSPORT	
ACCESS	**Improves access to destinations, goods, activities, and services (primary goal)**
EQUITY	Addresses the needs of marginalised populations to access opportunity
ENVIRONMENT	Minimises the impact of transportation on the environment, specifically climate change and air pollution
SAFETY	Enhances the safety of all users of the street, especially the most vulnerable (pedestrians and cyclists)
EFFICIENCY	Uses resources efficiently, especially limited street space, but also money, land, fuel, and energy

Table 1: The goals of high-volume transport

By focusing on how to support this definition of HVT, the report supports the Sustainable Development Goals (SDGs), which were created in 2015 when all United Nations member states adopted the 2030 Agenda for Sustainable Development. Several of the 17 SDGs aim to improve cities and urban transport. SDG 11 aims to "make cities and human settlements inclusive, safe, resilient and sustainable". Target 11.2 aims to "provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons"(1). Through its focus on transport that minimizes environmental impact, the report also supports the Paris Agreement under the United Nations Framework Convention on Climate Change, a non-binding 2015 agreement signed by 195 countries to cut greenhouse gas (GHG) emissions and reduce the impact of global climate change. Finally, the report supports the New Urban Agenda (NUA), a 2016 agreement among 197 countries establishing guidelines for urban development for the next twenty years. The NUA aims to leverage better urban development, governance, and management to end poverty; reduce inequalities; achieve gender equality; improve human health; and protect the environment(2). The five goals of HVT outlined above overlap significantly with the NUA goals. By consolidating and presenting information on how to achieve HVT, this report supports the goals of the NUA.

To assess the state of knowledge, ITDP divided this report on HVT into four components: Enabling Structures; Land Use and Urban Development ('Avoid'); Transport Infrastructure, Services and Supporting Regulations ('Shift'); and Technology, Innovation, and Integration ('Improve'). Each component is broken into subtopics related to HVT. For each topic we surveyed peer-reviewed academic journals and 'grey literature' and

[2] "Opportunities and Barriers for HVT Systems in India and Sub-Saharan Africa" and "Using Data and Technology to Integrate Mobility Modes in Low-Income Cities" were submitted to the peer-reviewed journal Sustainability.

consulted with key experts on various topics. The research was primarily done in English, but we have also included key sources in Spanish, Portuguese, and French. We analysed these sources to identify key lessons applicable to the topic which formed the basis of the literature review. We identified gaps in the literature where little information was available. In addition, we conducted a series of interviews with key stakeholders across a sample of the city, state, and national governments in sub-Saharan Africa and South Asia. The stakeholders mostly represent the government sector and have a broad understanding of the capacity in each location. From these interviews we developed an assessment of existing capacity to implement HVT measures in these locations.

To develop this report, we reviewed over 900 sources and conducted over 48 interviews and consultations with public officials, researchers, and leading experts to understand the state of knowledge for HVT. **Figures 1-4** show the spread of results by country.

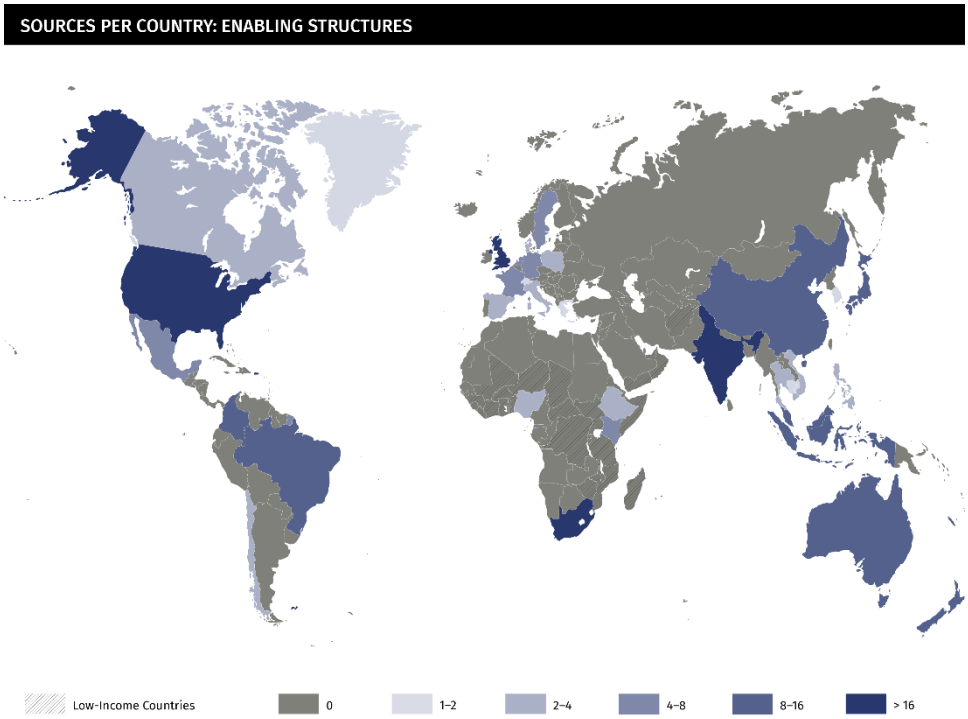


Figure 1. Distribution of Enabling Structures sources. Source: Created by the authors

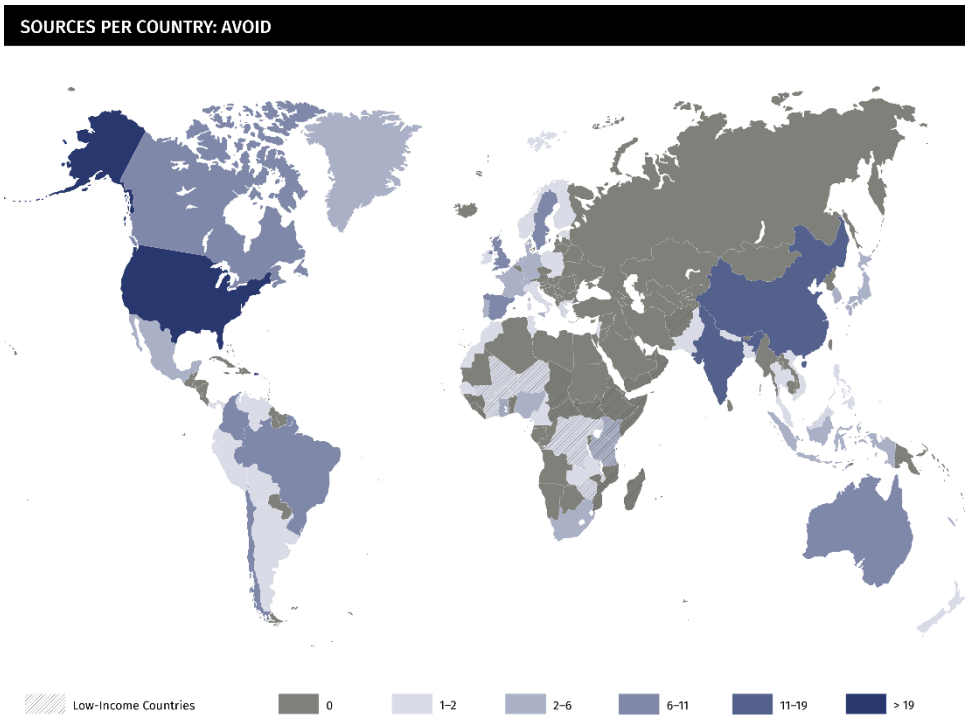


Figure 2. Distribution of Avoid sources. Source: Created by the authors

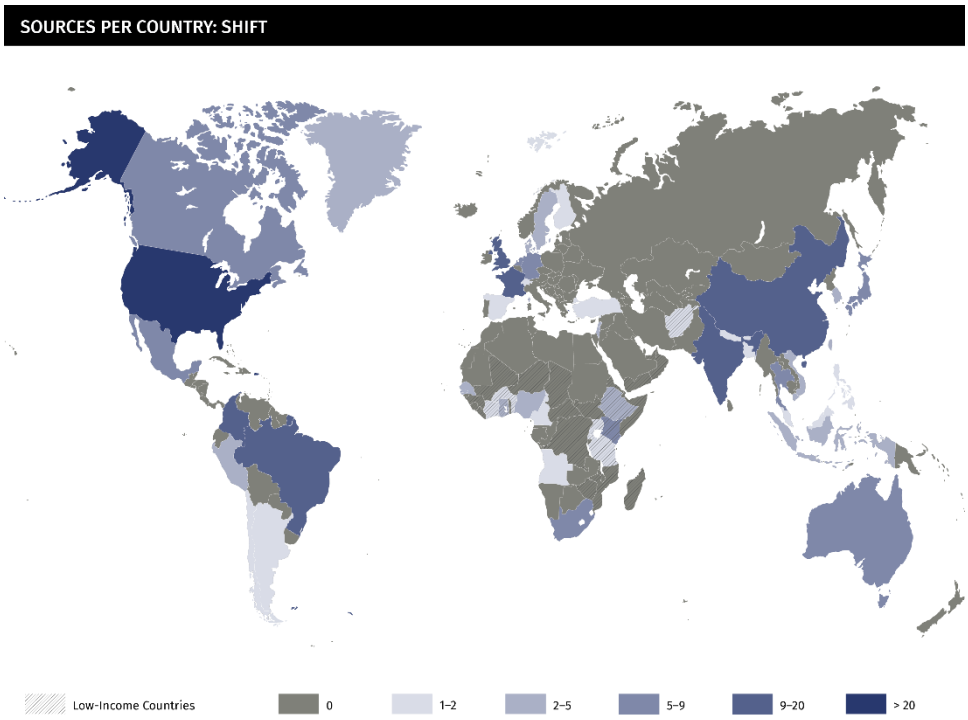


Figure 3. Distribution of Shift sources. Source: Created by the authors

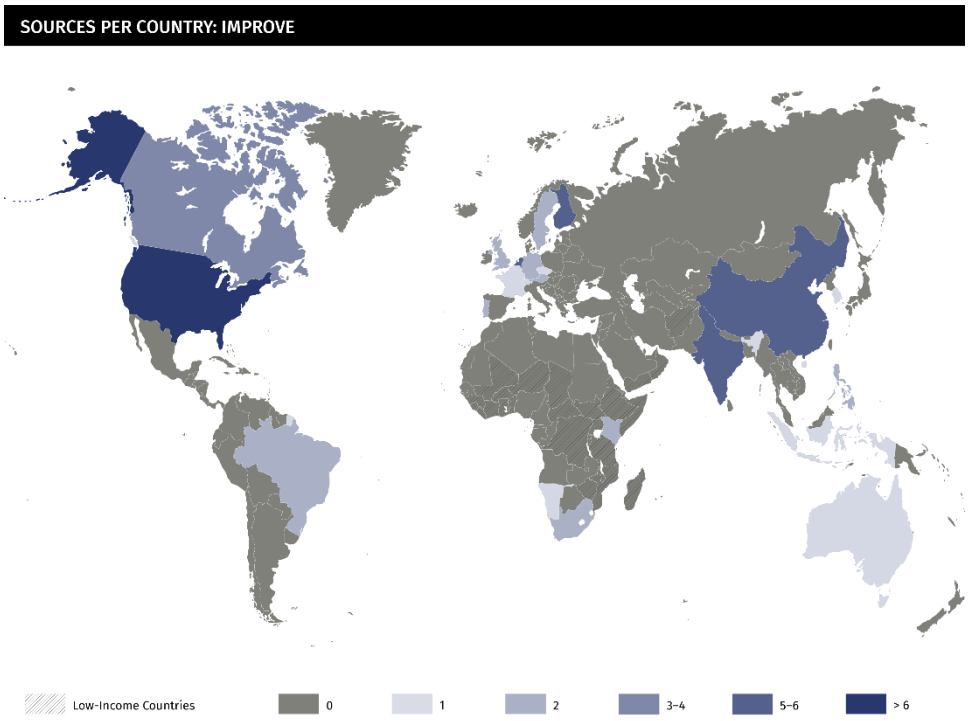


Figure 4. Distribution of Improve sources. Source: Created by the authors

We generally found that across all topics, academic-level knowledge was focused on HICs and MICs, with little research on LICs. We found a greater concentration of research in larger countries, particularly the United States, Brazil, China, and India. Across all topic areas, we found very little research in the Middle East and North Africa. Generally, Africa and Asia are also poorly represented in the research, apart from China and India. We were surprised to see the breadth of coverage for land use research across Africa and Latin America. We need a greater diversity of research across geographic and income level to more fully understand HVT.

We found more information about measures and technologies that have been in use the longest and experienced the widest range of use, such as metro rail and bus operations. We also found more detailed assessments of measures in the places where those measures are most prevalent. For example, we found more rail studies in the Asian context (where rail is more prevalent) and more BRT studies in the Latin American context (where BRT is more commonplace). There are differences in how large and capital cities function, but we did not account for this directly in the research. Our experience is that bigger and more prominent cities are wealthier and better represented in the research, while smaller, secondary and tertiary cities are poorer and are less represented in the research. While we attempted to account for this in the capacity assessment interviews, we did not find significant differences, and we were not able to quantify differences in the literature review.

Many of the studies we found focused on case studies in one or a small number of locations. We also found many highly specific technical research papers, which examined specific sub-aspects of measures, such as the impact of fare collection technologies and bus lanes. Broader assessments of measures, including meta-analyses and literature reviews, were rare. The result of this landscape is a fragmented understanding of the effectiveness of various measures for supporting HVT.

Research in the **Improve** section came predominantly from HICs, but studies of topics in the **Avoid** and **Shift** sections also focused more on HICs. Only for the **Enabling Structures** section did a majority of papers cover MICs. HVT freight research was low across the board. In the key geographies of South Asia and sub-Saharan

Africa, the amount of research was more or less comparable to research from other regions, especially other regions with many LICs and MICs. The most heavily researched topic area we identified is 'Shift: Modes and Services', which includes a large number of measures. Research from the Middle East and North Africa was particularly scarce.

We break our results into four categories: Needs for Urban HVT, Key Measures, Major Challenges and Knowledge Gaps, and Next Steps to Scale-up Urban HVT, shown in **Figure 5** below. Needs for Urban HVT reiterates the five goals of HVT and the general activities we identified to meet those goals. These reflect the general concepts that helped frame and inform the research. Key Measures describes the actions we identified in the literature that improve access and support the other HVT goals. There is more evidence for these in high-income countries (HICs), so applications to middle-income countries (MICs) and low-income countries (LICs) should be done cautiously in the local context. Major Challenges and Knowledge Gaps describes the primary areas we identified where HVT research and implementation capacity are lacking. From this, we identified key Next Steps to Scale-up Urban HVT. These are the priority areas for intervention to boost HVT. This includes new research areas, capacity building efforts, and which stakeholders to target.

NEEDS FOR URBAN HVT	GOALS OF HVT	IDENTIFIED NEEDED ACTIVITIES	
	1. Improve access to needs/goods	1. Enable HVT measure implementation	
	2. Reduce environmental impact	2. Integrate land use and transport planning	
	3. Enhance safety	3. Improve walk, cycle, and public transport	
	4. Increase equity in transport	4. Reduce vehicle travel/improve efficiency	
	5. Use resources more efficiently	5. Integrate passenger and freight transport systems	
KEY MEASURES	Raise awareness with study tours, etc.	Eliminate parking requirements	
	Build capacity of local governments	Implement curb management and road pricing for passengers and goods	
	Develop integrated master plans	Establish proactive arterial/street grid in rapid growth areas	
	Develop walking and cycling infrastructure	Adopt responsive policy measures	
	Improve public transport quality	Encourage standardised data for HVT	
	Allocate dedicated space for HVT	Integrate fare payments and structures	
MAJOR CHALLENGES AND KNOWLEDGE GAPS	KNOWLEDGE GAPS (GENERALLY)	CHALLENGES FOR URBAN HVT IMPLEMENTATION	
	1. Translating measures to LICs	1. Lack of political will/understanding of HVT	
	2. Role of private and informal sector	2. Poor stakeholder and public engagement	
	3. Government/institution structures in LICs	3. Poor technical and managerial capacity	
	4. How to counter sprawl in LICs	4. Poor coordination within/across governments	
	5. Means of transport integration for passengers and freight	5. Lack of funding and authority with local government	
	6. Impact of new technology applications		
NEXT STEPS TO SCALE-UP URBAN HVT	KNOWLEDGE NEEDED	CAPACITY BUILDING NEEDED	STAKEHOLDERS TO TARGET
	1. Capacity needs assessments	1. Rapid practitioner (re)training programs	1. Local decision makers (politicians)
	2. Rapid response tools for rapid growth	2. Peer-to-peer outreach and study tours	2. Local transport practitioners
	3. Transforming informal sector in urban development and transport	3. Institutional guidance and assessment tool	3. National transport ministries
	4. Design of policies and institutions for low-capacity environments	4. Pilot projects with documented results	4. Development banks
	5. Using technology/MaaS to leapfrog car ownership	5. Locally adapted standards and guidance	5. Research institutions
	6. Identify and equitably meet the needs of vulnerable groups		

Figure 5. Key research findings and next steps

The **Enabling Structures** research and **Capacity Assessment** interviews identified several factors supporting the implementation of HVT measures. We summarise the key capacity issues in **Table 2** along with measures we identified to address them. A lack of understanding of HVT and political will to implement HVT may be the biggest impediments to enacting HVT measures. Improved communications of the benefits of HVT and engagement with a broader group of stakeholders can help build political will and more resilient projects, in some circumstances. In our interviews, we found that there is a bias toward large projects, which are associated with more risk and less community engagement.

Enabling Structures Section	Capacity Building Needs	South Asia	Sub-Saharan Africa	Measures
Building and Engaging Political and Community Will	Lack of understanding and vision for HVT by decision makers and the public	✓✓✓	✓✓✓	• Study tours • Collaboration with NGOs and universities • Promotional and behavior change campaigns (car-free days, etc.) • Create strategic mobility plans (SMPs)
	Preference for large infrastructure projects	✓✓✓	✓	• Study tours • Involvement of informal stakeholders and local leaders • Increased capacity and authority at the local level
Governance and Institutions	Poor coordination within and among governments	✓✓	✓✓✓	• Unified metropolitan transport authorities (UMTAs) • Assessment tool for institutional creation (what staffing is needed, what levels, what skills) • Managerial skill development • Primers on contracting and managing the private sector
Education: Knowledge, Capacity, and Research	Lack of technical capacity in city staff for implementation and policy transfer	✓✓✓	✓✓✓	• Rapid response trainings (1-week courses) • Study tours • Peer-to-peer exchange • Collaboration with universities and NGOs
	Dominance of auto-centric solutions in decision-making frameworks	✓✓✓	✓✓✓	• Primer on causes of congestion and solutions to fix them • National and local standards and guides developed to reflect non-auto-centric planning
Funding and Finance	Lack of funding of local government and operations	✓✓	✓✓	• National government adequately funds local government and staff • Ongoing investment and subsidies for operations by national and subnational government • TDM pricing measures
	Lack of financing options for HVT implementation	✓	✓✓	• National policy for funding infrastructure big and small • Primer on PPPs and revenue risk • Developing financing shifted to HVT projects

Table 2: Capacity building issues and measures to overcome those issues

We found that more integrated governance structures are important to supporting measure implementation. While strong institutions are more effective at implementing policy, they are more resistant to change. Informal structures have greater flexibility. In LICs and MICs, the process of formalisation of transport services may increase government capacity and lead to safer and more efficient transport systems, but this may also lead to increased costs. The private sector can complement government in service provision if structured well, but further study is needed. The literature suggests that the national level can provide guidance, coordination, and resources for HVT implementation, but that the metropolitan and municipal levels may be best suited to implementing HVT measures if capacity exists.

The education and capacity of decision makers in government are also hypothesised in grey literature to play a key role in measure implementation. Multiple guides have been produced to boost local implementation capacity. Academic research has not addressed this topic well. There is a particular need to better understand the role of leadership in integrating agencies within governments.

In terms of funding, multiple researchers advocate for beneficiaries of measures to pay the cost of their implementation. In practice, many capital funding sources appear to be unrelated to policy beneficiaries. The literature suggests that the funding of service operations is more directly tied to beneficiaries through user fees, but that many places also subsidise services for low-income populations to improve equity. Many grey literature sources emphasise the need for continuous financial flows to support raising capital funds through debt and to support ongoing subsidies to operations.

In the Land Use and Urban Development section ('**Avoid**'), the literature suggests that a clear metropolitan-wide vision, effective coordination between land use and transportation planning actors, and effective governance structures to implement the vision and plans are key to developing land use that supports HVT. Within this framework, there are a variety of examples of success shown in the literature. The results were less clear on the role of national and subnational governments. There were many tools discussed in the literature, including land value capture and town planning schemes, that show promise as tools to implement

and finance land-use planning, although the details of measure implementation vary widely. The literature suggests that more inclusive methods of planning may be more effective at upgrading informal settlements to better achieve HVT.

The path to achieving sustainable HVT systems is not clear for cities in LICs and MICs, where the capacity to facilitate such metropolitan-scale coordination and visioning are often lacking. Several authors suggest simpler regulations can reduce the capacity burden on the government. Some proactive efforts have been made to prepare land for urban expansion, such as developing gridded street networks that support HVT, for both formal and informal development. Major gaps, however, include the tools governments in LICs might use to regulate land use, generate affordable housing and better integrate informal settlements into cities.

A number of guides provide recommendations on the specifics of how street and arterial networks should be planned. There is strong evidence that relatively high densities and a mixture of land uses are effective in supporting HVT. The literature suggests multiple strategies for changing land uses, based on different levels of government intervention. To maintain socioeconomic diversity, successful tools, particularly in LICs, include increasing density, limiting the size of housing units, and selling additional development rights to fund affordable housing. Other tools, such as inclusionary housing incentives and tax increment financing also work well in HICs.

The literature shows that urban design factors, such as active frontages and functional street lighting, strongly support walking in HICs. Design standards are used in many HIC cities and some MIC cities to facilitate environments that support walking. In addition, it shows that a greater supply of off-street parking leads to more driving. The research also suggests that increasing the price of parking may be an effective way to reduce parking demand and shift driving trips to other modes. Urban freight, however, has been studied less, particularly in LICs. In that context, the research suggests that planning for freight is rare and often done at the regional or national level. Finally, the impact of new mobility services on land use is not clear in the literature. It may reduce car ownership and lead to more compact cities, or it may lead to longer and more frequent vehicle trips and greater sprawl. More research is needed on urban freight, parking, and New Mobility as they relate to land use.

The information about transport infrastructure, modes, services and supporting regulations (‘**Shift**’) was the most technically robust of the four topics reviewed but still focused on specific cases, rather than on a broader understanding. The literature suggests a positive link between increased income and the use of private motor vehicles. Increased density and the provision of HVT measures and infrastructure are related to declining private motor vehicle use. Specifically, the literature suggests that increased street density and connectivity, particularly around transit stations, may lead to declines in private motor vehicle use. A number of studies have shown that dedicating space to HVT modes (walking, cycling, bus, rail, and HOVs) is associated with increased efficiency, accessibility, equity and road safety and with decreased environmental impacts. Finally, the literature links most road expansion to congestion and sprawl, but governments continue to expand road capacity to ease congestion. The street network, however, may benefit from increased connectivity as many cities in LICs and MICs have an insufficient network. This disconnect requires further study.

The provision of walking and cycling facilities is related to improved safety and health but is often neglected in LICs and MICs, despite a greater prevalence of walking and cycling due to lower incomes. Public transport usage varies widely around the world, with rail and buses providing most service in HICs and paratransit vehicles providing most service in LICs. The literature suggests that increases in public transit supply can help reduce traffic congestion. High public transport use is associated with lower greenhouse gas emissions and lower energy consumption. Urban rail and Bus Rapid Transit (BRT), in particular, are associated with higher land values and greater use of public transport in nearby areas. Research shows that BRT is the more cost-

effective solution and may be expanded more quickly, but rail has the advantage in operational speeds. BRT systems, particularly in LICs, have also experienced implementation challenges, including overcrowding, poor maintenance and low frequencies and are often regarded as 'second best'. Fare revenues rarely cover operating expenses, and many LIC and MIC governments, including in sub-Saharan Africa and South Asia, are reluctant to provide operating subsidies, leading to deteriorating service quality. Paratransit, or informal public transport, comprises most of public transport services in LICs, but it is associated with a lack of affordability and flexibility, poor road safety, poor quality of service and an inequitable distribution of service.

For public transit, walking, and cycling, a well-connected network is critical to improving HVT mode share. After that, the quality of service or infrastructure is the net driver for HTV mode share. For public transport, many users in LICs and MICs are sensitive to the affordability of services. In terms of service quality, users are sensitive to reliability, frequency, comfort, and safety—both in terms of personal security, especially for women, and road safety. In LICs and MICs, road safety is the main concern as those counties bear the burden of road crashes. Speed is the biggest factor in fatalities and injuries. The most vulnerable road users, pedestrians and cyclists, suffer the most. Motorcycle usage is rising in LICs and MICs exacerbating poor road safety. Little is known about how best to regulate motorcycles.

Travel demand management (TDM) measures, which aim to reduce demand for private motor vehicle travel, have spread from HICs around the world. Regarding parking, the literature suggests that the demand for on-street parking often exceeds the supply, leading to negative externalities, such as increased vehicle kilometres travelled. The literature suggests that pricing and access restrictions can be important tools in managing parking to avoid a negative impact. Additional research is needed to better understand how parking and curb space can be managed for Transportation Network Companies (TNCs), automated vehicles and urban freight, particularly in LICs. Road charging, or 'congestion pricing', in particular, has been shown to reduce congestion and emissions while raising revenue for governments, but researchers have found that the policy context and the planned use of revenue are important to political success. However, studies of traffic bans, commonly implemented in Latin America, show these measures to be ineffective at reducing congestion beyond the short term and leading to the additional purchases of cars.

The urban freight sector represents a large and growing portion of urban transport trips. Many academic studies have examined route efficiency, supply chain management, consolidation centres, non-motorised last-mile modes, and information and communication technology to improve the efficiency and sustainability of urban freight. The research in urban freight is dominated by HICs, while assessments in LICs have documented challenges such as extortion, poor road conditions, and insecurity. Many of the research gaps are from a lack of research in LICs, including the provision and distribution of infrastructure and services, and the process and structures for upgrading services, TDM, walking, cycling, and intermediate modes for freight delivery. Other key research gaps include measures for new mobility services and freight, broader geographical coverage for different modes, and better data and technology for monitoring progress.

In the Technology, Innovation, and Integration section ('**Improve**'), we found a small amount of academic research, possibly due to the rapid pace of change in the topic area. Yet there was not a lack of interest in the field. Many academics are closely following such changes, but the time frame required to produce academic-quality research means the research may be outdated by the time it is published. This suggests that a different approach to research may be necessary to understand this shifting topic. Academics have already adopted strategies to develop more rapid and qualitative assessments of trends and understanding based on expert consensus. There may be a greater need for such strategies as technology continues its rapid pace of change.

Recent research on information and modal integration reflects a shift from thinking about transport in terms of modes that compete for users, towards thinking about transport as a series of modes that can be combined to serve a variety of different trips, a concept known as 'Mobility-as-a-Service' (MaaS). Maas has benefitted from New Mobility options, such as TNCs, bikeshare and carsharing, which have grown substantially in the past decade. Research has shown that while these new technologies show promise in reducing pollution and congestion, TNCs have led to an increase in vehicle traffic in some places. In addition, many of the private business models that support these modes may include conflicts of interest that impede their success. There is some evidence, however, that carsharing has promoted a shift away from private motor vehicle ownership and use.

From a technology perspective, the literature suggests that the 'digital divide' appears to be eroding, with a growing presence of mobile and smartphones around the world. Now, the divide reflects a lack of access to data and internet service. Investment in technology and big data support the next wave of transportation improvements. The right technology network as a foundation could be an enabler of HVT. Vehicle automation could produce a variety of effects, including improved road safety and reduced emissions. It could also create increased road congestion and significant job loss in the transport sector. Researchers hypothesise that automated vehicles will become prevalent in HICs earlier than in LICs owing to the high cost of the technology. New technology is also enabling new means of data collection to better understand, regulate, integrate and improve existing services. This new technology and data also poses risks, particularly privacy.

New technology has fostered the rise of new business models, seen in TNCs and other New Mobility companies that have exploded in recent years. Business models specific to MaaS, however, have experienced obstacles to profit and growth, despite popularity among users. To catalyse new businesses and leadership environments, several HICs have created national programmes that fund innovative businesses in the transport sector working towards MaaS

Key research gaps include studies on more flexible, outcome-oriented policy frameworks, such as dynamic adaptive policymaking and the development of sustainable financing and business models. In addition, more research is needed into the role of leadership ecosystems in supporting more integrated and innovative transport systems. The freight sector, in particular, has received less attention and would benefit from additional research. There is a strong need for research in LICs to better understand the potential for leapfrogging (i.e., achieving rapid progress via new technology and integration).

Overall, we found a considerable amount of research on the implementation and assessment of HVT measures around the world. Generally, HVT measures are most extensively implemented and studied in HICs, but some measures, such as BRT, have been implemented more in MICs. Measures that have the longest history of implementation, such as metros, are the most widely implemented and studied. However, measures like congestion pricing have not gained widespread adoption, despite documented successes over multiple decades. Some newer HVT measures, such as bikeshare, have spread rapidly around the world, and are attracting commensurate research. Generally, the measures that promote HVT are frequently found in the mainstream of academia, civil society, development banks, United Nations organisations, most HIC governments, and many MIC governments. Yet acceptance of HVT implementation measures is lagging. LICs have seen little HVT implementation or research, despite rapid urbanisation and economic growth, except for some urban growth assessments. In South Asia and sub-Saharan Africa, many decision makers and technical practitioners are unfamiliar with HVT measures and appear to be strongly influenced by an auto-centric approach to transport and urban development developed in the United States. The most pressing next step is to increase understanding and acceptance of HVT among technical practitioners and decision

makers to increase implementation of HVT measures around the world, and to document these measures and implementation processes.

2. Introduction

The following report aims to describe the current "state of knowledge" of urban transport related to high-volume transport (HVT). We aim to identify effective HVT measures and the structures that support them, with a focus on low-income countries in South Asia and sub-Saharan Africa. The report reflects the Urban Transport theme of the United Kingdom's Department for International Development(DFID)'s five-year HVT research programme. In the first phase of the programme, researchers assess the existing state of knowledge of HVT, which informs the second future phase of research. DFID divide the first phase into four themes: Long Distance Strategic Road and Rail Transport, Urban Transport, Low-Carbon Transport and Gender, Vulnerable Groups and Inclusion in High-Volume Transport. In this report, we address the Urban Transport theme.

The report supports the Sustainable Development Goals (SDGs), created in 2015 when all United Nations member states adopted the 2030 Agenda for Sustainable Development. Several of the 17 SDGs aim to improve transport, as shown in **Figure 6**. A subset of the transport-related SDGs relate directly to cities and urban transport. SDG 11 aims to "make cities and human settlements inclusive, safe, resilient and sustainable". Target 11.2 aims to "provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons." SDG 9 also relates to urban HVT, aiming to "build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation"(1). The report also supports the Paris Agreement under the United Nations Framework Convention on Climate Change, a non-binding 2015 agreement signed by 195 countries to cut greenhouse gas (GHG) emissions and reduce the impact of global climate change.

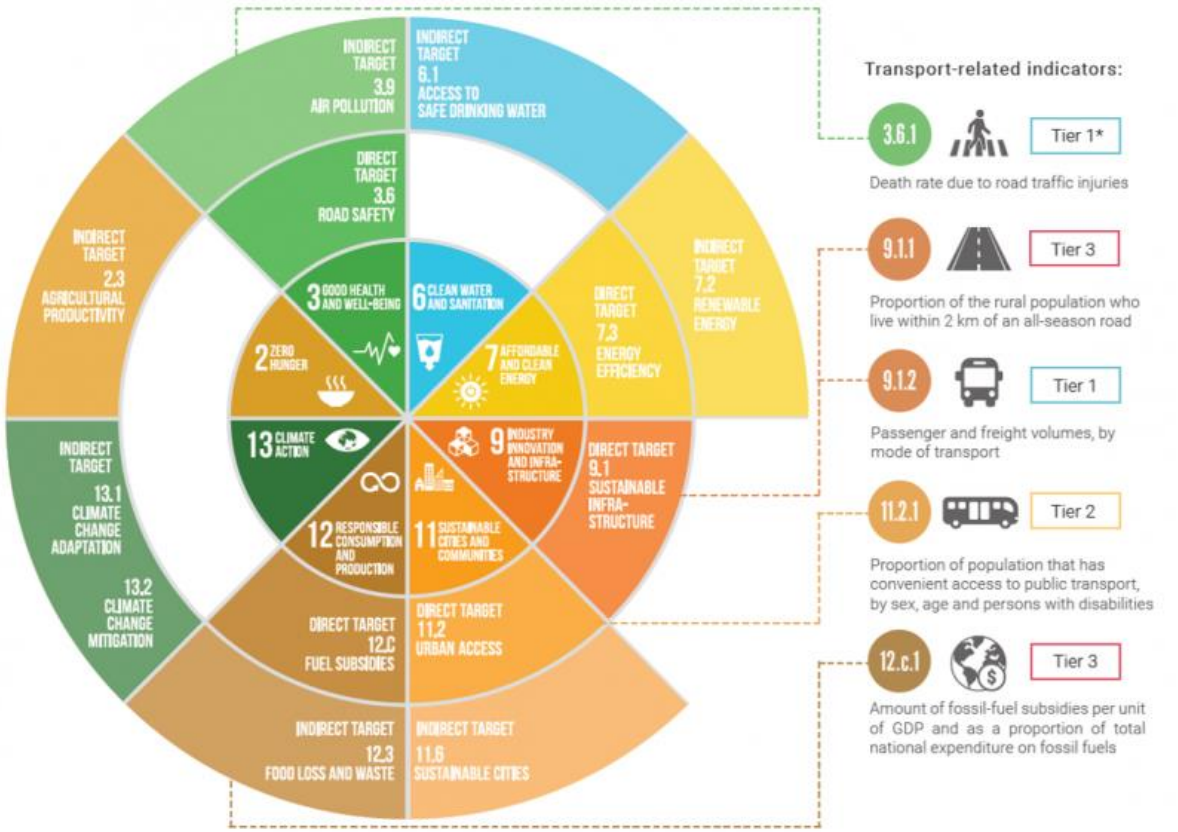


Figure 6: The Sustainable Development Goals related to transport. From the Partnership on Sustainable Low Carbon Transport

Transportation represents nearly 23% of global GHG emissions, and urban transport emissions are increasing quickly due to rapid urbanisation(3). The 2018 Intergovernmental Panel on Climate Change (IPCC) review Special Report on the impacts of global warming of 1.5° C[3] identifies urban transport as a key area to minimise climate change impact. The IPCC also recommends actions to avoid vehicle trips through land-use measures and to shift trips to modes with lower carbon emissions, specifically public transport, walking and cycling(4). Since HVT, by definition (see below), seeks to reduce environmental impacts, including lowering GHG emissions, a better understanding of how to develop HVT systems will support the Paris Agreement and meeting the 1.5° C climate change target.

The report also supports the New Urban Agenda (NUA), a 2016 agreement among 197 countries establishing guidelines for urban development for the next twenty years. The NUA aims to leverage better urban development, governance, and management to "help to end poverty and hunger; reduce inequalities; promote sustained, inclusive and sustainable economic growth; achieve gender equality and the empowerment of all women and girls in order to fully harness their vital contribution to sustainable development; improve human health and wellbeing; foster resilience; and protect the environment"(2). The five goals of HVT outlined below overlap significantly with the NUA goals. By consolidating and presenting information on how to achieve HVT, this report supports the goals of the NUA.

Researchers agree that there is great potential for a radical transformation of urban transportation, and that the existence of robust HVT measures is key to reducing the use of private motorised modes(5–9). This report aims to build on that opportunity. In the following introduction, we define HVT, discuss the context for urban transport with a focus on South Asia and Africa, describe the objectives of the research, and detail the scope of work we pursued.

2.1. Defining HVT and Resilience

Since we did not find a widely accepted definition of HVT, we assessed existing literature to develop our own definition. In a report by TRL and Evidence on Demand for the Department of International Development (DFID), high-volume transport is defined the following way:

"Most authors define low volume roads as being less than 200 to 300 vehicles per day and the definition of a high-volume road is then, by implication, any road with traffic levels in excess of this range(10).

In our view this is an incomplete definition because it focuses on the throughput of vehicles and not on the movement of people and goods. This definition reflects the traditional paradigm of vehicular mobility as the goal of transportation instead of seeking access for people and goods to destinations. For this report, HVT will focus on the modes that move the most people: walking, cycling and transit (see **Figure 7**), and efficient freight systems.

[3] Full title: "Global Warming of 1.5 °C: an IPCC special report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty."

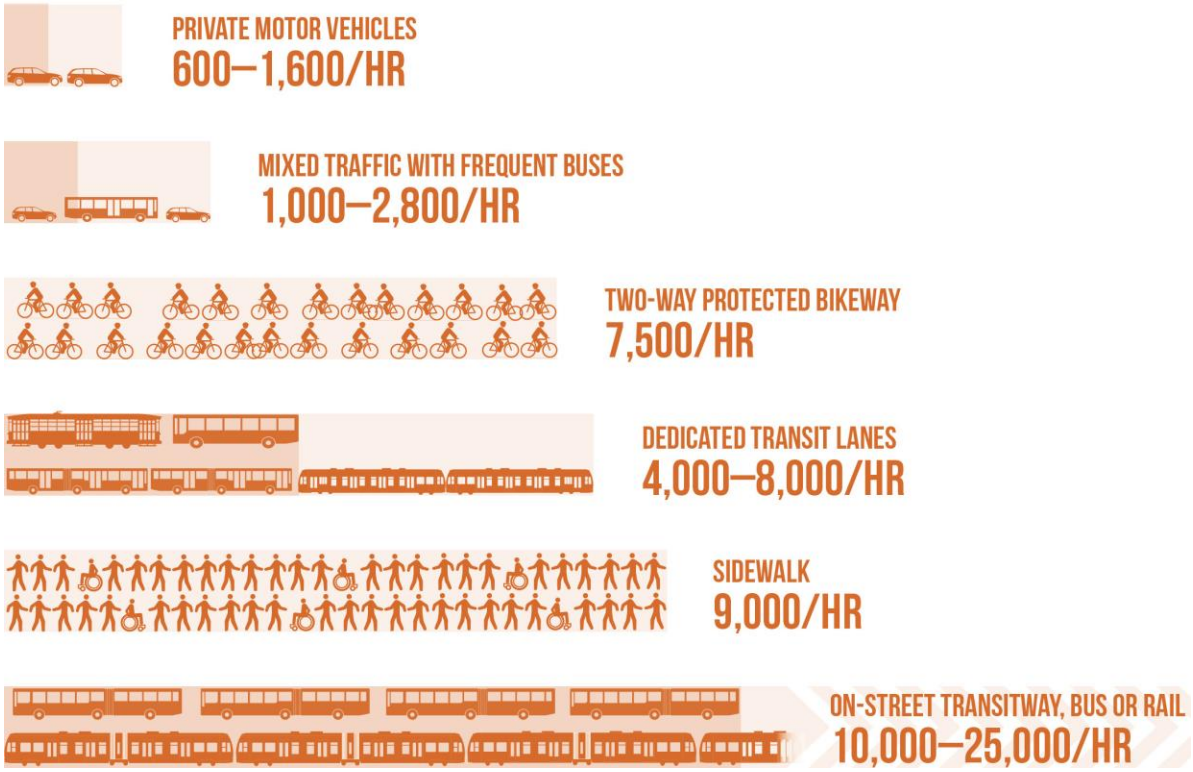


Figure 7: The capacity of a single 3-meter lane by mode at peak conditions with normal operations for road-based options. From NACTO's Transit Street Design Guide[4]

Transportation planners traditionally consider travel to be a derived demand (11–15), meaning the value of transportation comes from the activities that are realised at trip destinations, and transportation incurs costs that actors seek to minimise(11,16,17). This model minimises the costs of travel (both in resources and time) to the greatest degree possible. Conventional transportation planners seek to increase "mobility" by increasing the ability of travelers (and often auto users) to move around transportation networks at higher speeds(18).

However, researchers have questioned the benefits of higher speeds and mobility as the goal of transportation and have begun to prioritise access. Pointing to fixed travel time budgets (on aggregate, populations dedicate a fixed amount of time to travel), Zahavi (1974) questioned the validity of seeking travel time savings. While the concept of "mobility" seeks to reduce travel costs, "access" emphasises the ability to reach destinations are of value to travelers, which is the main goal of transport(16,19–21). Although access still views transportation as a derived demand (deriving value from the activities at trip destinations) because it de-emphasises speed and travel time savings (versus mobility), it emphasises transportation integration and land use planning(22). Further, emphasising access enhances opportunities to include the sustainable modes of walking, cycling and public transportation, as well as social equity and environmental concerns in transportation planning(23,24). Besides access, McCormick et al. point out the positive potential for urban transportation systems to impact energy security, environmental and social concerns, and improve equitable economic development(25).

Recently, international agencies and consortiums have adopted access as the basis of transportation goals. UN-Habitat's Planning and Design for Sustainable Urban Mobility used the concept of access to outline a normative framework to develop equitable and environmentally sustainable human settlements and transportation systems(26). By emphasising the need to provide affordable and safe transportation to

[4] BRT corridors with passing lanes and grade-separated rapid transit (elevated or underground) can achieve much higher capacities than those listed above.

vulnerable and marginalised groups (including pedestrians, the poor, and women), the report calls for improved conditions for walking and cycling, high-quality public transportation, and land-use planning to help create compact cities where these travel modes can thrive. Sustainable Mobility for All, a global consortium of 56 non-governmental agencies, global companies, United Nations agencies and development banks, founded in 2017 by the World Bank, developed a normative framework of sustainable mobility. The framework describes five pillars of sustainable mobility: Universal Access, Green, Safety, Efficiency and Gender(27).

The present State of Knowledge review is based on the normative visions presented in the UN-Habitat report and the Sustainable Mobility for All effort. We focus first on increasing access in cities, the primary purpose of urban transportation. For this review, we define high-volume transport (HVT) as **"regulations, infrastructure, and services that improve access to destinations in a way that enhances safety, addresses inequity, minimises environmental impact, and uses resources efficiently".** (We expand this definition in **Table 3**.)

THE GOALS OF HIGH-VOLUME TRANSPORT	
ACCESS	**Improves access to destinations, goods, activities, and services (primary goal)** [related SUM4All pillar: Universal Access]
EQUITY	Addresses the needs of marginalised populations to access opportunity [related SUM4All pillar: Gender]
ENVIRONMENT	Minimises the impact of transportation on the environment, specifically climate change and air pollution [related SUM4All pillar: Green]
SAFETY	Enhances the safety of all users of the street, especially the most vulnerable (pedestrians and cyclists) [related SUM4All pillar: Safety]
EFFICIENCY	Uses resources efficiently, especially limited street space, but also money, land, fuel, and energy [related SUM4All pillar: Efficiency]

Table 3: The goals of high-volume transport

In addition to defining HVT, we also attempt to assess the impact of measures on the resilience of the transport system. The concept of resilience is often viewed through the lens of climate change. Climate change actions include mitigation—efforts to reduce emissions of greenhouse gases from human activity, and adaptation—actions that reduce humans' vulnerability to a changing climate (28). The latter concept is also related to resilience, which IPCC defined as "the capacity of social, economic and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganising in ways that maintain their essential function, identity and structure, while also maintaining the capacity for adaptation, learning and transformation"(29).

Resilient cities with well-adapted urban planning and transportation systems can respond better to extreme weather events like hurricanes or floods(30). These events may incur significant social or economic costs, such as injuries or fatalities or increased travel times, delivery times for goods, and travel cancellations. Further, the cost of rebuilding transportation infrastructure after a disaster may be considerable(31). Transport and land-use planning are core activities of urban disaster risk reduction and require coordination between multiple stakeholders, according to Pelling. Local governments are excellent arenas to reduce urban vulnerability as they often have jurisdiction over transportation and urban form development, and can formulate creative responses to the challenges of adapting to climate change(32).

Noting that urban resilience is the topic of much research but is not well defined, Meerow et al. offer this definition: "Urban resilience refers to the ability of an urban system—and all its constituent socio-ecological and socio-technical networks across temporal and spatial scales—to maintain or rapidly return to desired functions in the face of a disturbance, to adapt to change, and to quickly transform systems that limit current or future adaptive capacity"(33)(p 45). The authors stress the need for researchers to consider five related issues: resilience for whom, what, when, where and why. Additionally, 100 Resilient Cities, an NGO established by the Rockefeller Foundation, adds that resiliency should address the chronic stresses (unemployment, food and water shortages, etc.) that may result from climate change. This would require a systems approach that strengthens the city's social and economic fabric(34). Thus, for this report, we define urban resilience as "**the ability of an urban system—and all its constituent socio-ecological and socio-technical networks across temporal and spatial scales—to maintain or rapidly return to desired functions in the face of a disturbance, to adapt to change, to address chronic stresses, and to quickly transform systems that limit current or future adaptive capacity**".

The study of resilience provides a broad socio-technical framework to analyse threats to infrastructure and disruptions to systems that include preparedness, response, recovery and adaptation(35). Resilience reflects a transportation system's capacity to persist when it is exposed to changes or shocks. Dynamic resilience relates to how quickly a transportation system can return to normal levels of functioning after a severe perturbation(36,37). We incorporated resiliency into the planning aspect of the literature review, but did not focus on how transportation systems need to respond to disruptions from climate change because research was limited. This is a gap that should be rectified in future research.

2.2. Context

The world is experiencing two simultaneous trends regarding urban transport (see **Figure 8**). In middle-income countries (MICs)[5] and especially in low-income countries (LICs). There is a widespread migration to cities that is projected to continue. This migration accounts for most of the world's urban population growth. Many poorer countries do not have the capacity to plan for and provide services for this migration. This has led to large-scale informal settlements and informal transportation services. As these countries grow wealthier, motorisation rates have increased, particularly since 1995. Much of this growth has come in the form of two-wheelers, also known as motorcycles, which greatly increase access for low-income people but are one of the most dangerous and high-polluting modes of urban transport(38–41). Although the supply of formal public transport service in LICs and MICs doubled between 1995 and 2012, it has not kept pace with urban population growth in these places(27). If this trend continues, motorisation will balloon in the coming decades, exacerbating existing issues of poor and inequitable access, injury and death, air pollution, increasing travel costs, and climate change.

In high-income countries (HICs), population growth has slowed significantly and is even declining in some places. This has corresponded to slower growth in motor vehicle use than in MICs and LICs, and even a decline in some cases. Some researchers have asked if HICs have reached peak travel(7). In Europe and most HICs, the supply of public transport has increased in proportion to the urban population and may account for some declines in motor vehicle use. Mode shares for walking, cycling, and public transportation are generally increasing, particularly in larger cities. However, despite these improvements, HICs have the highest rates of motor vehicle use in the world and experience the many downsides that accompany such heavy reliance on motor vehicles. The legacy of suburban and exurban development in the 20th century leaves a large part of

[5] Income levels are defined by the World Bank. In this report, we combine lower-middle income countries and upper-middle income countries as middle-income countries. https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups

the suburban population in HICs dependent on personal motor vehicles and without the urban environmental characteristics and density that enable HVT, such as public transport, walking, and cycling(27).

In cities, the movement of goods is an important component of the transport system, representing between 20% and 30% of vehicle travel, a number which is steadily growing(42). Researchers project freight volumes to grow by 70% between 2015 and 2030(27). Additional vehicle travel hinders HVT goals and is associated with more pollution, injuries, deaths and traffic. Given these trends, we ask whether rapidly growing cities can leapfrog past high rates of private car ownership and use HVT systems. (We discuss leapfrogging in more detail in the **Vision** section below.)

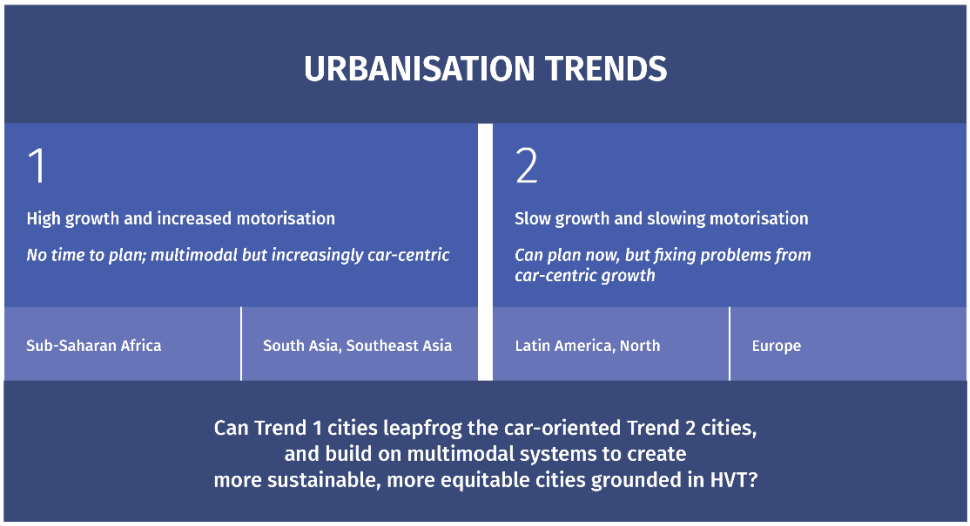


Figure 8: Trends in urbanisation. Source: ITDP

2.2.1. South Asia

With an estimated population of 1.8 billion people, South Asia is the most populous of the regions defined by the United Nations Geoscheme. Although there are eight countries in South Asia (MICs: Bangladesh, Bhutan, India, Maldives, Pakistan, and Sri Lanka; LICs: Afghanistan and Nepal) the three largest countries (India, Bangladesh, and Pakistan) account for over 95% of the region's population. India alone accounts for about 75% of the region's population. South Asia also has some of the planet's most populous cities: Delhi (25 million), Karachi (24 million), Mumbai (18 million) and Dhaka (16 million). India, Pakistan, India and Bangladesh are four of the largest megacities in the world[6]. South Asian cities have seen staggering growth in recent decades. They added 130 million residents (roughly the population of Japan) between 2001 and 2011 and an additional 250 million residents are expected by 2030 (43).

Cities in the region face large challenges regarding urban access. Over half of passenger trips and goods are made by walking and cycling (including rickshaws) in the region's densest, most congested cities; however, these modes "invariably" lack dedicated and safe right of ways(44)(p.1). Further, public transportation is characterised as overcrowded, inconvenient, and a mode for the poor. With large growth in peri-urban areas and relatively expensive (or non-existent) public transportation options, residents often face transport poverty(44). Motorisation often outpaces population growth in the region (e.g., increases in auto ownership are around 15-20% in most Indian cities), and motorcycles are also a burgeoning personal transportation mode(45). With this growth, the sustainable modes of walking and cycling now take a back seat to motorised transport in many cities in India.

[6] Population data from the 2018 Revision of World Urbanization Prospects: https://population.un.org/wup/

2.2.2. Sub-Saharan Africa

According to the World Bank's regional classification, sub-Saharan Africa contains 46 of Africa's 54 countries. Of the continent's 1.2 billion people, over 90% (1.1 billion) live in the sub-Saharan region. The largest urban agglomerations in sub-Saharan Africa include Lagos, Nigeria (13 million) and Kinshasha-Brazzaville, Democratic Republic of Congo and Republic of Congo (13 million people), Johannesburg, South Africa (9 million), and Dar es Salaam (5 million).

Urban population growth in Africa, while not as rapid as in Asia, has been historically high in recent decades(27). Research has shown that without affordable, effective public transportation options, regular use of motorised transport is unaffordable to poor residents(46). Related to the relatively high cost of motorised transportation (including public transportation), many African cities have a very high percentage of walking trips, e.g., about 70% in Dakar (REF Goddard) and Addis Ababa, and about 45% in Nairobi and Dar Es Salaam(47,48). Despite these high levels of walking, infrastructure for pedestrians is generally deficient, and efforts to improve conditions for people walking and cycling are scarce(49). A result of this is the world's highest regional percentage of pedestrian traffic deaths—more than half in the African sub-region(50). The region also has the highest overall rate of annual traffic deaths (26.6 per 100,000 people), nearly three times the rate in Europe (9.6 per 100,000 people). For LICs in Africa, the rate is even worse (29.3 per 100,000 people)(51). The elevated number of traffic deaths in many African countries threatens economic and social development(52).

Much of the urban growth in Africa is unplanned and in informal areas far from city centres, in areas with poor accessibility and infrastructure(46). These conditions exacerbate social inequalities in urban transportation(53). Despite these difficulties, some researchers highlight the innovative capacity of the urban transport sector in African cities as evidenced by motorcycle taxis becoming a major public transport mode(54), and others see existing low motorisation rates in urban Africa as a major opportunity to promote HVT modes(54,55).

2.3. Vision

Building upon our definition of HVT, we base our vision for urban HVT systems on several efforts. The first is ITDP's *Eight Principles for Better Streets and Better Cities*, released in 2011 (see **Figure 9**). ITDP develop these principles in collaboration with leaders in the field of urban sustainability: Gehl Architects, Nelson Nygaard Consulting Associates, the Shakti Sustainable Energy Foundation, and the ClimateWorks Foundation. The principles were published as part of ITDP's Our Cities Ourselves: Principles for Transport in Urban Life program(56).

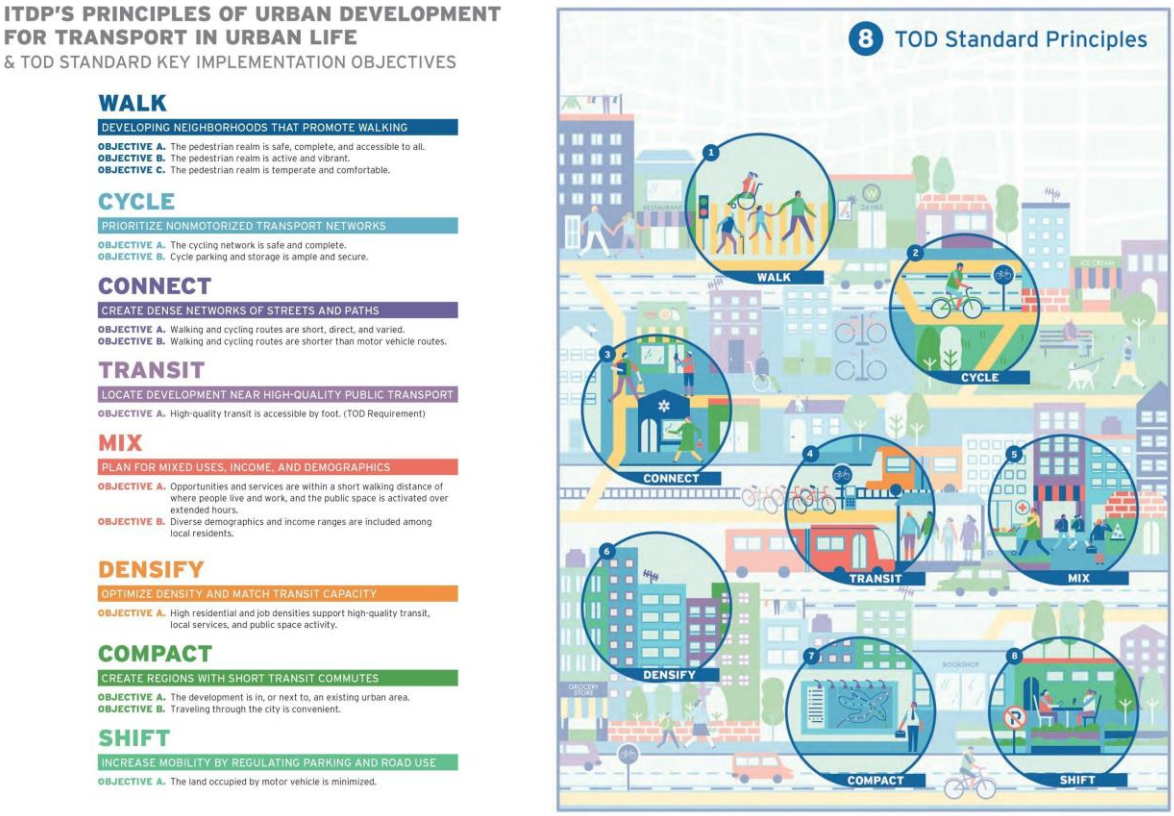


Figure 9: ITDP's TOD Standard Principles. Source: ITDP

We also base our vision for urban HVT on the 2017 Shared Mobility Principles For Livable Cities, which address recent developments in the urban transport space in setting a vision for the future of urban transport(57). A group of leading non-governmental organisations that focus on sustainable urban transportation developed the principles. Contributors include the C40 Cities Climate Leadership Group, ICLEI – Local Governments for Sustainability, Institute for Transportation and Development Policy (ITDP), Natural Resources Defense Council, Partnership on Sustainable Low Carbon Transport (SLoCaT), Transportation for America (T4America), Rocky Mountain Institute, Shared-Use Mobility Center, and WRI Ross Center for Sustainable Cities. Since the principles were released, over 132 businesses, organisations, and governments from over 25 countries and all global regions have endorsed them.

Ten Shared Mobility Principles for Livable Cities:

1. We plan our cities and their mobility together.
2. We prioritize people over vehicles.
3. We support the shared and efficient use of vehicles, lanes, curbs, and land.
4. We engage with stakeholders.
5. We promote equity.
6. We lead the transition towards a zero-emission future and renewable energy.
7. We support fair user fees across all modes.
8. We aim for public benefits via open data.
9. We work towards integration and seamless connectivity.
10. We support that autonomous vehicles (AVs) in dense urban areas should be operated only in shared fleets.

Finally, the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), a German development agency, lists the following 10 Principles for Sustainable Urban Transport:

- Planning dense and human scale cities;
- Optimizing the road network and its use;
- Implementing transit improvements;
- Encouraging walking and cycling;
- Developing transit-oriented cities;
- Managing parking;
- Promoting clean vehicles;
- Controlling vehicle-use;
- Communicating solutions;
- Approaching the challenges comprehensively(58).

Based on these three sets of principles and the concept of Mobility-as-a-Service (MaaS) (described in the **Improve** section), we envision HVT systems where all transport modes work together in a seamless, user-focused multimodal ecosystem. Transport modes and services are prioritised through space and resources by their impact on the goals of access, equity, environment, safety, and efficiency (see **Figure 10**). This results in urban areas built around networks of high-quality, frequent, and affordable public transport networks, complemented by safe, comfortable and well-connected walking and cycling networks. Dense and mixed land uses are planned and built in coordination with the transport network. People meet most of their needs by walking, and they meet other needs through a combination of bicycling and public transportation. Services, such as bikeshare, extend the coverage of the public transport network. Electric bikeshare, which is spreading in HICs and some MICs, has great potential to extend transit trips and reduce automobile trips. Private motor vehicles primarily serve the movement of freight and infrequent or specialised trips, e.g., transporting people who require personal mobility assistance.

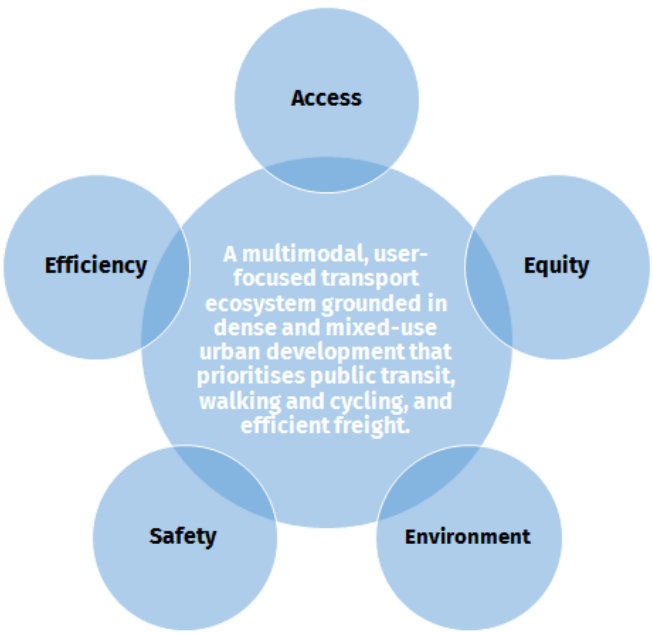


Figure 10: Vision for HVT. Source: ITDP

In LICs, cities channel rapid urban population growth into street grids that provide space for future public transport services and efficient freight movement. Innovations, such as blockchain and global positioning

systems (GPS), enable lower capacity governments to regulate private operators effectively and to create a seamless network. This trajectory allows LICs to leapfrog the typical pattern of transport policy pattern, described by the CREATE project (see **Figure 11**). In the typical transport policy development cycle, governments first implement expensive automobile infrastructure to accommodate increasing motorisation and demand. To mitigate increasing negative impact of car use, governments invest in public transport, walking, and cycling as alternatives to the car and impose some restrictions on car use. In the third phase, governments remove automobile infrastructure and place a heavy restriction on car use, and reallocate space to people(59). By leapfrogging the first step, governments avoid the high costs and negative impacts that have accompanied car-centric growth in other countries. The will save lives and money can be redirected to other development efforts, such as education, that will allow those countries to grow quicker, leading to a more equitable global distribution of wealth.

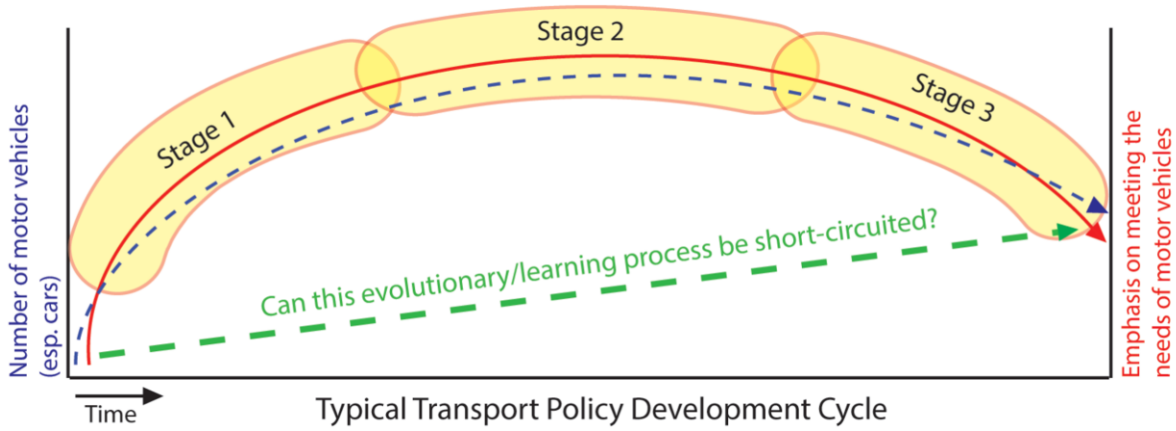


Figure 11. Leapfrogging the typical transport development cycle. Source: CREATE http://www.create-mobility.eu

2.4. Objectives

The main objective of this research project is to inform the future research agenda of the Department for International Development (DFID) by assessing the global state of knowledge regarding HVT for passenger and freight in urban areas. The aim is also to identify key gaps in the research, particularly as they relate to implementing HVT measures and transferring technology to LICs, with a focus on in cities in South Asia and Africa. By disseminating the results, we intend this work to lead to the implementation of more effective transportation measures on the ground.

Through an analysis of capacity needs in LICs and MICs, we seek to foster a better transfer of effective measures to these countries, a process also called technology and knowledge transfer. We assessed the existing capacity of governments at various levels in South Asia and Africa to implement effective measures and used that information to develop capacity-building guidance for those governments. We also aim to gain a better understanding, backed by evidence, of the measures that are most effective in improving passenger and freight transportation systems in urban areas served primarily by road and rail infrastructure.

By identifying research gaps, we intend to help develop a research agenda that clarifies key questions in urban transport, which will lead to better understanding capacity needs and improving selection of regulatory and engineering measures. Governments , development agencies, private sector actors and non-governmental organisations (NGOs) will be better able to select measures appropriate to local capacities, adapt measures to local contexts, and identify and improve capacity in a way that leads to the most effective measure transfers.

Our work should align with the work of the three other themes of the research project (Long Distance Strategic Road and Rail Transport; Low-Carbon Transport; and Gender, Vulnerable Groups and Inclusion in High-Volume Transport) and help provide the basis for a Phase 2 HVT research programme.

2.5. Scope of Work

The team has worked to clearly and discretely define the scope to ensure that this work is manageable in the time frame and with the resources available. The Enable–Avoid–Shift–Improve (E-A-S-I) framework, comprising four pillars (see **Figure 12**), first emerged in international urban transportation development practice to organise efforts to reduce transport-sector greenhouse gases(60–63). More and more, this framework is used to address social equity in cities, such as its adoption by the UN Centre for Regional Development(64), but that was not its original intent. As such, the E-A-S-I framework may be a little forced or rigid when addressing issues of equity. Given its common use in the transport sector (both practice and in academia) and its simplicity, it provided a reasonable framework for this research.

The E-A-S-I framework also aligns with a seminal paper by Banister that outlines a path toward sustainable urban travel(11). The paper emphasises measures that shift users to more sustainable travel modes (e.g., parking controls and road pricing to free road space for public transportation), reduce travel distances through land use policies (including dense mixed-use development), use technological innovation to increase efficiency in transportation (e.g., through improved fuel economies), and increase raise public acceptability (e.g., through educational events).

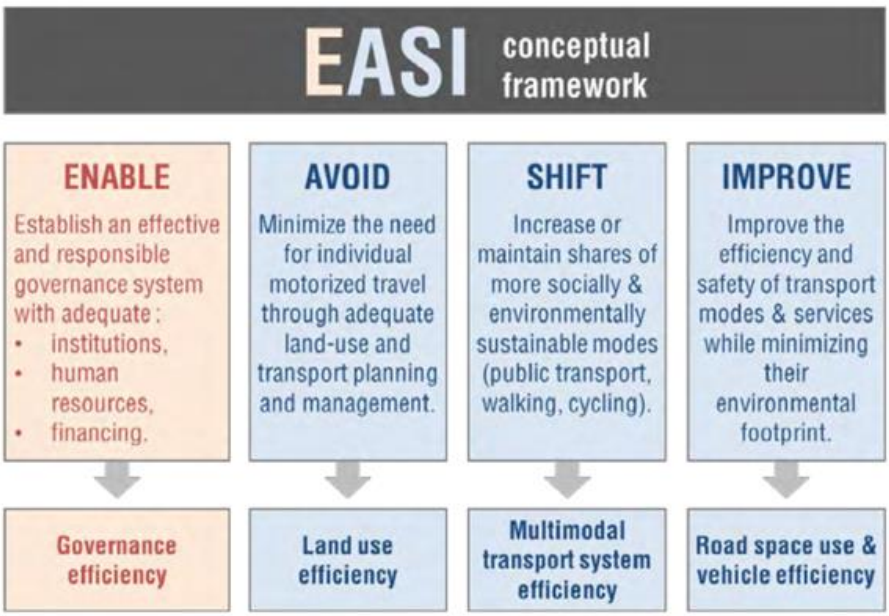


Figure 12: Schematic of the traditional Enable–Avoid–Shift–Improve (E-A-S-I) framework from Martin Stucki's approach and application to the African context. It expands the definitions to be more inclusive than just the traditional energy efficiency approach of A-S-I. (Stucki 2015)

While we recognise the limitations imposed by the E-A-S-I framework described above, we find it is a useful way to approach this research, given the breadth of the project. Finally, this framework was defined in the TOR research structure from IMC Worldwide. For all these reasons, we use the modified E-A-S-I structure to frame this review.

To address concerns with this framing, we attempted to define the framework to include as many measures as possible and not focus solely on the efficiency or environmental aspects. There was potential for measures that span multiple E-A-S-I pillars to be repeated or omitted. A good example of this was the street network which could be considered a land-use measure or a transportation infrastructure measure. To avoid

duplication or omission, we coordinated closely between pillars, erring on the side of duplication, as the impact of omission is stronger. We worked to combine sections when duplication occurred. (We explain this in more detail in the **Methodology** section.) Using this framework could also lead to including measures that meet the framework goals but have negative effects on one or more of the HVT goals. A good example of this could be the formalisation of informal transit systems, which may improve access and service, but could also generate higher societal costs and lead to job reductions for vulnerable populations. To account for this concern, we attempt to assess measures as comprehensively, using the HVT goals, to include negative impacts on HVT. Given the limited literature, the large number of measures considered, and the compressed timeframe of the research, this was not possible on a comprehensive scale, but we note these issues as much as possible.

Using the features of the (E-A-S-I) framework and Banister's paper as guidelines, noting the challenges described above, we defined the following four research areas for this review:

- AVOID: Increase land use and spatial efficiency to reduce trip distances; avoid longer distance, motorised trips; and create urban forms and land-use mixes supportive of sustainable transport modes;
- SHIFT: Increase transport system efficiency to shift modal share to more sustainable modes or shift the quality of service of those sustainable modes to retain modal share;
- IMPROVE: Increase trip efficiency by optimising and integrating systems for the user. This is the biggest departure from the traditional E-A-S-I framework: the team will not necessarily look at improving vehicle efficiency but at improving efficiency for the user;
- ENABLING STRUCTURES: Increase government efficiency to support a greater uptake by the public and improved implementation of sustainable urban transport.

To define our scope in a limited and manageable way within the allocated time frame and to avoid overlap with other groups, we used our understanding and expertise in the field to focus our research on a set of urban transport measures that support our definition of HVT (urban transportation that increases access in a way that addresses inequity, improves safety, reduces environmental impact, and uses resources efficiently) within the E-A-S-I framework described above. Within this set of measures, we aim to examine what the literature says about the impact of these policies and measures, focusing first on access to opportunity and then on the other four goals as time and resources permitted. (To better understand where specific policy measures are found within the report, we developed **Table 4** as a guide.)

Measure	Enabling Structures	Avoid	Shift	Improve
Public Transport	✓✓	✓	✓✓✓	✓
• BRT	✓✓	✓	✓✓✓	
• Rail	✓✓	✓	✓✓✓	
• Informal Transit	✓✓		✓✓✓	✓
Walking	✓	✓✓	✓✓✓	
Cycling	✓	✓	✓✓✓	✓
Ridesourcing/Shared Mobility			✓	✓✓
Parking (both on- and off-)		✓✓	✓✓	✓
Travel Demand Management		✓✓	✓✓✓	✓
Urban Freight		✓	✓✓	✓
Transit-Oriented Development	✓✓	✓✓✓	✓	
Compact Development & Sprawl	✓	✓✓✓	✓	✓
Governance and Institutions	✓✓✓	✓	✓✓	✓
Private Sector Integration	✓✓✓	✓	✓✓	✓✓✓
Education and Capacity Building	✓✓✓	✓	✓	✓
Funding and Finance	✓✓✓	✓	✓	✓
Data and Technology	✓		✓	✓✓✓

Table 4: Defining scope of work and specific policy measures

We intend our research to be practice oriented; in other words, we looked primarily at literature with findings that are most applicable to policy practice. This included examining policies that run counter to HVT goals, as eliminating them or reducing their impact would help improve access and other HVT goals. A review with a scope as broad as ours will inevitably omit many important areas of investigation and pieces of literature. However, by using internationally accepted normative frameworks for sustainable urban transportation (notably, access and the E-A-S-I framework), our review will produce intellectually rigorous results relevant to the multitude of actors involved in improving urban transportation systems, including researchers, multinational development banks (MDBs), government transportation officials, and civil sector organisations.

In this report, outlined in **Figure 13** below, we detail the information we collected since the urban transport project commenced on 25th July 2018. This includes an account of our methodology and protocols used to guide the work and mitigate risk. This report also details the state of knowledge research findings and the gaps in the research we identified across the four research areas. We conclude with an assessment of the literature, a summary of the research findings, and a proposal for future research.

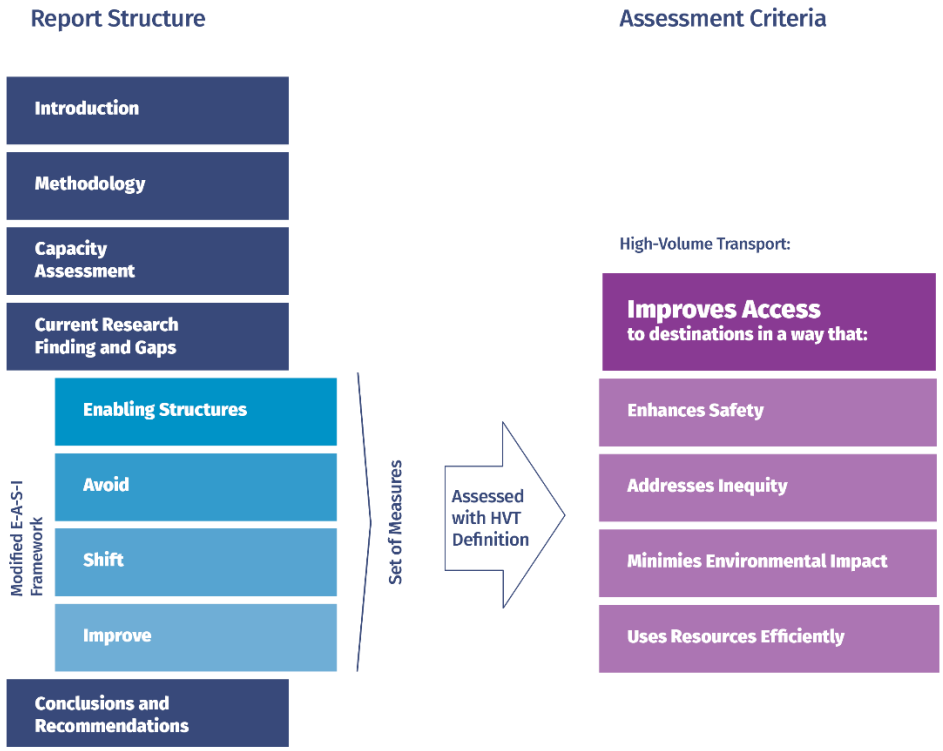


Figure 13. Outline of report structure

2.6. Relationship to Other HVT Themes

The Urban Transport theme is part of a larger research programme which includes three other research themes, described above. There is significant overlap between the Urban Transport theme and the other themes. We have the least overlap with the Long Distance Strategic Road and Rail Transport theme, which focuses on travel between urban areas and between urban and rural areas. Potential overlap occurs at the boundary of what is considered urban and rural. The definition and extent of what is considered urban determines which measures affect trips within urban areas (covered by the Urban Transport theme) and what measures affect trips between urban areas and between rural and urban areas (covered by the Long Distance Strategic Road and Rail Transport theme). The sources we found fell clearly within one of the two themes.

We found significant overlap between the Low-Carbon Transport and the Urban Transport themes. There are traditionally three pillars of carbon reduction in transportation: Avoid (unnecessary travel), Shift (to less polluting modes), and Improve (the emissions of modes), as described in the introduction. Researchers in the Low-Carbon Transport theme address all three pillars of carbon reduction across all modes and geographies of transport. For the Urban Transport theme, we only address measures related to urban areas. To avoid overlap, we only address measures related to Avoid and Shift measures, which are more focused on improving access. The measures discussed in the Urban Transport theme, by definition, reduce fuel consumption from motor vehicles specifically, resulting in some overlap.

Finally, the Gender, Vulnerable Groups and Inclusion in High-Volume Transport theme has significant overlap with the Urban Transport theme, as transportation is often distributed inequitably and people are excluded from the transportation system in urban areas. Anecdotally, crime against women is high in urban areas. Many of the measures investigated in the Urban Transport theme, such as improved walkability and a more robust public transportation system, foster significant improvements for women and vulnerable groups, if implemented well. We have addressed these topics in a limited way to provide context without large overlap with the other theme.

All areas likely overlap with the Urban Transport theme's enabling structures component. There are many structural preconditions to enacting successful HVT measures that do not vary by subject area or geography. These preconditions, however, may be difficult to combine without negating the direct links between enabling structures and the specific measures they address in each section.

3. Methodology

This section details how ITDP structured the research to be as comprehensive and as time efficient as possible. We approached the work through two main streams: the capacity assessment in sub-Saharan Africa and South Asia. We used a qualitative approach consisting of targeted stakeholder interviews and a more comprehensive state of knowledge literature review of both peer-reviewed and grey sources on HVT.

3.1. Capacity Assessment Methodology

The World Bank defines Capacity Building (a.k.a. capacity development) as "a locally driven process of learning by leaders, coalitions and other agents of change that brings about changes in sociopolitical, policy-related, and organisational factors to enhance local ownership for and the effectiveness and efficiency of efforts to achieve a development goal"(65). To understand how effective measures and are where capacity building efforts might be applied in cities in South Asia and sub-Saharan Africa (SA and SSA), ITDP conducted a series of interviews with stakeholders from countries, states and cities in these regions. More detail on the literature assessing the importance of different aspects of capacity can be found in the **Enabling Structures** section. The literature on capacity building efforts can be found in the **Capacity Building** section. The following section describes the goals and aims of the interviews; considerations for geographical selection; the framework for selecting countries and cities; the selected countries, states, and cities we assessed; and the process for conducting the interviews.

3.1.1. Aim of Interviews

We conducted 28 interviews with key stakeholders in India and Sub-saharan Africa who have a broad understanding of the conditions in their locations. Interview subjects described the conditions and capacities

of governments to implement measures, including any obstacles that prevent them. We combined this information with the information collected during the parallel state of knowledge research on effective measures and the enabling structures that support them. From this set of information, ITDP developed capacity-building guidance to support effective measures that would be most beneficial to those locations.

3.1.2. Considerations

To ensure that this effort is productive, we identified the following goals and constraints when selecting a geographic focus:

- Produce results within a narrow time frame;
- Reflect a range of conditions and political will for engaging innovative approaches across the two regions;
- Reflect the conditions faced at different levels of governance by a variety of stakeholders, including the private sector;
- Reflect countries that are strategically important to DFID (see **Table 5** below);
- Avoid overlap with other research themes.

3.1.3. Framework for Selecting Geographies

Based on the considerations defined above, we developed the following selection criteria to guide the selection of geographies.

1) Produce results in a narrow time frame:

   Given the need for a quick analysis, we focused on cities, states, and countries where we have strong existing relationships and partners with a breadth of knowledge so that multiple topic areas can be covered in each interview. This focus helped to reduce bottlenecks and ensure quick responses and action. We prioritised:

   - ITDP and partners contacts;
   - The PMU team;
   - DFID contacts;

2) Reflect a range of conditions:

   - We assessed three distinct subregions per region, with a minimum of one country/large state in each subregion. We selected the countries/states to reflect similar conditions with other countries/states in the subregion;
   - We targeted at least three (but no more than six) cities per subregion; the selected cities cover a range of sizes (small: <1 million, medium: 1-5 million, and large: >5 million) and different levels of capacity typically stemming from their level of prominence in a country (primary and secondary);
     - We focused on medium-sized cities (1-5 million population), since that is where projected urban growth in coming decades is expected to happen fastest, with populations growing 36% between 2014 and 2030(United Nations Department of Economic and Social Affairs 2014);
     - We aimed to capture at least one primary city in each region. This helped to account for unique conditions in these cities, given their increased level of influence, money and

capacity, and their tendency to support progressive work. Primary cities are also the places with the strongest private sector and research institutions;

- We did not focus on tertiary cities;

3) Reflect a range of levels of government:

   We interviewed at least two levels of government since capacities may differ by level:

   - In South Asia, we focus on national, state and city level governments. We focus on state governments as a locus of power in the region. The national government has a strong hand in capacity building and setting standards;
   - In Africa, we focus primarily on central and city-level governments. Except for South Africa, most countries in Africa are fairly centralised in power and capacity at the national level. Cities have relatively little money, authority or capacity;

4) Strategic importance:

   To produce practice- and research-relevant results for DFID, we chose countries and cities that:

   - Are DFID-defined LICs;
   - Are experiencing rapid urban growth;
   - Have significant levels of informality (in transport and urban development); and
   - Include some areas with an existing interest in innovative approaches.

5) Avoid overlap with other research themes:

   ITDP shared our proposed locations for analysis with the other research themes—Long Distance Strategic Road and Rail Transport; Low-Carbon Transport; and Gender, Vulnerable Groups and Inclusion in High-Volume Transport—to avoid overlap and to maximise coverage of different areas.

Based on the criteria defined above, ITDP identified geographic alignment between DFID-defined LICs and locations with ITDP presence in Africa and South Asia (shown in green boxes below).

Table 5: Country presence comparison Source: ITDP

On the basis of this overlap and the criteria for South Asia, ITDP and IMC Worldwide agreed to focus on India, targeting three states in different subregions of the country and at least one city within each state, and the national government. India is a big and diverse country, and each state essentially could be another country in terms of population and the different contexts in which the states function. For Africa, ITDP focused on three subregions: East Africa, Southern Africa, and West Africa. We chose one national government and one city in each. We excluded South Africa from consideration since it is an outlier in terms of the wealth and demographics in the region.

3.1.4. Selected Countries, States, and Cities for Assessment

On the basis of ITDP's proposal, subsequent discussions with the programme funder, and the programme management unit, ITDP selected the following geographies:

South Asia

- **National:** Indian National Government
    - **State:** Tamil Nadu (South India)—an example of a middle- to high-income state of India with a high state of urbanisation, but with smaller cities (top ten cities range in population from 345,000 to 7 million, and 15 cities have populations greater than 200,000)
        - **City:** Chennai (population: 10.7 million—the primary city of the state)
    - **State:** Maharashtra (Western India)—an example of a higher-income state of India (the wealthiest in the country) with a high rate of urbanisation and larger cities (top ten cities range from 550,000 to 18 million, and over 30 cities have populations greater than 200,000)

        - **City:** Pune/Pimpri Chinchwad (population: 6.2 million—the secondary city of the state)
    - **State:** Jharkhand (Eastern India)—an example of a lower-income state of India (it is the second poorest state in the country) that is mostly rural (the top ten cities range from 120,000 to 1.3 million and 6 cities have a population greater than 200,00)
        - **City:** Ranchi (population: 1.3 million—the primary city of the state)

Africa

- **Region:** East Africa
    - **National:** Ethiopian National Government
        - **City:** Addis Ababa, Ethiopia (population: 3.6 million—the primary city of the country)
        - **City:** Mombasa, Kenya (population: 1.4 million—the secondary city of the country)
- **Region:** Southern Africa
    - **National:** Zambian National Government
        - **City:** Kitwe, Zambia (population: 0.7 million—the secondary city of the country)
- **Region:** West Africa
    - **National:** Nigerian National Government
        - **City:** Accra, Ghana (population: 2.4 million—the primary city of the country)

3.1.5. Participants

We selected study participants, decision makers and private sector actors, via non-random convenience and snowball methods. We recruited the first group of participants based on pre-existing relationships with the researchers and their knowledge of implementation and transfer of HVT policies (convenience sample), according to the criteria above. Researchers also asked participants from the convenience sample to recommend other interview subjects (snowball sample).

Field researchers spoke to 28 participants (14 from each region). (See **Table 6**.) Study participants were overwhelmingly from the public sector, with a few participants from NGOs and the private sector (consultants). All but two participants were male, although we do not have information on the representation of women in each institution at different levels. We believe that this reflects a lack of women in leadership and professional transport positions. However, it may also reflect our own gender biases in the participants we identified to interview.

	Profession						Gender	
Region	Consultant	Government - Municipal	Government - National	Government - State	NGO	**Total**	Female	Male
Sub-saharan Africa		7	5		2	**14**	2	12
South Asia	2	6		5	1	**14**		14
Total	**2**	**13**	**5**	**5**	**3**	**28**	**2**	**26**

Table 6: Interview subject information

Public-sector participants came from various levels of government. In India, participants were from the national, state, and municipal levels. Partly due to India's large size, state governments are very important in urban transport policy formulation. The state level is, however, much less important in the African countries we spoke to. In Africa, participants came from the national level or from municipalities.

ITDP's field offices in India and Africa identified the participants, leaders in the general field of HVT in their respective organisations, who occupied influential positions. Most were career technocrats, but a few were in political positions and elected officials. Participants had considerable professional experience in the field, ranging from five years to several decades.

ITDP's field office staff in India and Africa made clear the importance of maintaining anonymity for study participants. The information participants shared was sensitive as their professional standing could be harmed should their identities be revealed. For this reason, we removed all names from the data and refer to the participants by region and interview number. For example, participant "I6" is the sixth interview from India, and participant "A12" is the twelfth interview from sub-Saharan Africa. We also do not specify the identity of the participants beyond their country (for Africa) or state (for India). This is an effort to protect participants from any potential negative consequences of this study.

3.1.6. Interview Protocol

Similar to the above effort, the content manager, with assistance from the core research team, developed an interview protocol for the capacity assessment interviews. The following summarises the protocol found in **Appendix A**.

The lead researchers and field researchers are employed by or affiliated with ITDP, which has been working in Africa and South Asia since the 1990s. The researchers interviewed 28 government and private-sector employees. Researchers recruited study participants through telephone and/or email notifications.

We designed the study to gather rich research- and practice-relevant data while minimising risks for participants. Researchers carried out most interviews in person. We interviewed government employees and public transportation operators in their private offices or homes, and public spaces, such as cafés and outdoor eating areas. This approach is culturally sensitive to the social norms of each group of participants. When face-to-face interviews were not possible, researchers conducted interviews via telephone or web-based tools (e.g., Skype).

Researchers obtained verbal consent from all participants. This consent statement includes an acknowledgement that participants can remove themselves from the study at any time and that the decision to participate or not to participate will not jeopardise their professional standings. During the verbal consent process, we asked the interview subject to state who he/she is, the reasons for the study, that the interviewees are not obligated to answer questions that would make them uncomfortable, and that they

have a right to stop the interview at any time. The researchers also asked permission to document the conversation with written notes and an electronic recording device.

All interview subjects are identified generically. At the close of the interview, the field researchers asked the interviewee how best to be identified to protect their anonymity. (For example, 'municipal transportation planner, Accra'.) During interviews, no participants were asked to reveal insider information about their companies or organisations, which could pose a risk to their professional or social standings if such responses were disclosed. Instead, questions were framed broadly to gain insight without exposing specific people or important information.

We developed instructions for field researchers, including a list of questions to ask the interview subjects. A webinar was conducted to train all field researchers in this interview protocol. The webinar was recorded and uploaded to the project intranet site with the protocol. The interviews were conducted by ITDP staff with close connections to the interview subjects in each geographic location. The interviews were open-ended, meaning that the questions and answers are not as specific as in a survey, which only has a limited amount of possible responses. Field researchers in India and sub-Saharan Africa tailored the interview questions to best fit the local context. The questions were on topics related to the governance of HVT and interviews lasted between 40 and 60 minutes. The interviewers took notes during the interviews while using the interview protocol. We recorded the interviews (with subject approval), and stored the material in a central database. From the interview and notes, we compiled information about the interview. Interviewers shared their transcripts and first impressions of takeaways from the interviews with the core research team, who compiled all interview transcripts. The core research team used the transcripts and notes to discover common themes and emerging topics from this qualitative data. The researchers used "lean coding" to organise the interview content into themes(66).

3.2. State of Knowledge Methodology

We centred the methodology for the state of knowledge research on desk-based research. We aimed to develop a catalogue of actions for sustainable urban transport and to document the existing research about what is understood about these actions, as they relate to HVT. As part of this research, four teams each focused on one component of E-A-S-I.

The 'Enabling Structures' team examined the following as they relate to supporting measures that improve HVT:

1. Building and engaging political and community will;
2. Governance and Institutions;
3. Education: knowledge, capacity, and research;
4. Funding and finance.

The 'Avoid' team focused on urban development and land use and its relationship to transport in three areas:

1. Regulation of land use and built form;
2. Metropolitan compact growth and urban retrofit measures;
3. Land use and urban freight.

The 'Shift' team focused on the transport infrastructure and services in cities, including:

1. Infrastructure;
2. Modes and services;

3. Urban freight services and regulations.

The 'Improve' team focused on measures that improve both the components and the systems of HVT, which include:

1. Integrative technologies, data, and platforms;
2. Innovative business, financial, and regulatory approaches;
3. Leadership ecosystems.

We treated this section of research as a literature review of each topic. Each team was instructed to focus first on collecting peer-reviewed research. When academic, peer-reviewed information was not available, the teams relied on non-academic 'grey literature' to complete the picture of the state of knowledge for each topic area. We stored the literature sources in a spreadsheet that ITDP constructed for this work. The core team focused efforts on research published since 2008. This corresponds to the publication of the seminal papers and (Santos et al. 2008), which set the stage for future research on the subject(11).

We used different search terms in Google Scholar to find peer-reviewed articles. These were also documented in the sources spreadsheet. Finally, strategic consultations were conducted with key experts in transportation and land-use research to identify additional sources relevant to the topic areas. These experts also helped to identify additional experts, in a process we refer to as 'snowballing'. The consultations also identified crucial literature and key emerging trends. These consultations were also documented in the shared sources spreadsheet. (A full list of consultations can be found in **Appendix B**.)

Data about the sources was documented on the spreadsheet to ensure that information could be easily reviewed, compiled and cited as part of the full literature review

3.2.1. Research Languages

The project team assessed sources in several languages, including French, Portuguese and Spanish. Key experts in each language were consulted to identify sources in each language. For example, Portuguese- and Spanish-speaking experts were consulted with to identify literature in those languages that covered transportation infrastructure and services as well as enabling structures. While most sources were in English, we included 24 sources in French, Spanish, and Portuguese.

3.2.2. Assessing HVT Measures

The literature on HVT measures is broad and varied. Our general approach for assessing transport measures involves assessing how well the measure leads to the five HVT goals (access, equity, safety, environment, and efficiency) defined above. When the literature did not address these criteria, particularly for passenger transport, we looked at how the measures support increased use of the HVT modes (walking, bicycling, and public transportation); higher use of these modes is a general proxy for support of the HVT goals. Within each section of the literature review, we structured the assessment as follows:

Overview and Context:

- Overview of Topic Structure;
- Description of General Trends;

State of Knowledge—For each measure we include the following, as available:

- Introduction;
    - Definition of the measure;
    - How the measure relates to HVT;

    - Any theory on impact (as applicable/available);
- Description of the current implementation extent, distinguishing HIC, MIC, and LIC, as available;
- Description of measure/set of measures impact on HVT goals as demonstrated in literature, distinguishing HIC, MIC, and LIC information, as available;
- Summary of knowledge and gaps in knowledge for measure/set of measures, particularly as they relate to adaptation and implementation of measures in LICs.

3.2.3. Identifying Research Gaps

In identifying key gaps in the literature, we outlined the prevalence of information on each measure by geographic location and income status. Each research team did a qualitative assessment of the contribution to HVT of the measures they assessed based on the literature they reviewed and professional and expert experience. From this, we identified the measures with both a high contribution to HVT goals and limited information, particularly for LICs and MICs as key areas to explore for future research.

3.2.4. Style Guide Adherence

ITDP was provided with the style guide developed by DFID. We provided all project team members access to the style guide via email and the ITDP intranet. The research manager and content editor used the style guide to review and edit the document to ensure that the guidelines were followed.

3.2.5. Literature Review Protocol and Research Webinar

The literature review was guided by a research protocol that clearly delineated the process for identifying, documenting and citing sources, and drafting the document. The literature review was led by four area leads, and eight researchers worked under the team leads.

When identifying sources of information, primarily from peer-reviewed academic journals, we instructed researchers to enter all information into a shared spreadsheet. In that spreadsheet, researchers identified the most relevant findings from each source, and information about the source. A full list of mandatory and optional information to include in the spreadsheet is listed below.

Mandatory for all sources:

- Person inputting information;
- Date of input;
- Outline section;
- Search term/method;
- Source (e.g., Google Scholar, organisation website);
- URL (for grey literature);
- Topic;
- Author;
- Year;
- Title;
- Geography covered;
- Peer-review or grey literature;
- Type of study/report;
- Data sources;

- Main takeaway for review (one to two ideas).

Optional information:

- Notes;
- Case studies;
- Key evidence (including data and facts);
- Quotes.

All research sources (journal articles, reports, white papers, etc.) were entered in a common database using Zotero reference management software. A citation manager was tasked with ensuring that all sources were properly added to a shared Zotero database and that they could be easily accessed by all researchers working on the project and inserted into the document once writing was completed. During the drafting phase, the content editor developed interim guidance for citing sources within the text as a placeholder for future citations.

For the drafting of report sections, we allowed each team to divide up the work as they saw fit. The teams, including 17 researchers, used Google Docs to allow for a collaborative and concurrent writing process, and to avoid issues with document versions and drafting history. The structure of each section was based on the structure of the interim report, which all team leads reviewed. Each team was given a page limit for their section, based on the interim report outline and a page limit of 100 pages.

This information in the research protocol was conveyed to all the researchers via a webinar, which was led by the content editor and presented twice to accommodate people in different time zones. The webinar was recorded and posted to the project site on ITDP's intranet for reference. Additional instructions to researchers were also posted to ITDP's intranet, updated as needed.

4. Capacity Assessment

As described in the **Methodology** section, ITDP conducted a series of interviews to better understand how and where capacity-building efforts might be applied in cities in South Asia and sub-Saharan Africa (SA and SSA). The broad objective of this research is to identify challenges and opportunities to the implementation and sustained operation of HVT systems. These include issues related to the broad topics of governance, capacity, stakeholder involvement, and funding. This paper uses qualitative data gathered from interviews with public, civil, and private-sector stakeholders in these regions. Researchers analysed the qualitative data to discover facilitating factors and barriers to implementing HVT systems in the urban areas covered by the sample. To the best of our knowledge, this is the first study that examines this topic in SA and SSA specifically. This study may be of great use to researchers and practitioners who seek to improve HVT systems in either region or in MICs and LICs that may face similar challenges.

We present the full results in a separate capacity building strategy paper as well as an academic paper intended for publication in a peer-reviewed journal.[7] In this section, we present a summary of our research in the two regions, along with potential strategies for addressing capacity needs and gaps.

[7] "Opportunities and Barriers for HVT Systems in India and Sub-Saharan Africa" was submitted to the peer-reviewed journal Sustainability.

4.1. Results from India

The data we gathered in India offers interesting insights into barriers and opportunities for creating sustainable urban transport systems in India.

Study participants identified a range of issues that hindered HVT, including a lack of coordination among public sector institutions; a lack of capacity in public sector institutions; a lack of understanding of sustainable transport by politicians and the public; the prevalence of implementation of auto-based transport infrastructure; the tendency to favour large infrastructure projects; and, a lack of funding for public transportation operation.

For other factors and topics, participants viewed them as having a more mixed or positive impact on HVT. Participants had mixed reactions to several topics, including recent efforts to create unified institutions for urban transport in India (UMTA) and private sector involvement in urban transport. However, participants mentioned that policy transfer from other Indian cities, collaborations with universities and international NGOs, and marketing for HVT had been successful in supporting HVT.

Emerging topics include the need to integrate vulnerable groups (e.g., the poor) and traffic police into efforts for HVT, and travel demand management (TDM) projects.

4.1.1. Suggestions for How to Overcome Some Identified Problems in India

Based on the results of the survey and ITDP's internal understanding of urban capacity constraints in India we developed the following three-pronged approach to strengthening urban governance:

1) Develop Stronger Understanding and Vision for HVT

The research shows that many of the interview subjects in India noted that a lack of understanding and/or vision for HVT among government leaders and institutions was a key hurdle to implementing HVT measures. While large HVT projects are able to secure funding (along with elevated highway and flyovers), basics HVT measures like footpaths, cycling facilities, and buses are unable to secure funding.

To begin with, city leaders and key decision makers require training on the full scope of HVT. This can include targeted study tours to locations of international good practices, especially to places with economic and social characteristics that a relatable to tour participants. This will increase the understanding of how HVT systems function and lay the groundwork for stronger political support going forward. With strong support for HVT among leaders, cities can create strategic mobility plans (SMP) which provide a blueprint for HVT systems that addresses needs of people in cities in a smart and sustainable way. Cities over 1 million people are required to prepare comprehensive mobility plans (CMPs), but these often neglect walking and cycling and do not engage a range of stakeholders(67). An SMP, however, identifies the transport challenges within a city, lays out a strategic roadmap of how conditions can be transformed, and outlines the budget required for the city to adopt the sustainable transport approach. This can help focus HVT goals across the full spectrum of needs.

2) Improve Staff Capacity to Plan, Implement, and Monitor HVT Systems

As described in the interviews, some Indian cities have staff that are limited in number and/or skills. In multiple interviews, the subjects described staff focused on automobile-centric goals. In ITDP's experience, this is due to the automobile-centric guidance (see **Guides and Tools** section below) and education provided to technical staff. This limits the ability of staff to plan, implement, and monitor HVT systems effectively.

There is an urgent need to establish this capacity, not just in increasing the number of staff required at appropriate levels, but also augmenting staff understanding and skills. Training programmes could be implemented for municipal officers across India in planning and implementing sustainable mobility initiatives.

Technical leaders, such as transportation department leaders, can also benefit from study tours to learn from international good practises, especially those with characteristics that are familiar to tour participants. In 2017, ITDP India led a team of officials from the city of Ranchi to learn about Mexico's Ecobici. In 2019 Ranchi implemented its first cycle-sharing system, drawing inspiration from Mexico.

3) Communication and Coordination Across Agencies

Authority is fragmented in many cities in India, and many interview subjects described silos within different government departments. Metropolitan areas have multiple municipalities with limited jurisdiction over mobility issues. Often, bus services, key arterial streets are administered by provincial highways or public works departments. Heavy suburban rail (where it exist) comes under the national railways. Each one of these agencies has its own plans and budgets that do not communicate with the rest. Only now are some cities, like Chennai, starting to institute unified metropolitan transport authorities (UMTA).

Coordination among various agencies within a city can be achieved by creating one functional body, like an UMTA, that should focus on:

- Addressing the lack of clarity for state governments on the appropriate legal basis and status for an UMTA;
- Convincing state governments to appoint an UMTA as the nodal agency to manage the state's urban transport funds. Routing project funding through an UMTA could ensure the cooperation of line departments and timely completion of projects by implementing agencies;
- Supporting governments to identify suitable technical staff, depending on the functions of an UMTA, to be deputed from a line department or hired externally;
- Enabling the integration of the line and department staff to ensure their participation in an UMTA;
- Supporting an UMTA to form appropriate executive and advisory committees internally for efficient functioning.

4.2. Results from Sub-Saharan Africa

The themes that emerged from the qualitative data from sub-Saharan Africa were governance, finance, capacity building, awareness of HVT, stakeholders, and travel modes. All but two of these had sub-themes. (See **Table 7** below.)

Major Theme	Sub-Themes
Governance	Local Control Coordination Corruption Local context
Funding	
Capacity Building	Study Tours Staff Data and Indicators Manuals
Awareness of HVT	
Political Will	

Stakeholders	International Organisations Public Participation Civil Sector Private Sector
Travel Modes	Walking and Cycling Public Transportation ● Bus Rapid Transit ● Informal Transportation Automobiles and Traffic Demand Management

Table 7. Themes from results in sub-Saharan Africa

The data from sub-Saharan Africa was notable in several ways. First, local control was the most important issue for participants related to governance. Participants also mentioned a lack of coordination between institutions as a barrier, and lack of funding for HVT. Issues with staffing, including lack of staff, high turnover rates, and lack of capacity for HVT. The need to build awareness of sustainable urban transportation, and the lack of a strong civil sector advocating for sustainable transportation, was another important issue. Some participants also mentioned a lack of data on transportation as a barrier to HVT.

Participants also brought up issues that could be opportunities for HVT. For example, participants appeared to be very interested in projects for walking and cycling. A few participants also mentioned BRT as a possible solution. International organisations and informal transportation stakeholders were particularly important players in the region. Some participants mentioned that involving local leaders in HVT projects would be effective, and others reported working with informal public transportation providers. The use of traffic demand management tools such as metered parking was also brought up by some participants. Participants saw study tours as particularly effective tools to raise awareness of HVT options. Emerging themes included new urban design manuals and adapting policies to the local context.

4.2.1. Suggestions for How to Overcome Some Identified Problems in Sub-Saharan Africa

We developed the following approach to overcome capacity challenges to improve HVT in sub-Saharan Africa:

1) Pursue Educational Initiatives/Build Technical Awareness of HVT at All Levels of Governance

A key issue in sub-Saharan Africa identified in the interviews was a lack of understanding and awareness of HVT and a lack of political will to support HVT measures.

To address this issue, capacity building for officials in road agencies, transport authorities, local governments, and national ministries could be highly beneficial. This could include study tours to Dar es Salaam, Kigali, and other cities that have taken steps to improve public transport service and walking and cycling facilities. These examples can show how HVT systems can look like in a familiar African context. Finally, the city can introduce car-free days and other public events to build the broader understanding and support for HVT interventions. These events help change how people think about transportation in cities, creating a space to implement new HVT initiatives.

2) Reform Institutions, Standards, and Processes Within Government

Reform to government structures and processes could remove key barriers to HVT measure implementation. Multiple participants described the lack of coordination among government agencies or the lack of capacity at the local level as a hindrance to HVT implementation. Several participants mentioned that outdated and inflexible standards guided work toward automobile-centric outcomes.

To address these issues, transport authorities could be established at the local level to manage public transport systems and facilitate a transition to formal public transport operations based on gross cost contracts. Institution building is a long-term activity that needs continual support to build capacities for new government skills to manage public transport. In addition, national governments should adopt HVT-focused urban street design standards to replace outdated highway design standards. A design review process should be implemented within road agencies and local authorities to ensure that the guidelines are being followed and that streets incorporate adequate facilities for walking, cycling, and public transport.

3) Expand and Reform Sources of Funding and Finance

In the interviews, multiple subjects described a lack of funding for HVT, particularly at the local level, and for operations and maintenance.

Bilateral and multilateral development banks still provide an important source of financing for countries in sub-Saharan Africa. It is critical that we ensure that these funds are used for urban transport supportive of HVT and not highways and flyovers. This will depend on national government officials understanding the benefits of HVT over flyovers. We need to raise awareness around the downsides of PPPs and "free" financing from bilateral and multilateral agencies. Governments also need to understand the interests of donors, specifically the desire to finance large infrastructure projects, such as roads and metros, as opposed to smaller walking, cycling, and bus projects or ongoing maintenance and operations expenses. All of these (except many road expansion projects) are important to HVT and require funds.

All urban road projects that receive donor funding or financing should include facilities for walking, cycling, and public transport. Similarly, national, state, and local governments can adopt similar policies at the level (depending on who has budgetary authority) to ensure that HVT receives adequate investment. A discussion about why cities need to invest in operations (also referred to as subsidies) for public transit needs to be the first step to ensure adequate funding. Finally, governments can introduce personal motor vehicle user charges (e.g., parking fees and fuel taxes) to increase ongoing funding support for HVT, particularly, for operations and maintenance.

4.3. Discussion: Opportunities and Barriers in India and Africa

Participants from both India and sub-Saharan Africa (SSA) provided rich qualitative data that allows for unique insights into the dynamics of projects that promote HVT. While there are many similarities between the two places, there are also important differences we will briefly outline in this section.

The themes that emerged from the data are included in **Table 8** below. The first group of themes are frequently discussed in policy documents, white papers, and academic literature. The next group, "emerging themes", are entirely or relatively new, but may be relevant to researchers and practitioners. The priority assigned to the themes—high, medium, low—is based on our interpretation of the qualitative data we gathered, including frequency and way participants mentioned the topics. Priority cells were left empty if this topic was not addressed in India or SSA.

Below we summarise issues and measures to overcome those issues:

Enabling Structures Section	Capacity Building Needs	South Asia	Sub-Saharan Africa	Measures
Building and Engaging Political and Community Will	Lack of understanding and vision for HVT by decision makers and the public	✓✓✓	✓✓✓	• Study tours • Collaboration with NGOs and universities • Promotional and behavior change campaigns (car-free days, etc.) • Create strategic mobility plans (SMPs)
	Preference for large infrastructure projects	✓✓✓	✓	• Study tours • Involvement of informal stakeholders and local leaders • Increased capacity and authority at the local level
Governance and Institutions	Poor coordination within and among governments	✓✓	✓✓✓	• Unified metropolitan transport authorities (UMTAs) • Assessment tool for institutional creation (what staffing is needed, what levels, what skills) • Managerial skill development • Primers on contracting and managing the private sector
Education: Knowledge, Capacity, and Research	Lack of technical capacity in city staff for implementation and policy transfer	✓✓✓	✓✓✓	• Rapid response trainings (1-week courses) • Study tours • Peer-to-peer exchange • Collaboration with universities and NGOs
	Dominance of auto-centric solutions in decision-making frameworks	✓✓✓	✓✓✓	• Primer on causes of congestion and solutions to fix them • National and local standards and guides developed to reflect non-auto-centric planning
Funding and Finance	Lack of funding of local government and operations	✓✓	✓✓	• National government adequately funds local government and staff • Ongoing investment and subsidies for operations by national and subnational government • TDM pricing measures
	Lack of financing options for HVT implementation	✓	✓✓	• National policy for funding infrastructure big and small • Primer on PPPs and revenue risk • Developing financing shifted to HVT projects

Table 8. Capacity building issues and measures to overcome them. (✓=relevant, ✓✓✓=highly relevant)

In terms of governance, there was a striking difference between India and SSA. While concerns regarding coordination dominated discussions in India, the most important topic in Africa was local control of urban transportation. (Coordination was a secondary topic of governance in Africa, and local control was mentioned by one participant in India.) Efforts to empower local governments have been underway in India for several decades. The relative omission of this topic by participants may be evidence that this effort has been somewhat successful. This is consistent with the literature on this topic. An assessment of India's attempts to empower urban bodies, via the National Urban Transport Policy (NUTP) and the national urban renewal mission in India, found that a national reform programme linked to a national policy can orient state/city urban transport policies and programmes towards HVT goals(68). However, Hidalgo et al. found that although the national government's effort to fund cities to combat poverty via improved urban transportation under the Jawaharlal Nehru National Urban Renewal Mission (JnNURM) was a major advance, this programme did not significantly impact funding for sustainable transportation over auto infrastructure (e.g., road widening). Further, our experience has shown that states still wield much budgetary control over cities and are appoint the municipal commissioners which often hold most of the power within the city government(69). We also found that the Smart Cities Mission, launched in 2016 by the national government, was bogged down by insufficient clarity and capacity within city administrations and in the consulting sector. This failed to bring about systemic change despite a well-intentioned transport focus on HVT. We expect the next iteration of the mission to focus on capacity building, monitoring, and evaluation to ensure its success.

Another striking difference is the role of international stakeholders. While some participants mentioned them in India, participants from SSA made it clear that these were very important players. However, the participants from SSA also had sharp criticism for some of these players and suggested that local contexts needed to be considered. This was consistent with Marsh and Scharman's finding that aid agencies may also act as coercive actors, pushing governments to adopt agendas, best practice policies and programmes(70). Participants from India and Africa also frequently mentioned the need to adapt policies to local realities. This topic raises the question of how this can be achieved. While there is undoubtedly a role for policy transfer

and international players in the promotion of HVT, any initiatives should carefully consider local context. This is consistent with Marsden and Stead's finding that different contexts call for different policy solutions(71).

5. State of Knowledge Literature Review

The successful implementation of HVT measures relies on multiple policies and structures working together to generate success. A 2010 review by Pucher, Dill, and Handy on the impact of interventions to increase bicycling in the US, South America, Europe, and Australia is instructive. The researchers observed that while individual pro-bicycling interventions may increase bicycling, substantial increases require an integrated package of different, complementary policies and interventions. These include not only pro-bicycle policies but also transport, housing and land use policies, car pricing and restraint policies, and pro-bicycle programmes and infrastructure provisions. Each of these measures requires a suite of enabling structures to facilitate successful implementation.

The following sections detail the current state of knowledge and research gaps of the four subject areas addressed in this research project: Enabling Structures, Avoid, Shift, and Improve.

Each section includes an assessment of the literature for several measures or sets of measures that relates to that topic area. We define the measures, where they are applied, how they impact the goals of HVT (improving access in a way that improves equity, the environment, safety, and efficiency), and how well they support the HVT modes of walking, cycling, public transport, efficient urban freight, and other space-efficient modes which we define as proxy measures for meeting HVT goals. Our findings cover measures employed across the LICs, MICs, and HICs.

5.1. ENABLING STRUCTURES

In this section, we identify several factors and structures that may support or hinder the implementation of HVT measures that improve mass transit, cycling, walking or freight systems to support HVT goals (improving access in a way that improves equity, the environment, safety, and efficiency), rather than measures to improve individual motorised vehicle mobility(72). We aim to assess the structures and factors that support the implementation of HVT-supportive measures, but sometimes, the same structures and factors may support the implementation of measures that go against HVT goals. In this section, we use the terms structure and factors interchangeably to refer to the various elements and conditions that support the implementation of HVT measures.

Since there are several steps in developing and implementing measures, a temporal framework is useful to describe how and where these factors are relevant. We base the following framework on discussions with researchers, experts, and our own analysis:

Stage 1 — Persuasion and Decision

This is when decision makers change their paradigm towards one that gives pedestrians, cyclists, and public transport preference in city streets. This process includes problem identification, agenda setting, and policy formulation.

Stage 2 — Project Execution

This is when a government implements the measure.

Stage 3 — Continuity

The success of many HVT measures is what enables them to endure. This includes ongoing operations, maintenance, and monitoring to ensure that the measure continues to deliver the intended benefits. Continuity also plays a major role in supporting policy transfer(71).

Stage 4 — Policy Transfer and Learning

The final stage of policy development is the transfer of successful measures within a country, region or beyond. Marsden and Stead found that regional or international examples are a potent way to generate policies and could be linked to Stage 1 ("Persuasion and Decision") (71). In many HVT projects, policy transfer reaches a tipping point if a project is well implemented and disseminated. BRT and bikeshare have seen this kind of replication internationally(73).

This framework synthesises the main steps of the measure implementation process. We added "Continuity", a step we found lacking in the literature but critical in the field. In our experience, this often neglected stage can affect the policy transfer process(71). Typically, the last step is "Evaluation". Because we focus on spreading HVT measures, we added an explicit policy transfer step. We also split the evaluation step into monitoring (part of "Continuity) and identifying lessons and impacts over time (part of "Policy Transfer and Learning").

In our assessment, HVT enabling structures do not fit neatly into the four steps identified above; this process is too limited for a neat, linear time frame. Rather, many structures and factors support multiple steps. To better categorise the factors, we looked to prescriptive policy documents (e.g., United Nations Secretary-General's High-Level Advisory Group on Sustainable Transport; 2016, UN-Habitat 2013). In these documents, examples of factors needed to achieve HVT systems include political will, public support, the 'right' institutional arrangement, and 'proper' implementation. In general, the peer-reviewed literature we describe below provided a more nuanced view(71,74–80). These researchers and others emphasised the local conditions, and the socially embedded nature of the conditions needed to achieve sustainable urban transportation systems. They eschewed generalisations in favor of a more context-specific approach.

Based on this assessment, we divided enabling factors into four categories: 1) building and engaging political and community will, 2) governance and institutions, 3) education, and 4) funding and finance. We hypothesise that each factor serves to support one or more steps in the policy implementation process (see **Figure 14**) and each other, in a complex system of mutual dependence. The goal of the research is to understand what the body of knowledge says about the importance of these factors in general and specific geographic locations.

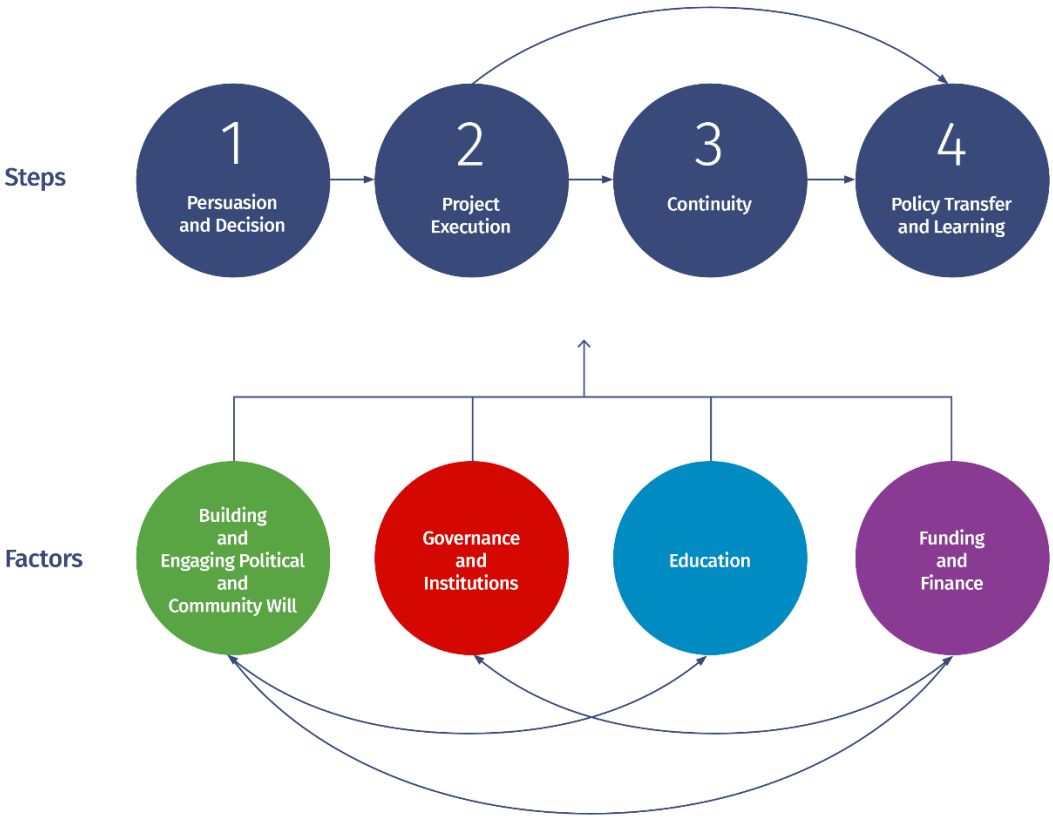


Figure 14. ITDP hypothesis on the relationship between enabling factors and implementation steps.

5.1.1. Context

HVT implementation varies dramatically across and even within geographies(27). We have found that government capacity and resources are much lower in poorer countries and that this has lowered their ability to plan for the future. We have also seen that governmental structures and power, particularly the ability to raise revenue and borrow money, also are more concentrated at the national level in poorer countries. This leads to fewer context-specific measures implemented in each city. In Africa, HVT is generally underfunded and when large amounts of funds are spent on transport, they typically go to nationally relevant infrastructure projects, typically roadways(62). We confirmed these perspectives in the interviews we conducted as part of the **Capacity Assessment** section above.

We have found that the impact of future scenarios varies depending on how the policy goals in each location align with HVT. We have seen governments adopt visionary HVT policies but fail to implement them effectively. In Chennai, for example, weak enforcement and a lack of local expertise on sidewalk implementation hampered a well-funded and expansive sidewalk construction programme, harming HVT in the city. A lack of capacity to implement car-centric policies may have a positive effect in some places. In another example, in Abidjan, Côte d'Ivoire, we saw the car-centric and single-use zoning policies hindered by weak enforcement. This led to higher densities and a greater mix of uses, which combined to support HVT, and created a situation where a greater government ability to implement measures would have a negative effect on HVT.

5.1.2. State of Knowledge

The following section details the current understanding of enabling structures, as defined by the research. Different positions come from the reliability of information and how much authors are willing to put forward in terms of the strength or importance of these enabling factors. There seems to be agreement that the

factors described below must be assessed when thinking about policies and policy implementation. During the process of HVT policy implementation and policy transfer, enabling or disabling factors can improve or lessen the probability of policy success. For each factor, we provide references about how they are assessed in different places and how they act as enabling or disabling elements. This section discusses the following factors:

1. Building and engaging political and community will;
2. Governance and institutions;
3. Education—knowledge, capacity, and research;
4. Funding and finance—for capital projects, maintenance, and operations.

Because this topic is overarching in nature, we discuss it within the broader framework of policy development (not specifically transport). We include general policy literature rather than just transport-related sources. This section also seeks to understand the broader area of enabling within the context of African and South Asian countries, as described in the literature we encountered in our search. In **Table 9**, we apply this frame to the previous section on capacity building to understand how it applies.

Identified Capacity Building Needs	Factors from Enabling Structures	Measures	Steps towards Developing and Implementing Measures
Increased Technical Awareness by Decision Makers	• Building and engaging will	• Study Tours • Collaboration with NGOs and universities • Promotional and behavior change campaigns (car-free days, etc.)	• Persuasion and decision • Policy transfer and learning
Increased Technical Capacity by city staff	• Education	• Rapid response trainings (1-week courses) • Study tours • Peer-to-peer exchange • Collaboration with universities and NGOs	• Project execution • Continuity • Policy transfer and learning
Creation of new institutions such as transport agencies	• Governance and institutions	• Assessment tool for institutional creation (what staffing is needed, what levels, what skills) • Managerial skill development • Primers on contracting and managing the private sector	• Project execution • Continuity
Funding of local government and operations	• Funding and financing	• National government funds adequately local government and staffing • Ongoing investment for operations by national and subnational government • TDM pricing measures	• Continuity
Better financing options	• Funding and financing	• National policy for funding infrastructure bug and small • Primer on PPSs and revenue risk	• Project execution
Development of non-auto-centric solutions	• Governance and institutions	• Primer on causes of congestion and solutions to fix them • National and local standards and guides developed to reflect non-auto centric planning	• Persuasion and decision • Policy transfer and learning

Table 9. Steps African and South Asian countries can take to develop and implement capacity building measures

5.1.2.1. Building and Engaging Political and Community Will

The literature suggests that the political will of decision makers, enabled by a clear understanding of policies, is an important enabler of HVT policies. Similarly, the will of residents and NGOs helped to catalyse or sustain HVT measures. Political will is necessary to ensure that sectoral administrative departments share a vision, problems, information, and solutions, rather than defending their policy territory(81). Multiple grey literature sources describe political will as one of the most important factors in achieving policies, though peer-reviewed articles refrain from using that terminology and include the issue within the aspect of governance(82–84)(WRI 2011). In its Global Report for Human Settlements, UN-Habitat states that strong political leadership is critical to delivering adequate implementation of sustainable transport and land-use integration(26). Mckinsey has identified a similar factor in the "5 C's" approach to public sector transformations called "committed leadership"(85). Finally, Hull finds that clear political priorities and strategies, along with transparent and shared organisation goals and commitments are fundamental to designing and securing HVT outcomes(86).

Our searches for literature on political will in Africa and South Asia uncovered peer-reviewed studies on the political context, forms of government, political conflicts, and democracy. These studies looked at effective measures across the fields of public health, agriculture, nutrition, and food security. We often note a general lack of a political will, particularly in LICs where environmental sustainability and efficiency issues can be perceived as less pressing than economic development and meeting basic needs like food security, health care, housing, and employment(87). The most related assessment of political will comes from UITP India (MIC), which looked at eight cities in Europe, North America, and Asia with strong transportation policy initiatives, to understand the most favorable scenario for achieving effective policy implementation and policy transfer(88). In the grey literature, the Hewlett Foundation discussed how to gain political will for climate action(89). While the Foundation's insight on the need to strengthen collective initiatives is inspiring, many of its comments lack ballast in peer-reviewed literature. Curitiba, Brazil, and Bogotá, Colombia, are examples where strong political will and the leadership of successive mayors ensured a continuous vision for integrated HVT and urban development(90). Finally, in our interviews with relevant stakeholders in Africa and South Asia, many subjects described a lack of political will as one of the key roadblocks to implementing HVT. (See the **Capacity Assessment** section above.)

Existing trajectories of HVT may strongly influence future trajectories. Several papers point to the history of automobile-centric planning and pro-automobile lobbies as significant obstacles to implementing HVT modes in cities ranging from Brisbane, Melbourne, and San Francisco (HICs) to the Bangkok, Delhi, and Lima (MICs)(16,75,79,91–93). Research has noted that the recent boom in ride-hailing services has added to congestion, making drivers feel that cities cannot take any more road space away from cars(91). Support and funding for sustainable transport infrastructure and compatible urban development patterns are often trumped by competing national policies, such as encouraging personal motorisation as a mean of economic growth, especially in countries with powerful national automobile industries (e.g., the US [HIC], China and India [MICs])(94). Conversely, Kottenhoff, and Brundell find that high-quality transit increases the price elasticity of driving a car and that a high initial public transport share increases acceptance of policies oriented towards reducing car use (congestion charges, in this case)(95).

The following subsections detail factors in the literature that help to establish political and community will, including creating and communicating a vision, participating in study tours, and engaging the public.

5.1.2.1.a. Visions for HVT

Our examination of the literature shows that vision helps to catalyse and organise actions to achieve HVT goals, such as safety. Governments can develop vision internally or it can come from outside sources (e.g., development agencies and civil society). External vision, however, can be coercive, especially in low- and

middle-income countries. Even with a strong, transparent vision in the HIC context, competing goals and agendas have stymied implementation.

Prescriptive policy documents frequently emphasise the importance of vision to achieve HVT. For example, UN-Habitat's 2013 report states, "The coordinated planning of urban mobility and land development starts with a collective vision of the future city, shared by the city government and major stakeholders of civil society"(26)(p.88). Some research has explored how a vision for the transport system and long-term planning can lead to positive results. A prominent example of this is "Vision Zero," a policy that originated in Sweden (HIC) to eliminate deaths and serious injuries from road transportation. This policy, adopted by the Swedish Parliament in 1997, was a "radical innovation"(96)(p.171). It envisioned zero deaths as the goal and introduced a systems approach to road safety(97). The policy gathered road transport stakeholders from the political, public, private, and civil sectors in a wide-ranging effort to improve traffic safety. Project implementation stemming from Vision Zero ranged from high-level political initiatives (e.g., passing a national law) to neighborhood-level projects (e.g., implementing traffic calming measures)(98).

While some quantified road safety targets adopted as a result of Vision Zero were not achieved, these targets served as a management tool to organise stakeholders behind a common goal(99). Countries and cities outside of Scandinavia and Europe have recently adopted Vision Zero (e.g., New York [HIC] in 2013 and Mexico City [MIC] in 2016). In addition to the above-cited sources on Vision Zero, the most relevant literature on vision and transport planning was from Scandinavia. In Finland (HIC), two expert workshops with researchers and public sector transport stakeholders were successful in establishing a vision for a safe and secure transport system—dominated by rail, with walking and cycling prioritised in urban areas—by the year 2100(100). (See **Figure 15** for an assessment of Vision Zero along the implementation framework.)

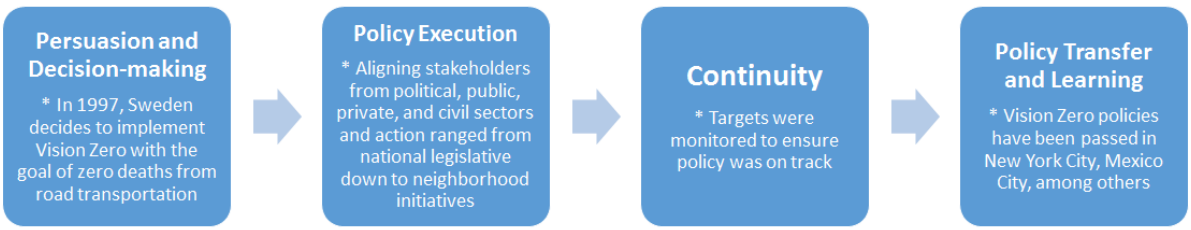


Figure 15. Mapping Sweden's Vision Zero along the measure implementation framework

Other stakeholders, from international development agencies to civil society, can help provide vision and change. In sub-Saharan Africa, international agencies and NGOs may play a significant role in knowledge construction to contribute to and disseminate quality research, good practice experiences, and standard measures, while also advocating for better HVT planning and implementation(101). However, aid agencies may also be coercive actors, pushing governments to adopt agendas, measures, and programmes(71). Our searches for literature on the role of international organisations in promoting HVT found outdated or no relevant sources. Further, we consulted websites of international agencies and organisations and found that they do not present the outcomes or effectiveness of activities related to their missions.

Even in Scandinavia, where institutions and governance are relatively effective and transparent, some researchers have pointed out difficulties in implementing idealistic visions for urban transportation. Examining car-oriented suburban sprawl outside the Swedish city of Örebro, Hrelja found that "lofty political visions of an economically and ecologically sustainable transport system" were usually defeated by "the tyranny of small decisions" (102)(p.521). This means that daily decisions made by local planners in a retail area on the outskirts of the city (e.g., to approve retail outlets with large amounts of parking places) undermined the long-term goal of compact growth and environmental goals for land use and transportation. In Sweden, Petterson found that the impetus for economic growth trumped visions for environmentally friendly transportation systems(103). Further, even the implementation of Vision Zero has had shortcomings;

the goal of making “system designers” (public and private actors that create the transportation system) liable for the safety of the transportation system failed 14 years after the implementation of the policy in Sweden(104).

Despite the current dominance of automobility, Geels identifies some important “cracks in the regime”(105)(p.479). Cities have taken the lead in stimulating bus lanes, bicycles, and road pricing, making them important new actors in the challenge to automobility. In the UK, car mobility in passenger miles travelled has dropped in recent years. Geels also sees evidence of automobility weakening as the policymakers switch from the “predict and provide” paradigm to new principles such as demand management, traffic management, and sustainable mobility. However, the recent bailout of the car industry during the financial crisis suggests that there is still a substantial commitment to the car industry.

5.1.2.1.b. Study Tours and Good Practices

A few MIC studies show that study tours and the creation of good practices inspire the replication and transfer of measures across contexts (Stage 4 of measure implementation: “Policy Transfer and Learning”). In the HIC cases, good practices inspired a different perspective on local practices rather than wholesale measure adoption. There is a need to understand the role of international development, philanthropic organisations, and advocates because contextual relevance and institutions are policy transfer barriers. This will help us understand how to create and legitimise good regional practices.

Montero notes that there is little attention given to how policy actors learn and the “politics of learning”(106). This is especially true for the roles that narratives, emotional dispositions, persuasive messengers, and platforms like conferences, forums, workshops, and study tours play in urban planning decisions and policy change. Drawing upon Bogotá’s transport programmes, TransMilenio BRT and Ciclovía, Montero argues that “persuasive practitioners” and simplified narratives of progress help to define and legitimise a small set of HVT measures as ways of governing urban space across contextual boundaries, driving policy education and adoption in other contexts(106). According to Montero, study tours were key to the adoption of Bogotá’s TransMilenio BRT and Ciclovía policies in Guadalajara(107). They educated local policy actors through “experiential learning”; expanding local coalitions through the trust building and consensus around a policy model; mobilising public opinion through references to existing policy solutions in Bogotá. Drawing upon Ciclovía, he identifies four key actors and networks: (1) former Bogotá mayors and local officials who traveled globally to speak about its urban transformation; (2) a transnational network of HVT and public health advocates funded by international development and philanthropic organisations; (3) a network of Ciclovía experts who implemented Ciclovía initiatives in their home cities and shared the technical and administrative details for organising such events; and (4) the digital technologies that enabled the instant circulation of photos and videos of Bogotá Montero briefly discusses how ITDP sought to build at least one BRT system on each continent to become the best practices for smaller culturally proximate cities(106).

Pojani and Stead’s research observes that while the Netherlands is a model for land use and transport integration, only a handful of countries have applied its knowledge and experience(108). The practices that were transferred tended to be isolated policy elements or small-scale, built environment features adapted to the local context. While there was willingness within Europe to learn from the Dutch experience, most individuals involved in these exchanges did not find them helpful to understand their “home” situation. While there is emerging research on transferring Bogotá’s TransMilenio BRT system to Guadalajara and cities in Africa, there is a lack of literature on how it influenced South Asia(109,110). Similarly, even though the car-free day Ciclovía has influenced many global events, research on its role in bolstering non-motorised transport advocacy and infrastructure in South Asia and Africa is lacking.

5.1.2.1.c. Communication of HVT Measures

In the LIC and MIC context, experts recommend communicating measures in terms of how they align with local priorities, not necessarily international goals. Montero highlights the importance of narratives, narrators, experiential learning, and multimedia in policy development and paradigm change(106,107,111). Hrelja also concludes that clear communication of goals and a shared vision between politicians and implementing officers leads to successful enactment of policies(112). Similarly, Goldman and Gorham indicate that policy needs to be easy for implementers to understand while providing a comprehensive view of the transport system and its interaction with other social and economic systems(72).

One way to merge political will and public support for HVT is to emphasise the benefits that HVT modes would bring to other areas of people's lives (i.e., HVT as an "agent of change" for individuals and society). Several researchers we encountered emphasised the possibility that improvements to urban transport systems to realise benefits in other spheres, for example, health, social equity, and the environment(113–116). The impact of transportation in multiple spheres is also the logic behind using multi-criteria analyses (MCAs) as planning tools for urban transport (described in greater detail in the Guides and Tools subsection below). Finally, several researchers argue that since climate change is a low-priority issue in LICs and MICs, climate-focused donor organisations should communicate synergies between climate goals and higher-priority energy, air quality, and social goals(117,118).

5.1.2.1.d. Public Participation

Participatory planning has its origins in Habermas' theory of communicative action, which emphasises understanding, an unconstrained debate between equal members of society, and consensus building. Under Habermas' "ideal speech situation",(119)(p.24) citizens engage in debates, and the "force of the better argument" leads to consensus and the evolution of society. This approach is also called "communicative", "deliberative" or "participatory" (Forester, 1999), and "collaborative planning"(120,121). Many scholars have called for more public participation in planning to improve the resilience and sustainability of urban transportation systems(11,122–125).

Our searches on participation in transportation planning found a lot of literature from Europe and North America. In many countries, the law requires public participation (e.g., the Netherlands, Germany, Denmark, Sweden and the US [HICs]). The EU encourages it with projects like "CH4LLENGE" which supports stakeholders who wish to incorporate public involvement in Sustainable Urban Mobility Plans (SUMPs) implementation(80,126). The literature on participation in transportation planning in LICs and MICs was lacking.

Some research links increased public acceptance and stakeholder engagement in the planning processes to better implementation outcomes(11). For example, demonstrating congestion pricing for a trial period in Stockholm (HIC) helped consolidate public support for permanent implementation. Comprehensive stakeholder involvement in the development of integrated land use policies in regional transport planning in the Puget Sound region of the US led to improved implementation(127,128). Other EU case studies have also shown positive results from strong public participation programmes in HVT planning, including efforts in Leuven, Belgium; Boulogne, France;Kassel, Germany; Bari and Salerno, Italy; Ponta Delgada, Azores/Portugal; and Wolverhampton, UK; (129–132). A crowd-sourced design for bus stations in Salt Lake City, Utah yielded positive results(133). Also, a pilot for a mobile web system connecting riders and transit services in Pittsburgh, Pennsylvania allowed users to report service problems and vehicle occupancy, resulting in positive evaluations of the system from users(134).

International institutions such as the World Bank (2015) and UN-Habitat have advocated for participatory processes in urban planning in LICs and MICs, particularly for upgrading informal settlements(135,136). There are multiple case studies on this and similar topics from a broad range of locales in LICs and MICs (e.g., Haiti,

India, Kenya, Morocco, Nigeria, and Timor Leste,) including participatory budgeting in Porto Alegre, Brasil(137). Our search did not uncover prominent examples of participation in urban transportation planning in these contexts.

Insufficient and ill-defined public participation have hampered some HVT measures, particularly in more democratic countries. Curtis examined the implementation of a metropolitan plan for Perth, in Western Australia, based on dense, public transportation, walking, and cycling-friendly urban centres(138). Despite a strong planning framework, Curtis found that stakeholder relationships were not sufficiently strong, leadership was weak, and planners lacked the necessary skills and proactive approach. As a result, the plan was not successfully implemented. Similarly, the "top-down" manner of implementing BRT in South Africa (MIC), has negatively impacted existing paratransit operators(139). Although in Johannesburg, a comprehensive engagement strategy with the existing minibus operators led to their incorporation into the new system but added time and cost to the implementation and operations of the system(140).

The literature points out important challenges regarding public participation. In Bulgaria (MIC), researchers found low levels of public participation in urban transportation projects and no evidence that public participation had impacted the sustainability of transport projects(80). They found the public reluctant to participate, and skeptical that their participation would influence policy outcomes. These researchers found that participation is a socially embedded mechanism. It depends on the socio-cultural context in which it is carried out, including traditions, social knowledge, and "established social rules"(p.65). Similarly, researchers in Montreal (HIC) found that local community groups made limited contributions to the development of local transportation plans(141). Reasons for this included insufficient structure for participation at the borough level and a lack of expertise from community groups. This suggests that there is not a guarantee that the benefits of engagement will transfer across social contexts, and that participation in measures that promote HVT may be an under-explored area of research and practice in countries of all incomes levels. We also did not find research into public participation in more autocratic governments, a gap in knowledge.

Several scholars have offered ideas on how to improve participation. For example, Wagner suggests that accessible events, engaging interactions, and an outcome-oriented process will lead to the successful engagement of the public for urban transportation projects(142). DeLuca argues that planners should involve the public early in the process (e.g., when identifying problems and solutions). Boisljoly and Yengoh posit that we need skilled facilitators to promote social equality through public participation, and we should provide community groups with needed resources(141). Public participation actions in the European HIC contexts has included holding stakeholder workshops, discussing and promoting sustainable mobility plans, supervising and monitoring those plans, and using web-based software tools to gather information on stakeholder preferences(129,132).

A community is also a powerful force in developing HVT measures—a version of bottom-up public participation based on an engaged community or citizen advocates. Vasconcellos examines a set of examples of Brazilian (MIC) transport policies and shows that strong and persistent social pressure from public transport users catalysed the creation of an integrated bus system with limited fares for salaried workers. He found that social movements advocating for equity, accessibility, and environmental quality backed by local and international NGOs can support the disenfranchised and advance sustainable mobility policies(143). Montero has described how citizen stakeholder involvement is crucial to the long-term continuity of Sunday car-free streets (open streets), citing San Francisco (HIC) and Bogotá (MIC) as examples(111). Marsden and Stead describe how it is crucial to have a variety of stakeholders to enable effective policy transfer in transportation, including government, but also advocacy groups and even advisors and the private sector(71).

McKinsey (2018) identified citizen experience as an important driver of policy, but couples it with "design thinking and agile practices" to improve the odds of successful policy implementation(85). Rode suggests that evidence-based or in-depth interviews are a powerful tool to map the most influential stakeholders in transport planning and policymaking. He also finds that, in London and New York, cycling and public transport activists are gaining influence. A greater understanding of this issue for HVT may be useful(144).

The engagement of vulnerable groups may lead to more equitable outcomes. In the US and Canada (HICs), public participation is a strong component of the effort to improve "environmental justice," which seeks to increase social equity by redressing the disproportionate burden of environment-related health issues borne by minority and low-income populations(145–147). Herrle et al. illustrate how NGO engagement has shifted the discourse from housing for the urban poor to housing by the urban poor(148). Similarly, community housing groups in the Philippines, South Africa, and Thailand (MICs) have developed broad networks to extend their reach and influence. Engagement must recognise existing power structures. Drawing from the informal settlement upgrading programmes in Nairobi (2007–2008), Rigon cautions that existing power imbalances between landlords and tenants can be institutionalised in structures of community governance(149). Rigon argues that participation needs careful management and external agency to achieve genuine social transformation.

The lack of engagement leads to less equitable results. The lack of slum dwellers participating in housing programme development in Mumbai resulted in programmes that failed. It also directed resources away from those most in need(150). Inclusive engagement of vulnerable groups requires resources and regulations. Critiquing South Africa's 1996 housing subsidy programme, Bradlow et al. recommend making the informed participation of residents of informal settlements a precondition for state support(151). Scholars in Kenya have called for decision makers to reorient planning, education, and training to be participatory and include informal settlements(152). In terms of urban resilience, multiple scholars emphasise the need to include and prioritise the needs of vulnerable populations into holistic planning while adapting practices to the local context(77,153–155).

Women are another vulnerable group whose engagement is important. There is a broad acknowledgment that women are under-represented at all levels of decision-making in institutions of national or decentralised governance, which limits their ability to influence laws and policies(156,157). Peters outlines that women have inferior access to both private and public means of transport while assuming a higher share of their household's travel burden(158). Engagement with women may require different tactics. These tactics include women-only focus groups (women may not feel comfortable speaking in a meeting with men), going to where women already are located (women are time-poor), and providing childcare during workshops or meetings (women are still mainly responsible for domestic caretaking duties).

Violence against women and girls is a major barrier affecting women's mobility(156). One method for engaging women in HVT is the safety audit, developed in 1989 by the Metropolitan Toronto Action Committee Violence Against Women and Children (METRAC). This tool is used globally to address the growing concern about violence against women and women's perceptions of insecurity. Women in Cities International's (WICI) preliminary results from a 2007 global survey of 163 local government-community partnerships on women's safety found that the safety audit was the most frequently used assessment and action tool(159). Wekerle (2005) describes how the safety audits were used to advocate for changes in the design of bus shelters and subway stations by the Women's Security Advisory Group of the Toronto Transit Commission. The group's advice was not followed, and it disbanded. WICI states that few safety audits have been formally evaluated, making it difficult to identify failures and successes for subsequently improving the tool(159).

According to literature, engagement with a variety of stakeholders in the decision-making process benefited the successful implementation of HVT measures in MICs and LICs and is often codified into law. While promoted in these contexts, there is evidence that participation is not always related to public acceptance or the success of HVT measures. Engagement may be a socially embedded mechanism that cannot be replicated across contexts. We need more research on this, especially in LICs. Multiple strategies have been proposed and tested for improving engagement, but often communities have a proactively engaged government to enact HVT measures successfully. For more vulnerable groups, such as low-income residents and women, engagement may be critical to designing HVT measures that address safety and equity issues effectively. Engagement, however, does not guarantee effective measure design to address the needs of these groups or assure their buy-in.

5.1.2.2. Governance and Institutions

The following section discusses governance generally, then assesses several aspects and levels of governance as they support or hinder HVT implementation. In the academic realm, governance refers to flexible forms of political power that involve multiple actors and decision makers, who do not necessarily correspond to the state or public entities. Governance also includes institutions, social or private groups, and other actors who coordinate to reach goals and policies, including the provision of services(160,161). Academic and grey literature suggest that governance can be an important enabler of HVT policies, but one that may require coordination and integration with government institutions and enablers like finance and the private sector. Peer-reviewed literature suggests that there is no single blueprint for successful transport governance.

The research of Kennedy et al. argues that the first pillar of sustainable urban transportation is effective governance for the adequate integration of land use and transportation(162). In the grey literature, UN-Habitat identifies coordination between organisations involved in transport and land-use planning, and with the participation of other stakeholders (e.g., civil society organisations, private sector), as a crucial factor that can enable mobility policies(135). This is similar to one of the four areas that Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and Embarq indicate are critical to improving urban transport planning ("integrated mobility planning")(163). Mckinsey identified two factors in the "5 C's" approach applicable to public sector transformations: "clear purpose and priorities" and "cadence and coordination in delivery" (the other three C's are "committed leadership", "compelling communication", and "capability for change")(85). Finally, the Sub-Saharan Africa Transport Policy Program argues for strengthening governance and capacity, planning, managing transport infrastructure development, and regulating transport services more adequately(164).

Other overarching aspects of governance include transparency and accountability. Researchers have described these as key enablers of engagement with the private sector and civil society stakeholders to enact HVT measures(165–167). Political leadership, which plays a critical role in urban governance integration, should be transparent and accountable not only to enhance people's trust in the institutions and governance structures but also to ensure that these institutions and structures do not collapse once their champion leaves office(26). Technology can help improve government transparency and accountability. For example, it can map and differentiate types of informal settlements in the Philippines; engage multiple stakeholders through online portals for Singapore's Land Transport Master Plan; or deliver services in the form of billing, certificates, and other record-keeping(165,168,169).

We describe a more detailed assessment of other aspects of governance and institutions in the sub-sections below.

5.1.2.2.a. Institutional Frameworks

A more concrete structure than governance, institutional frameworks relate to the arrangements of institutions. These include relationships between national, state, metropolitan, and municipal levels,

authority, and jurisdiction. Institutional frameworks can make transport decisions quicker, more transparent and effective. GIZ and Embarq (2013) define “better institutional arrangements” as one of four areas to address to improve urban transport policy(163). Mckinsey (2018) stresses the need for government agencies to adapt their institutional arrangements to reflect new challenges and functions(85). In the case of urban transport, this entails separating the responsibility for infrastructure from service provision, with a focus on contracting, managing, and monitoring urban transport services. Mckinsey indicates that this presupposes a fundamental change not only in the structure but also in the leadership, organisational mindset and culture, and the adoption of a customer-oriented and commercial business approach.

For formal public transport systems, a multiplicity of actors make legal and institutional arrangements important to developing the contractual arrangements needed to tender of public transport services to private companies(93). In particular, Flores-Dewey compares the cases of Mexico City and Santiago, where the planning, implementation, and regulation of BRT systems have followed different paths depending on the government capacity to generate an institutionalised space for negotiating with private operators(170).

Well-established institutions have both positive and negative effects. Cervero found a politically insulated regional planning organisation benefited Curitiba(90). ITDP Brasil found that successful transport infrastructure investments require strong and effective institutions to ensure good planning, implementation, integration with the existing network and quality of service delivery(171). Improving institutional arrangements also improves urban resilience in the transport sector(77,154). However, Marsden and Stead found that while strong (i.e., well-established and structured) institutional frameworks can increase the likelihood of implementing policies, they can also reduce flexibility in implementing innovative solutions that would be possible with smaller or less structured institutions(71). Similarly, Goldman and Gorham conclude that new innovations require radical and complex institutional changes, such as public transit agencies transforming from organisations that operate vehicles into customer-oriented mobility service providers(72).

The lack of institutional frameworks can impede the achievement of HVT goals. Cipoletta et al. have shown how Latin American countries have not implemented ‘sustainability’ policies effectively, as they lack long-term visions and do not have supportive institutional frameworks(172). Better frameworks, however, do not guarantee success. In Medellin, Colombia, a good institutional design exists, but no effective mechanisms enable implementation(173).

Scholars note that understanding the institutional structures is important to policy transfer. Marsden and Stead find that local context matters if policy transfer is to achieve successful outcomes(71). Hrelja et al. indicate that it is important to incorporate an analysis of power dynamics into the study of relationships between politicians and officers in policy enaction to understand better how to generate change(112).

Thus the literature suggests that we need a strong institutional structure to implement more formal and goal-oriented transportation measures. However, the literature also suggests that strong institutions have less flexibility to respond to change and enable innovation. We need more research on the level of institutions required to balance these competing interests, particularly in the rapidly evolving LIC context. Finally, a better understanding of existing structures is critical to policy transfer.

5.1.2.2.b. Informality

Informality is a defining characteristic in many MICs and LICs. Therefore, urban governance institutions must address informal arrangements and non-written rules that determine the distribution of power and incentive structures. The study of these arrangements is important for LIC and MIC cities, which are characterised by large informal sectors, including a high prevalence of informality in the urban transport sector(8,174). In the Mexico City metropolitan area, for example, arrangements in the informal transport sector are regularly enforced through corruption and backdoor agreements with authorities(175). The lines between formal and

informal transport systems are often blurry, falling along the spectrum from unregulated to highly regulated. Many informal transport systems have elements of formalisation, including clear origins and destinations and/or predetermined routes(176).

Informal arrangements and institutions play an important role in the mobility system and travel behaviour of urban residents, with positive and negative impacts. Suarez et al. find that the commuting patterns of the urban poor in Mexico City (MIC) have shorter commutes thanks to the flexibility economic informality offers(177). In the public transport sector, Kumar and Barret argue that a moderate regulatory framework allows operators to adapt to local demands(178). In African urban areas, the Volvo Research and Educational Foundations indicate that informal transport is highly adaptable to local needs and contexts, offering a robust and wide range of services(101). These are often the only transport option for the low-income population. In South Africa, these types of services are responsible for 65% of all public transport trips(176). Similarly, in Uganda (LIC) matatus form the base of the public transport system, offering cost-effective transportation of people and goods(179). Yet, according to Kumar and Barret, informality in the public transport sector in Africa leads to unreliable operations and fare policies (Kumar and Barret, 2008). Informal transit also presents key challenges to HVT goals. Challenges include poor safety, long waiting times, and a lack of data collection(176).

Recent research on public transport in MIC and LIC cities have explored both formal and informal relationships. Grey literature from development agencies and NGOs working on sustainable mobility advocate for integrating informal transport operators into formal enterprises that run more efficient BRT-like systems(82,180). In Uganda (LIC), attempts to formalise and regulate the informal public transport system have systematically failed(179). In Asian cities, the decentralisation of transport decision-making and the economic crisis of the 1990s forced many local governments to restructure informal services into mass transit or to establish transport corporations(181,182). In Latin America, the transition from informal to formal transit has had mixed results. In a study of informal routes consolidated into BRT systems in Bogotá, Mexico City, and Santiago, Paget Seekins et al. find that industry formalisation increased government capacity and decreased the negative externalities of bus transport but also increased overall costs(183). In the African context, Cartwright argues that governance frameworks should not crowd out informal local initiatives and private sector investments(87). It should combine the best employment-based approaches with city-scale initiatives and transformative national projects(87).

The literature discussed above suggests that informality in the transport sector is widespread in LICs. While this fosters some HVT goals, it also has downsides. More formal institutions can support effective policymaking and efficient services, but they are often costlier and more resistant to change. This topic needs to be studied in more depth. In addition, given their prominent role in the provision of transport in many areas, paratransit operators are important actors to consider when researching other forms of transport organisation and management.

5.1.2.2.c. Role of National Government

National governments play a variety of roles in enabling HVT. Leading scholars argue that national governments can best support HVT through a combination of strong and consistent political support, urban development frameworks, policy guidance, and regulations that empower local governments(184–186). The working papers on the new climate economy have focused on the importance of urban-influencing policies (e.g., housing, energy, and environment) in addition to direct urban-intervention measures. For example, the Republic of Korea (HIC) adopted national policies to encourage compact city planning and sustainable transportation supported by investments in multimodal transfer centres, which combined new housing and commercial developments with public transportation(187). In India (MIC), 28 interviews with a wide range of

actors in the transportation sector revealed that requiring comprehensive mobility plans (CMPs) in the NUTP was a significant reform that encouraged cities to think about mobility in a more holistic way(188).

A key challenge is aligning and coordinating large, multi-level, and multi-sector government structures(165,166,187,189,190). Overlapping national programmes and planning may reduce the capacity to develop compact cities. In China's low-carbon eco-cities programme, different ministries independently initiated several similar programmes, adding to the burden of cities(191). Similarly, Yeun has critiqued the sequence of socioeconomic development, spatial, and sectoral plans by different ministries in Vietnam(192).

The coordination of national institutions, while challenging, can help to streamline policies and investment for HVT. Large institutional reforms, such as Brazil's 2003 creation of a national Ministry of Cities and Environment and City Statute legislation, have enabled comparatively holistic social and environmental policy integration, setting a precedent, despite difficulties and limitations(193). However, institutional integration on the national scale is rare because it involves challenges and overhauls of land-use planning and regulation systems. The Organisation for Economic Co-operation and Development (OECD) established half of its government land use institutions before 1979 and three before 1940. This, however, did not preclude significant evolution in practice(194). Fostering coordination between national agencies through new policy, monitoring, evaluation frameworks, or new formal and informal cooperation networks (that mimic the integrated behaviour of single agencies) can go a long way to ensure coherence across different scales of government(81).

In many places, municipalities may be the best level of government to plan and manage urban transportation. The national and, where applicable, subnational governments can play a critical role in bolstering capacity at the local level. In Brazil (MIC), decentralisation of local traffic planning and management to municipalities (i.e., devolution) was successful in improving conditions for urban transport in cities(143). An assessment of India's attempts to empower urban bodies, via the NUTP and the national urban renewal mission, found that a national reform programme linked to a national policy can orient state/city urban transport policies and programmes towards HVT goals(68). Researchers found that this programme to improve the efficiency of HVT systems through the financing of projects in metro and capital cities had varying degrees of success and efficiency(195,196).

Local governments in European cities have had an increasing role in public transit regulation. This is due to the decentralisation wave of recent decades and the ambitious commitments to reduce greenhouse gas emissions(197). Fenton and Gustavson argue that the most effective governance action that impact the SDGs) is to empower and financially support municipal governments. Incentives for locally appointed leaders to be more radical and transformational are useful in advancing HVT(118,184).

The literature shows that the devolution of power to local municipalities needs more study to understand how to empower the right level of government in a beneficial manner. In India and Malaysia (MICs), transport and planning are managed by subnational governments, which transfers functions, funds, and functionaries to lower levels of government and provides an enabling environment through legislative and institutional reform. The national government only provides strategic leadership(169). The impact of this configuration is unclear. ITDP Brasil argues that many municipalities still lack strong planning and implementing institutions, while GIZ and the WRI Ross Center for Sustainable Cities indicate that capacity at the local level is critical to achieving concrete sustainable mobility goals and ensuring adequate monitoring and evaluation of transport policies(163,171). In some Asian countries, decentralisation has been more nominal—a transfer of administrative function rather than a true transfer of power—with the national governments exercising financial control over local governments (e.g., the Philippines [MIC] or appointing senior staff, e.g., China [MIC])(190).

The literature suggests that national governments can help the implementation of HVT measures by setting national priorities and providing guidance and funding to lower levels of government. However, overlapping and poorly coordinated national institutions or direct control of local decision-making can impede the ability of local governments to implement HVT measures. We need more research on the positive role of national governments, especially in the LIC context.

5.1.2.2.d. Metropolitan Governance and Coordination

Metropolitan visions, planning, and governance are key to HVT integration and urban development. Scholars emphasise a general lack of regional coordination at the metropolitan level as a major barrier to effective planning and implementation(198). Governments coordinate when they align actions across multiple jurisdictions toward a common goal. An example in transportation is a bus route that crosses multiple jurisdictions, which requires coordination to implement. Competition among jurisdictions can impede coordination on metropolitan-scale projects, as a gain for one jurisdiction can be seen as a local loss for another jurisdiction. A lack of coordination hinders the creation of metropolitan-wide infrastructure projects(199). Centralised governments, however, can execute a level of autonomy by using the tax system to finance infrastructure, and enable TOD or land use and transport integration(198,200–203). OECD cities with metropolitan agencies are better at containing peripheral land consumption than those without governing bodies(199).

Coordination is achievable by creating a regional level of government that directs actions at the metropolitan level. There are different types of urban regional governance. Amalgamation—the merging of local governments—or changing to a two-tier system with a single metropolitan-scale of upper-level government and multiple smaller jurisdictions of lower level government may be ways to offset fragmentation of governance. The higher level of government typically oversees metropolitan-scale issues, while the lower level oversees more localised matters. An amalgamation also reduces competitiveness further supporting coordination(199). Even in highly fragmented governance structures, there are informal coordination mechanisms between municipalities(199).

Governance can change over time because of growth and economic or political changes. Sprawl also poses big challenges to create and maintain metropolitan governance. A growing urbanised area may grow beyond administrative boundaries, leaving core municipal governments unable to plan for and regulate development, as seen in cities like Bangalore and Kolkata in India(166). In India, there is a governance discourse when considering peri-urban areas. Local rural bodies govern towns that are not granted as statutory, including peri-urban areas. This means that these areas cannot be served by the core urban areas(199). Both Bangkok and Yangon experience a lack of coordination in local and regional governance. In Bangkok, the issue is a lack of collaboration between municipal and city services. In Yangon, the issue is a lack of clarity and delineation of roles between the city and regional government(204). We can find good practices for regionally integrated governance around the world. The EU has worked since 1992 to institutionalise integrated urban development and transport policy for HVT(205,206). This has led to the development of guides for integrated development (see **Guides and Tools** subsection below). Good practice examples of metropolitan transit coordination or built form include HICs (Singapore, Copenhagen, Stockholm, Tokyo, Munich, Ottawa, Zurich, Melbourne, Karlsruhe, Adelaide, and Hong Kong Special Administrative Region [SAR]) and MICs (Curitiba and Mexico City)(90).

Cities in HIC contexts (Toronto, London, and Cape Town) and LIC contexts (Abidjan) have transitioned to more regionally coordinated governance structures(178). Other cities, such as Tokyo (HIC) and Bangkok (MIC), have the human and financial resources and power to function as effective regional governments. The Tokyo Metropolitan Government illustrates the critical role such institutions can achieve by crafting a regional vision, facilitating regional infrastructure implementation, and defining and coordinating clear roles

and responsibilities with local governments(207). Similarly, in Santiago, Chile (HIC), metropolitan integration is a major factor in successful policy development(173). However, formal institutional integration does not guarantee success. For example, the Metro Manila Development Authority, a branch of the national government, is responsible for metropolitan governance, however, its funding is insufficient, curtailing its capacity to act(207). Since 1992, Indian states (MIC) have delegated urban development functions to metropolitan bodies. However, the process is slow and only a handful of metropolitan committees, such as Kolkata, have been formed so far. A middle-ground has also been proposed. Drawing from the subsidised commuter bus industry in the MIC context of South Africa, Walters (2014) makes a case for creating provincial transport authorities between local and provincial governments to develop and implement integrated transport plans(208).

Institutional integration may not be required to facilitate metropolitan coordination. Singapore has largely achieved land use and transport integration without administrative and legal integration. It relied on interagency planning and implementation committees(209). In this case, it did not require integrated institutions to develop integrated plans. However, a unified transport authority at the metropolitan scale, with the power to plan and implement across local boundaries is essential for planning, coordination, monitoring, and evaluation as demonstrated by the Land Transport Authority in Singapore(210). In some cases, higher level mandates have driven less formal integration. In Colombia, many cities have struggled with inter-municipal coordination and treatment of city peripheries belonging to different jurisdictions since the passing of National Law 388 (mandating the creation of territorial land use plans) in 1997. Sprawling cities had to establish joint policies and agreement to implement territorial plans(211).

Overall, there are many types of metropolitan governance, ranging from amalgamation to coordination, and the research shows that a lack of metropolitan planning authority hampers coordination for HVT. We find formalised integrated structures around the world, but their presence does not guarantee successful integration. Conversely, we have found informal means of integration even in highly fragmented regions. The latter, however, are few and only found in MICs and HICs.

5.1.2.2.e. Private Sector Involvement

The private sector often plays an important role in implementing transport projects and, in many cases, is the main stakeholder in their operation (traditional public transport and shared or app-based services). We consider the involvement of private-sector companies an enabling factor for HVT, especially when there are clear responsibilities designed to achieve public HVT goals(212,213). Grey literature has provided insight on how to improve private sector involvement, but often without a critical approach or a review of its efficacy compared to other options(163,180). Some of these documents distinguish between private sector involvement and public–private partnerships (PPPs), although not with an interest in their effectiveness to improve transport, but in how adequate they are as part of an investment. First, we look at private sector engagement generally, and then we look in more detail at public-private partnerships, which typically include risk sharing between public and private actors.

The institutional arrangements of public transport operations in European HICs take several forms but usually involve private companies whose performance is overseen through contracts—issued via a process—'procurement', 'contracting' or 'tendering'—which is the core focus of research(214–216). The practice of contracting public transport services has become increasingly common in the HIC context of Europe in recent decades. A wave of privatisation began in the UK in the mid-1980s and in Scandinavian countries in the late 1980s, becoming widespread in the 1990s(217). European Union directives on public procurement between 2007 and 2009 reinforced this privatisation trend and made it transparent by requiring the tendering of all public services above €125,000 (USD $161,000). In France, most local governments contract service provision to private companies, under a system of contractual practices, governance structures and strict regulations,

leading to great technical efficiency(218). In Sweden, contractual governance has led to the sustainable provision of public transport service(215). The Indian state of Surat (MIC) also contracted bus services with the private sector(219). In South African cities, BRT projects used a combination of national government funding and private operator contracting to implement the BRT services.

More broadly, the literature on traditional contractual relationships between the government and the private sector has been positive, with notable exceptions. For example, tendering public transportation operation has been favorable in the HIC context of the Netherlands, Poland, Australia and Scandinavia, with some disappointments in France and Italy(217). Incentives for the private sector to participate in TOD projects in Johannesburg, South Africa (MIC) include the reduction in the time needed for development and building approvals, the provision of incentives to reduce the cost of construction, and specific financing for TOD property development(220).

In contrast, PPPs describe situations where the public sector agrees with private companies to share investment in the provision of utilities, services, and infrastructure (including water, toll highways, and airports). Examples of PPPs in urban transportation include public transportation infrastructure building and operation, bike- and car-sharing, and building multi-modal transport hubs. Evaluating the success of PPPs inherently poses a challenge as each actor (public sector, private sector, and users) has its own objective(221). The public sector seeks value for money, the private sector seeks profitability, and users seek a level of service. Mladenovic et al. determined if PPPs were successes or failures by using a combination of the different stakeholder objectives.

Based on this framework, many studies on PPPs for public transportation have found generally but not entirely favorable results for improving HVT access and efficient use of resources. An expanded definition of PPPs includes “space users and space organisers”(222)(p.1079). These can include bike- and car-sharing, transport pooling (e.g., carpooling for passenger travel and logistics pooling with urban consolidation centres

for freight), and Mobility-as-a-Service (see **Improve** section). These multi-stakeholder collaborations between public and private actors including public-private innovation (PPI), which engages a flatter and broader range of actors earlier on in the design-build process and generally involve a broader range of collaboration and contractual approaches(223).

Willoughby (2013) found that PPPs have been successfully developed for infrastructure, rolling stock and operation for BRTs (e.g., Cape Town and Bogotá), and conventional buses and metros in MIC cities such as Bogotá, São Paulo, Beijing and many urban areas of India. While there have been mistakes and delays, Willoughby concluded that PPPs resulted in innovations and improvements in the technical and managerial aspects of public transportation provided by facilitating more effective interaction between the public and private sector(74).

PPPs may facilitate BRT implementation in several ways. They may increase the financial sustainability of BRT systems by attracting private investment to maintain high-quality service(93,224–228). Decentralisation policies (see **Role of National Government**) give city authorities the requisite autonomy to leverage private-sector capital and craft sustainable PPP models. PPPs may also provide an opportunity to transition informal transit operators to a BRT system, staving off resistance and unemployment.

PPPs for Toll Roads: A case study in Nairobi, Kenya

In Nairobi currently, the government is considering a PPP for an elevated, limited access highway, paid for by the Chinese government, in exchange for toll revenue. This highway will link to the airport along a proposed BRT corridor, and is supposed to address congestion. While this seems like a free highway project for the Kenyan government, when the revenue forecast do not meet the projections, the government will likely be on the hook to pay for it. We believe the toll revenue forecasts are high, as our experience has shown that people in Nairobi (MIC) are very sensitivity to price. For example, people stop driving and even taking transit towards the end of the month when they run out of money from their monthly paycheck. Moreover, Thika Road was recently reconstructed to be a toll road, yet the tolls were never implemented due to political pressure.

Looking at the MIC context of India, Singh also found PPPs to be an innovative way for municipalities to create bus services(219). Indore, which did not have a public transportation system until 2006, created the Indore City Transport Services Ltd. (ICTSL) to operate and manage the public transport system through PPPs(219). Mahalingam shared the same positive evaluation of PPPs in India and suggested that additional revenue for PPPs is possible through value capture from joint development of public transportation and land use or TOD(229). A report from India's Ministry of Urban Development highlighted challenges for urban transportation PPPs in that country(230). These challenges included financing, planning, operations, and social issues (e.g., conflicts with auto rickshaw drivers).

Some literature on PPPs focuses on the interaction between government and private companies to the exclusion of the public's role (e.g., Liu and Wilkinsen's 2013 paper about Beijing's Metro Line 4). Ng et al. noted the lack of meaningful public engagement in Hong Kong's PPPs(231). The development of an old airport site and a waterfront park exposed the weakness of the public engagement process. The authors propose "public-private-people partnerships" (P4, p. 371) as a framework to embrace bottom-up policymaking and effective public engagement for infrastructure planning(231).

Experience with PPPs in non-HVT measures may also be instructive. In a SSATP working paper, Runji argues that PPPs have been deployed effectively for African ports and could serve as a basis for road sector

transport investment(232). Successful PPP models have featured annuity payments, design-build, performance-based contracts, and up-front public sector investment in fixed assets. However, for global road building, it is worth examining PPP history to evaluate their utility and lessons. Often with PPPs, the government bears the risk of the project and absorbs it when a project fails.

The literature shows that private sector involvement, either through traditional contracting or PPPs, is common across country incomes and regions. This can leverage the strengths of the private sector to engage private sector actors to implement different HVT measures without sacrificing government control. However, PPPs are also viewed with skepticism, as most risk still lies in the public sector. Despite efforts to evaluate PPPs, our review of the literature shows that we need more research on how effective they are and ways to improve them. Moreover, understanding the skills the public sector needs to manage PPPs is critical to understanding how to make this a more successful model.

5.1.2.2.f. Approach: Megaprojects Versus Smaller Projects

Research acknowledges the importance of integrated, multi-modal transport and that no single measure will achieve HVT alone. However, a common debate among practitioners is between "megaprojects"—those that typically require the greatest amount of financial resources and the longest time to complete, such as metros or other rail projects—and smaller projects, which are less capital intensive and may be implemented in shorter times frames (BRT systems, cycle lanes, and traffic calming measures). The debate centres on the best approach to develop HVT systems and meet HVT goals over time. Focusing on small- and medium-sized cities in LICs and MICs, Pojani and Stead (2015) emphasise the success of low-cost measures—traffic calming, pedestrian-only zones, parking fees, protected bus and bicycle lanes, and upgrades to existing public transportation—over large infrastructure projects, which are less economically viable(108).

However, there is variation on the appropriate technology of mass rapid transit. Based on a review of international empirical evidence and the Delhi metro-rail system, Mohan argues that metro-rail systems have not achieved the projected ridership and are unlikely to in cities that do not have a very dense and large central business district. Further, elevated and underground rails systems are too expensive in large cities of low-medium income countries(233). Similarly, Flyvbjerg argues that even though large sums of money are being spent on transportation infrastructure, the literature lacked statistically valid answers to the key question of whether transportation infrastructure projects perform as forecasted(234). When comparing forecasted and actual traffic in 210 transportation infrastructure projects across 14 HIC, MIC, and LIC countries, researchers found that rail passenger forecasts were more inaccurate and biased (inflated) than road traffic forecasts. Sixty-seven percent of passenger forecasts for rail projects overestimated by over two-thirds. However, 50% of road projects had a difference between actual and forecasted traffic of over 20%. Finally, a comparison of actual and forecasted costs of 258 transportation projects showed that cost escalation happened in almost nine out of ten projects, with rail infrastructure and projects incurring an average increase of 44.7% and 20.4% respectively. This is partly a question related to who is driving these projects and who benefits from the construction of these projects.

Priemus evaluated the initial stages of transport project decision-making in the Netherlands and concluded that in megaprojects the solution was presented too early. The process did not begin with a proper analysis of the problems involved or an impartial appraisal of the alternatives(235). In contrast, Dimitriou et al. draw lessons from 30 case studies of decision-making in the planning, appraisal, and delivery of mega transport projects(236). They conclude that the success of megaprojects depends on how well risks, uncertainties, and complexities in decision-making are addressed, and how context-sensitive decision-making is throughout the project life cycle. Policy-led multi-criteria analysis (PLMCA) frameworks (see **Guides and Tools**) may offer a more effective basis for judging the success of such investments.

In summary, the literature shows that smaller projects are often successful. Megaprojects may be presented as fait accompli and circumvent traditional planning approaches. Rail megaprojects, in particular, are associated with overestimating passenger ridership and underestimating costs. To a lesser degree, car infrastructure projects also suffer from poor projections. For smaller projects, we found little information comparing projected versus actual impact, making it difficult to draw conclusions. We did not find information on the potential for large projects to create momentum for additional HVT measures. Thus additional research is needed.

5.1.2.3. Education: Knowledge, Capacity, and Research

The capacity of staff, tools, guides, and data are important to the design and implementation of HVT policies. A lack of capacity may pose a key challenge for LICs, where local governments often lack the staff, capacities, and expertise to support HVT systems. They cannot envision and prepare long-term urban development plans, develop and communicate clear project pipelines, secure funding commitments and sufficient guarantees or manage infrastructure projects effectively(237,238). For example, the implementation of Kenya's National Urban Development Policy will be difficult owing to limitations in the human, technical, and financial resources required to achieve its objectives(152). According to Ahluwalia (2011), the staff and management in urban local bodies are typically not accustomed to innovation (taking up new tasks) and are more comfortable with traditional methods of procurement and working with government grants and loans(239). The literature on this is not uniform. In a study of cities in the MIC context of India, Swamy and Sinha conclude that technical or technological expertise was not a constraint; it is a strong political will, favourable social, economic, and cultural ethos that lead to success(240). This differs from the result of our **Capacity Assessment**, where interview subjects listed technical capacity as a leading concern in India.

This section focuses on elements commonly considered when formulating policies and implementing HVT, including capacity building, the influence of engineering manuals, and knowledge flow.

5.1.2.3.a. Guides and Tools

Key components of education are the guides and tools that transport and planning professionals use daily in the project execution (Stage 2), policy transfer (Stage 4), and portions of the measure implementation process described above. In the 1920s, traffic engineers became a dominant force in city planning and their efforts to increase capacity and speed for cars in cities were unquestioned for much of the last century(241,242). Traffic engineers created manuals that dictated standards for road networks and streets. The Institute of Transportation Engineers published the first manual, the *Traffic Engineering Handbook*, in 1942. In 1950, The Highway Capacity Manual (HCM) was published as a joint venture between the US government and the Transportation Research Board. These manuals are biased toward automobiles at the expense of other modes. They focus almost exclusively on minimising automobile delay, measured in terms of Level of Service (LOS). Impediments to speed, including signals that allow pedestrian crossings, are potential degradations to LOS that should be mitigated(243)(p.15-2). Most jurisdictions in the US adopted these requirements for LOS in the 1970s(92). While the 2010 version of the HCM includes expanded guidance for public transportation, pedestrians and cyclists, it remains oriented toward minimizing automobile delay. The HCM is used internationally; many countries, including MICs and LICs, have created their own manuals based on its methodologies(244). Since 1991, the International Conference on Highway Capacity has discussed technical aspects of the HCM[8] and its influence beyond the US. These manuals set the standard for approaching and evaluating transportation. The pervasiveness of this effect has not been adequately studied, but below we see how the HCM has been shaping specific examples.

[8] The last edition of this conference was held in the UK in February 2018 (see https://waset.org/conference/2018/02/london/ICHCP)

Academic research on the MICs of Nigeria, South Africa and India, and the LICs of Ethiopia and Nepal, applies the HCM assessment methodology, including the emphasis on automobile speed, to the African and South Asian context(245–250). These publications either ignore pedestrians, cyclists and public transport users or treat them primarily as sources of delay. In the largest city in Tanzania (LIC), the Dar es Salaam Transport Policy and System Development Master Plan uses the HCM to assess roadway capacity, although it also includes a significant discussion of prioritisation of walking, cycling, and public transport(251). While the HCM appears to be commonly used in LICs and MICs in South Asia and Africa, we did not find a comprehensive review of its prevalence. More research is needed.

Multiple researchers have pointed out that increasing the volumes and speeds for autos (the aim of the HCM) negatively impacts other modes. For example, high auto speeds discourage walking and cycling trips, as these modes become relatively slower, less comfortable, and more dangerous(252). Ishaque and Noland's support this and find that longer signal cycles for autos create less favorable conditions for pedestrians(253,254). As we discuss in **Road Safety Measures**, speed is the leading risk factor of road crashes and fatalities. Buehler (2011) contends, among other factors, that roads that allow high travel speeds facilitate auto travel in the US(255). In German cities, auto use is expensive and slow (despite a lack of speed limits on expressways); public transportation, walking, and biking are safer and more convenient.

Despite this research, conventional traffic planning largely continues to associate speed with safety. In the US, "every effort should be made to use as high a design speed as practical in the interests of safety"(256)(p.67). The American Association of State Highway and Transportation Officials guidelines call for wide roads that maximise auto speed. Traffic engineers consistently follow these instructions to build more car infrastructure for higher speeds, even in residential areas(16,257). In this ongoing conflict between HVT and standard transportation planning practices, Noland and others have made clear the inherent tradeoffs between safety and mobility(17). Ewing and Dumbaugh (2009) explicitly state that high speeds cause worse safety outcomes(258). Patton shows how a pedestrian master plan conflicted with LOS requirements mandated by the HCM to maintain traffic flow in Oakland, California(259). Further, Litman and Handy show how LOS-based mobility planning decreased accessibility for people because it did not consider other aspects like destinations, land uses, and models to boost walking and cycling modes(260).

The traditional LOS-based transportation planning is often underpinned by cost-benefit analyses (CBAs)(16,236). Analyzing road network growth in the UK, Metz (2008) said 80% of the monetary benefits of CBAs of major road schemes are measured in travel time savings. However, as travel time has remained constant, Metz found no evidence that travel times would have been higher in the absence of road construction.

Partly in response to the results of CBAs, planners developed more robust transportation models that incorporate positive and negative impacts on criteria including safety, the environment (greenhouse gases and local air pollutants), 'environmental capital' (e.g., landscape, biodiversity and heritage), as well as social and distributional impacts. These tools are called multi-criteria analyses (MCAs) or policy-led multi-criteria analyses (PLMCAs)(236,261). The main difference between them is that CBAs rely on market pricing and economic efficiency criteria and rarely take into account the distributional effects of transportation projects. MCAs/PLMCAs are led by objectives and policies. Further, the quality of life and ethical concerns are difficult to quantify and monetise, and therefore difficult to include in CBAs and MCAs. PLMCAs are more adept at including these issues in transportation planning and project evaluation(236). In the HIC context, the UK Department of Transport's Web-Based Transport Analysis Guidance (WebTAG) MCA appraisal guidance and toolkit considers the potential impact of noise, air quality, greenhouse gas emissions, impact on the landscape, as well as social and distributional outcomes. It is a leading model and frequently referenced by other countries(261). When outcomes are difficult to quantify, WebTAG provides guidance to transportation planners so they can measure and consider impact using analyses outside the model. In addition, the Asian

Development Bank (ADB) recently developed Sustainable Transport Appraisal Rating (STAR) to assess the accessibility, affordability, safety, and environmental sustainability of its transport projects, many of which are in MICs and LICs(262). This rating system seeks to be objective-driven and transparent. While it is supported by quantitative indicators, the assessment is explicitly qualitative, relying on the judgment of the evaluator.

Other alternatives to the auto- and speed-oriented manuals and tools mentioned above have recently emerged. The UK's Department of Transport Manual for Streets emphasises "inclusive design"(263)(p.11). This means placing people at the centre of the design process instead of motor traffic. The Departments of Transportation of New York City and Chicago, and the US National Association of City Transportation Officials (NACTO) have released their own street design manuals(264–266). These manuals emphasise traffic calming measures that slow auto travel and design elements that improve conditions for public transportation, pedestrians, and cyclists. The EU Sustainable Urban Mobility Plan framework implementation guides promote the adoption of land use and transport integration processes(267). They focus on urban functional units (metropolitan/regional) and offer several good practice examples across the EU. These implementation guides are high level and advisory, and they rely primarily on local uptake(267,268).

Grey literature provides other capacity tools to assist in project implementation. For BRT, there is strong support in planning and design manuals, reviews, and case studies(269). The most referenced publication is ITDP's *Bus Rapid Transit Planning Guide*, which provides a comprehensive approach for the planning, implementation, and operation of BRT systems(270). Another review, Restructuring Public Transport through Bus Rapid Transit, offers an interdisciplinary perspective on implementing BRT systems worldwide (271). To promote high-quality BRT systems, ITDP has also published annual iterations of the BRT Standard, which defines a scoring method based on a series of evaluated attributes(272). There are more guides than we had time to catalogue on different issues (e.g., NACTO's Transit Street Design Manual and ITDP's TOD Standard).

New tools and indicators also assess climate impact and resiliency. In the San Francisco Bay Area, Wall et al. use dynamic adaptive planning (DAP), an emerging general strategic planning method, to identify the key strategies that public officials and other stakeholders need to implement to improve the resilience of transportation infrastructure(273). For HIC Hungarian cities, researchers developed a set of indicators to evaluate the resilience of urban transportation systems. The indicators include emergency strategies for public transportation systems, mapping climate risk and vulnerability, early warning systems, and public transport fleet procurement that reflects the changing climate(274). Finally, in India (MIC), researchers proposed developing climate resilience toolkits to guide municipal governments on actions that improve resilience. These actions include conducting risk and vulnerability assessments, sectoral impact studies, data collection and management, and mechanisms for participatory planning with relevant stakeholders(275).

New tools to measure access to destinations (the ability to reach desired destinations within a given amount of time or money) are increasingly easy to use. There is recent progress in the application of accessibility metrics in cities in HICs, such as London and Boston(276,277). Open data sources, like OpenStreetMaps (OSM) and the General Transit Feed Specification (GTFS) have made network-based accessibility analysis cost-effective, particularly for cities in LICs which have traditionally been limited by a lack of data and resources(278). (See **Improve 4.3.2.2 Integrative Platforms and Technologies** for an in-depth discussion.) Access studies have also been developed for Latin American cities in MICs: Bogotá, Rio de Janeiro, and Cali(278,279). These studies look at distributional implications of transit networks and find they often concentrate their benefits on the higher end of the income distribution. This equity assessment may have a significant impact on how HVT measures are applied, especially in MICs and LICs where distributional consequences are frequently overlooked. Even a basic accessibility indicator can be useful to analyse the equity impact of technical decisions.

The literature shows that many of the transportation planning tools and guides developed in the 20th century, particularly those from the US, work against the goals of HVT worldwide. The power of and impact of the HCM needs more study, but evidence from the **Capacity Assessment** interviews and reviews of the literature shows that auto-centric guidance is dominant in MICs and LICs, specifically in sub-Saharan Africa and India. While these guides and tools are being used in LICs and MICs around the world, it is not clear how prevalent they are. Many new tools and analysis provide HVT-focused guidance to practitioners and leaders, including multi-criteria analyses, HVT-focused standards, and guides. We need to study the uptake and adoption of new guides. The HCM was introduced in 1950, but the path to global influence and implications for newer guides and models are unclear. New technologies have enabled the application of these tools in the LIC context. As the access to basic data has improved, governments are better able to measure accessibility. With some notable exceptions, we need more research on how well the newer HVT-focused tools and guides developed in HICs translate to MICs and LICs. We also need more research on the use of HVT-focused tools and guidance on implementation in the MIC and LIC context compared to traditional LOS-based tools.

5.1.2.3.b. Capacity Building

The World Bank defines capacity building (a.k.a. capacity development) as "a locally driven process of learning by leaders, coalitions and other agents of change that brings about changes in sociopolitical, policy-related, and organisational factors to enhance local ownership for and the effectiveness and efficiency of efforts to achieve a development goal"(65). In the decades after World War II, the donor country approach to development in LICs and MICs began with direct grants and loans, which often led to heavy debt and dependence on foreign aid. The approach then shifted to direct technical assistance, which led to dependence on foreign expertise and often aligned poorly with local goals. It shifted to technical cooperation, which increased the local ability to implement projects but still primarily reflected external goals. Finally, it shifted to capacity development (capacity building), which aims to boost local ability to fund and implement projects to meet local goals(280). The institutionalisation of capacity building was seen in major international agreements. Agenda 21, the action plan developed as part of the UN Conference on Environment and Development (Earth Summit) in 1992, calls for the exchange of ideas and increasing the capacity of local and national governments, the private sector, and NGOs in LICs and MICs(281). Similarly, the Kyoto Protocol of the United Nations Framework Convention on Climate Change, which most countries signed in 1997 as a commitment to greenhouse gas reduction targets, includes capacity building goals, specifically for LICs and MICs to help achieve emission targets(282).

GIZ and Embarq indicate that national training programmes may enable better local decision-making and governance—even in developed countries with a decentralised structure. The knowledge and the capacity of people (staff and consultants) are fundamental to effective policy implementation(163). Capacity building is widely accepted in grey literature and development agency circles as a potent agent of change(283,284). (See initiatives such as the Sustainable Urban Transport Project and its current embodiment, the Transforming Urban Mobility Initiative, and the World Bank's Leaders in Urban Transport Planning programme.) Planning tools and guides may also boost capacity to implement HVT measures. (See the **Guides and Tools** section above.)

Detailed reviews of how to achieve capacity building for HVT are not frequently found in peer-reviewed literature. UN-Habitat has shown how institutional capacity building and training staff in the urban transport and land-use sectors are fundamental to guarantee better policymaking and implementation(26). This finding relates to McKinsey's "5 C's" approach as "capability for change," and is one of the four areas that GIZ and Embarq indicate need to be addressed(85). GIZ and Embarq have indicated that a greater technical and organisational capacity at the local level is required to achieve improvements for decentralised financing policies and funding frameworks(163). This research suggests that education and local capacity may play an

important role in HVT policy implementation. Some grey literature on capacity assistance exists, especially for BRT systems, but peer-reviewed research has not engaged in this issue directly.

The search for relevant capacity building experience from fields outside of transportation presents a considerable amount of peer-reviewed literature linked to public health, agriculture development, and the non-profit organisation sector. Although capacity building is a key factor for effective policy implementation, there is a dearth of assessments on the success of such programmes(285). Peer-reviewed literature is more prone to analyse challenges within the capacity building theme and propose theoretical models to evaluate the effectiveness of the measure. Much of the grey literature focuses on capacity building toolkits and recommendations. Many sources, from different fields, agree that limited administrative and organisational capacities play an essential role in an organisation's ability to reach desired outputs.

However, Mizner's research brings an interesting view on capacity building evaluation from the nonprofit field(285). The study assessed the capacity building outcomes on the short-term organisational capacity of non-profit organisations supported by the US federal government's Compassion Capital Fund Demonstration Program (CCF). The evidence-based findings demonstrated that the organisations engaged in the programme achieved improvements in five analysed critical areas: organisational development, programme development, revenue development, leadership development, and community engagement. However, this research didn't measure client outcomes. We need more research to know if capacity building can yield positive results for final clients or service users. An older but interesting reference is Andersson and Isaken's report on capacity building for public finance in African countries, funded by Norwegian and Swedish development agencies(286). The authors conclude that while public finance management systems in the analysed countries failed to reach a minimum desired standard; it takes time to reach the desired standards. Inventions must be designed for short, medium, and long-term outcomes.

The literature shows that while there is widespread acceptance of the value of capacity building efforts, there is no robust analysis to support this belief within the transport sector. Outside of transport, there have not been assessments of how well this translates to better service to clients. We need more research to answer these questions, particularly regarding LICs.

5.1.2.3.c. Education

The area of education and knowledge building for HVT remains understudied, particularly in middle- and low-income countries. We did not uncover literature on the influence of secondary and post-secondary education opportunities in fields related to HVT or how these could create a greater capacity for HVT policy implementation. In the interviews we conducted in the **Capacity Assessment** section, interview subjects noted the auto-centric perspective of transportation professionals in sub-Saharan Africa and India hampered HVT implementation there. In the **Guides and Tools** section, we document the continued use of auto-centric transportation evaluation tools among academic researchers in LICs and MICs in Africa and South Asia. Presumably, this perspective was taught to the researchers and professionals in local universities, although auto-centric standards may also be adopted into policy by the government, limiting the ability of professionals trained in HVT to implement effective measures. We need to evaluate the existing curricula as it relates to HVT goals.

Scholars have posited that better education in LICs and MICs could lead to more use of research-based (or evidence-based) policies, which researchers associate with more and better HVT systems, especially when policies are assessed (or tested) rigorously before, during, and after their implementation(287). We also need better benchmarking of local knowledge production, which can be shared to reach policy decision makers and technicians. For example, while the number of publications in Africa has increased since 2005, only 54% of African scholars publications were indexed in Google Scholar(101). Increased local knowledge could produce HVT solutions better tailored to local contexts. We need more research to understand how to

develop universities, professional associations, and other educational paths that train technical staff in the details of HVT implementation, steer academics toward HVT research, and educate decision makers about the benefits of HVT.

5.1.2.3.d. Research: New Data for HVT Governance

In recent years, researchers have analysed new ways of collecting and using data for urban HVT systems. Some research has emphasised the impact of these new data sources on governance for cities in general and transportation in particular. Themes related to these new data sources include “smart cities,” information and communication technology (ICT), and “big data.” (We describe this in greater detail in the **Integrative Technologies, Data, and Platforms** section.)

Some research is optimistic about the promise of new data and smart cities. Mohanty claims that such cities are “greener, safer, faster and friendlier"(238)(p.60). Similarly, Chow applies new data and uses to public transport, freight and shared mobility, and proposes that smarter technological solutions for urban transport will reduce financial, social, political and environmental costs(288). Within this context, smart governance often refers to new possibilities for public participation in policymaking enabled by ICT, as verified in a comprehensive review of smart city literature(289).

Research on practical applications of new data sources and smart cities is still limited. This area of practice and research is new(289). There is, however, a growing amount of research that uses big data sets to examine urban travel patterns and propose solutions. For example, researchers used big data from a bike-sharing scheme in New York City to examine the effect of the public cycles on bus ridership(290). Researchers used taxi-derived GPS data to propose a dockless bike-share system that would facilitate last-mile trips using public transportation(291).

An early example of the practical application of new data came from the MIC context of Bangalore, India, where traffic police collaborated with a social technology startup and a private cell phone provider to use cellphone data to create a traffic monitoring tool on the road network(223). According to this research, the project was useful in terms of governance. Various heads of municipal agencies collaborated on the creation and implementation of the tool. The main outcome of the project allowed the police to respond better to traffic events (e.g., helping reduce congestion on the roadways in the city).

By examining smart city initiatives in two cities in the HIC context of the UK, researchers gathered qualitative data from planners to understand the challenges of using new data collection techniques to tackle urban issues(292). The smart city projects included initiatives to increase public participation in municipal activities, enhance the scope and availability of open data, and encouraging active travel. Projects included an app that collected data on cyclists’ paths to help plan bicycle infrastructure and an app to report issues (e.g., uncollected trash) and track the city’s response. Interviewees pointed out that the ICT-enabled tools provided users with alternate travel options when some parts of the infrastructure (e.g., a key rail link, were no longer available). Related to the participatory aspects of the projects, there was an issue of managing expectations—just because people could raise issues did not mean that they could make decisions; “consultation does not mean everybody gets what they want”(p.161).

Researchers in Ghana (MIC) found that cities in that country had not applied smart city and smart mobility initiatives. They suggested that there were major obstacles to implementing information-based transportation solutions, including weak information sharing across institutions, budget limitations, and politicians giving a higher priority to social issues. These challenges were found in Ghana and also across sub-Saharan Africa(293). However, they suggested that improving information networks for urban transport in Ghana and across the region could enhance public transportation, and create space for walking and cycling. Also in sub-Saharan Africa, a project carried out in the LIC context of Addis Ababa, Ethiopia, used an app that

gathered GPS data to create a map of the paratransit system. This allowed public officials and passengers to visualise the existing public transportation system for the first time(294).

Although not peer-reviewed, we encountered evidence of a public authority using big data to support HVT. New York City used GPS data from taxis to evaluate the traffic effects of the pedestrianisation of Times Square. This provided evidence that allowed the measure to become permanent(295). Further, public authorities used regularly reported data sets, such as taxi GPS and MTA Bus Time information, to understand how travel speeds are changing across the city and how to improve services(296). A key concern here is the public sector having the capacity to use and analyse big data in places where capacity is already constrained, such as LICs and MICs.

Despite the promise of new data sources and smart cities to improve transportation systems, important challenges remain. Bettencourt contends that while big data has vastly increased the information available to planners to make decisions, familiar challenges persist(297). Planning issues are still "wicked problems," as defined by Rittel and Webber in 1973—problems that cannot be solved in practice by a central planner. Bettencourt posits that regardless of the amounts of data available, comprehensive city planning is not possible. This argument is supported by Bibri's finding that ICT, new data, and smart technology still has not had an impact on promoting urban sustainability and compact urban form(298). Privacy is also a major concern for these data sources, particularly regarding passenger travel. There are major tradeoffs between accuracy and anonymity of this data(299).

In summary, there is potential for new data to improve HVT, but researchers have identified familiar issues related to planning, participation and governance, and new issues related to privacy. How to collect and use new data will undoubtedly command more attention from planners and researchers in the future. Potential uses for new data sources—services, system integration and regulation—are discussed in more detail in the **Improve** section.

5.1.2.4. Funding and Finance

The existence of funds, through direct government resources or loans, has a role in making projects a reality(300). Multiple scholars describe financial constraints as barriers to effective HVT planning and implementation, including BRT(93,198,224,301). However, this aspect may become a significant disabling structure when other structures are not in place to support HVT (the money may go instead towards car-centric transport). We investigate the role of 'sustainability' thinking in the financing world (i.e., the ability to achieve a project's economic and financial sustainability), as it relates to urban transport and more traditional approaches to project finance. Compellingly, the financial cost of HVT infrastructure is comparatively low. As Simes points out, "relatively aggressive pedestrian and cycling improvement programmes only cost about 1-4% of the total per capita roadway expenditures or just 4-10% of general taxes spent on local roadways"(302). Researchers have argued that budget allocations for walking and cycling should be at least equal to their mode share where the latter is high. They should be consistent with sustainable mode share targets where the turn to more sustainable patterns has not occurred(303).

To discuss this topic, we must first distinguish between funding and finance. The funder is the person or entity that pays the costs, while a financer provides temporary money (often in the form of a loan) but expects repayment, typically with interest. For example, a bank may finance a bicycle path by loaning a city government $10 million dollars. The government funds the project, spends the money on the bike path, and pays back the loan to the bank. However, if a development agency provides a grant to the city government, that agency is effectively funding the project, and they do not require the city government to pay back the money. Multilateral development banks and other development institutions often provide 'soft loans', loans with interest rates below the market rate, leading to lending institutions losing money on the loan. Soft loan interest payments may be skipped or loan balances may be forgiven to ease the burden on countries.

There are two types of investment for the promotion of sustainable urban transport policies aiming to increase or retain HVT ridership: capital investments and operations(163). Capital investments refer to investments in infrastructure (e.g., metro and light rail lines, dedicated bus lanes, segregated bike lanes, stations, stops, and garages). It also includes the supply of complementary services like traffic management systems, fare collection, administration services, and passenger information systems. National or local governments typically own or manage all the infrastructures described above. However, there are exceptions, like fleet management and fare collection systems in some Latin American cities, such as Mexico City and Bogotá (MICs), where private companies supply them. Buses and rolling stock are also part of capital expenditures; in many cases, especially in middle- and low-income cities, these investments are the responsibility of private operators(304). The operation costs of urban transport systems include daily running expenses, administration, staff salaries, and fuel(163). The funding for operating costs supports the continuity stage (Stage 3) of the measure implementation process.

The funding of HVT, including both capital and operations costs, relies on steady and predictable flows of revenue from national, subnational, and local government(305). The availability of regular and continuous credit through more predictable financing sources is crucial to the expansion of rapid transit(171). "Continued financial flows" is one of the four areas that GIZ and Embarq indicate are critical to improving urban transport policies(163). Continuous funding sources for operations may include farebox recovery, subsidies, and advertising revenues from pricing schemes (e.g., London's congestion charge), and resources from value capture policies(306). In HICs and MICs, fare subsidies usually cover a considerable portion of the operational costs, often above 50%. A review of transport systems in European cities (mostly HICs) by Parry and Small supports the efficiency of large fare subsidies(15). In the case of MICs and LICs, Serebrisky et al. and Ardila-Gómez and Ortegón-Sánchez encourage a move away from supply-side subsidies towards demand-side subsidies to improve the welfare of low-income people, who are the majority of public transport users(213,307).

The question of which level of government or which institution or private sector should fund and/or finance HVT project is much debated. Ardila-Gomez and Ortegon-Sanchez examined a wide range of measures for funding HVT(213). Innovative funding schemes included instruments such as public–private partnerships, land value capture or ring-fencing (the practice of separating and protecting funding and finance streams for specific uses), and property taxes. They found that PPPs for public transportation or road building, could be successful, but this required careful management by the public sector. Land value capture had been most frequently used to contribute to financing roads and streets and bus networks. Property taxes emerged as a key tool to finance capital, operations, and maintenance costs of transportation systems. The MIC experience of India shows that upfront government capital subsidies or grants for urban transport projects helped private developers in PPP arrangements to internalise the value from externalities(308). Hook and Hughes examined funding sources for large transportation projects in France, Colombia, China, Indonesia, South Africa, Mexico, Brazil, India, and the United States. They found a diversity of funding sources across different countries(309). (See **Figure 16**.)

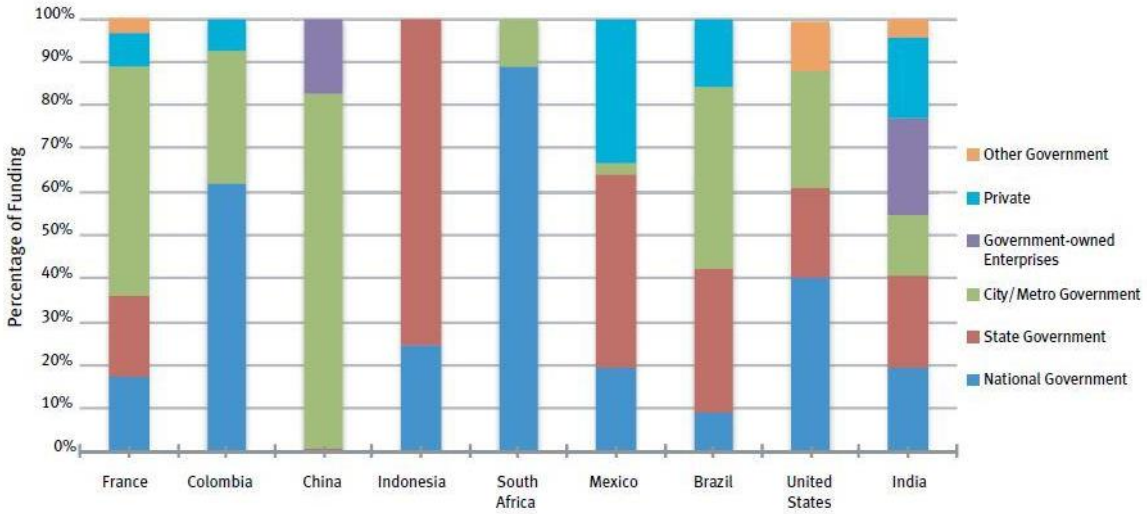


Figure 16. Funding sources for large transport capital projects. Source: ITDP: Best Practice in National Support for Urban Transportation

How funds are collected and allocated can be crucial to enabling HVT policy measures and meeting HVT goals. In a recent review of the literature, Ardila-Gomez argues that cities should take a "who benefits pays" approach to urban transportation finance. This means that those who benefit from a measure should bear the costs of providing it(213). He assesses 24 types of financing instruments used in HIC and MIC contexts under this framework and evaluates their social, economic and environmental impact, as well as their ability to fund urban transport capital investments, operational expenses, and maintenance. His main recommendation is that charging direct, indirect, and general beneficiaries successfully (user fees, public transport fares and land-related charges) can create sustainable revenue streams that make projects financially viable. Zegras also mentions fiscal equivalence (matching beneficiaries and payees) as a desirable feature in transport financing, along with efficiency, net external effects, equity impact, and administrative ease. He argues that metropolitan governance requires an appropriate governance structure, and that mobility is the defining factor of a metropolitan area(304). Conversely, Vasconcelos shows that in Brazil (MIC), a tax on fuels—introduced in 2001 with funds earmarked for HVT initiatives—failed and was discontinued in 2012 because most revenue was being directed to highway agencies(143). The federal government retained the remaining funds to maintain debt limits imposed by international financing agencies (an unintended negative consequence of international financing).

The following subsections describe the various sources of funding and finance that can support HVT systems in greater detail.

5.1.2.4.a. Government Funding Sources

The government is a major source of project funding, including raising revenues through a combination of taxes and fees, some of which are dedicated to transport. As with the previous enablers and disablers, this topic has been widely discussed in literature on policymaking, although not necessarily for transport.

The capital costs of urban infrastructure and recurring costs are often met through budgetary support from national governments. However, few studies exist on how national governments in LICs and MICs invest in urban transportation. In the MIC context, ITDP Mexico tracked federal spending in sustainable urban mobility projects in Mexico's main metropolitan areas. It found that the proportion of 2005 federal funds invested in the expansion or maintenance of car-oriented infrastructure was disproportionately higher than those invested in HVT modes, with 47% going to urban highways and car infrastructure, 33% for paving roads, and less than 5% for public transport, and only 1% for cycling infrastructure(305). In a study for India (MIC), Hidalgo et al. (2012) analyse how a large national infrastructure programme, Jawaharlal Nehru National

Urban Renewal Mission (JnNURM), was invested. Similar to the case of Mexico, the authors found that nearly 57% of the projects were related to roads and flyovers.

In addition, research has examined the role of national governments in funding and implementing projects, as opposed to sub-national or municipal governments. For example, Holuigue recommends that resource allocation for HVT measures should be the responsibility of metropolitan agencies(173). Hook and Hughes found that one of the key factors for increasing mass transit kilometers was having reliable, long-term revenue flows, as well as the cost-effectiveness of spending and local capacity to implement the projects. This analysis also revealed the role of national government grant programmes and loans to catalyse infrastructure development(309).

Other researchers found that innovative funding mechanisms at the local level, and the devolution of financial power, enhance the fiscal capability of local authorities and reduce their reliance on national government allocations(185). Within grey literature, GIZ and EMBARQ evaluated both centralised funding programmes and decentralised financing policies used to fund sustainable urban transport in eight middle- and high-income countries—Brazil, Colombia, France, Germany, India, Mexico, the United Kingdom, and the US. The analysis revealed that decentralised policies require a higher degree of organisational and technical capacity at the local level as it shifts the responsibility of project identification, design, implementation and evaluation to local authorities. Decentralised policies provide the flexibility to adjust project needs to local priorities. Centralised funding programmes provide more technical guidance to local authorities, but also keep fundamental decision-making powers regarding project design and implementation with the national government(310). Transfers of funding from higher to lower levels of government can be useful to foster sustainability goals or reform-based assistance, but it is challenging because it means that cities need to spend significant amounts to maintain or improve current levels of service(311).

Looking at HVT outcomes, transfers of funding from higher to lower levels of government have had mixed results. For example, transfer of responsibilities for transportation planning and financing from the provincial governments to city districts may have caused the deterioration of Karachi's commuter rail and its subsequent closing in 1999. Now Karachi is the only megacity in the world without a rail-based mass transit system(312). In contrast, India's NUTP enables cities to access transport improvements funds through Jawaharlal Nehru National Urban Renewal Mission, as seen in the Janmarg BRT system in Ahmedabad(313). The Indian Ministry of Urban Development requires cities seeking JnNURM funding to align their mobility plans with funding(69,314). Another study of India found that upfront government capital subsidies or grants for urban transport projects helped private developers in PPP arrangements to internalise the value from externalities(308). By translating negative HVT externalities into financial costs, and positive HVT externalities into revenue, governments create a financial, actionable incentive for developers to work towards HVT.

5.1.2.4.b. Land Value Capture

Land value capture (LVC) is an effort by governments to divert the increases in private land value resulting from public sector investment, such as infrastructure development, back to government bank accounts for public benefit. For example, in the US (HIC) implementation of sustainable urban transport projects can create a virtuous circle, in which improving accessibility leads to an increase in land prices, pushing the demand for densification along transport corridors and stations. Part of these economic gains can finance the operation or improvement of the transport network(315,316). Thus, LVC represents a potentially untapped reservoir of transit agency or local government own-source financing. Suzuki et al. (2015) argue that LVC holds important advantages over more traditional taxes and fees. It is less likely to face public opposition and may be easier to enact in low- and middle-income countries with an inadequate property tax system(317). A recent World Bank study on sustainable urban transport financing included LVC as a premier mechanism(213). Both peer-reviewed and grey literature suggest that in most cases—including in developing

countries—LVC may be actionable at the local level, reducing dependency on higher levels of government, the private and NGO sectors, and on farebox revenue.

Land-based financing can take various forms, including taxes and fees (e.g., betterment levies, property taxes, sale of development rights and premium FAR) or tax increment financing. It has been applied in several HIC and MIC locations: China (including Hong Kong SAR), France, Germany, India, Japan, the UK and the US(318). Japan, Hong Kong SAR and China have leveraged LVC specifically for HVT infrastructure and TOD(198). Drawing on the experience of the US, Walters suggests that annual property taxes can be effective LVC instruments(208,318). Further, Voith and Wachter discuss the relationship between affordable housing and LVC, using inclusionary housing requirements and community land trusts in the HIC contexts of the UK and the US as examples(318,319). Voith and Wachter argue that the ability to capture the value generated by a flexible zoning scheme is a precondition for the successful implementation of inclusionary housing schemes.

Public land resources can also finance public infrastructure. This can be done by intensifying the use of public land, structuring PPPs to build HVT infrastructure, and implementing robust land valuation systems, which are still evolving in the Asia and Pacific region(190). In the MIC context of China, Anderson (2012) discusses the limitations of long-term leases of public land, which constrain the government's ability to capture land value through property taxes(320). This reliance on public leaseholds to finance infrastructure has negatively impacted low- and middle-income households(318). James Wen argues that a private and public land market need to coexist to set leasehold charges and tax assessments, also a constraint in China(318).

Drawing from the experience of Latin America, Smolka summarises that successful implementation of LVC requires a proper understanding of land market conditions; comprehensive property monitoring systems; a fluid dialogue among fiscal, planning and judicial entities; and the political resolve of local government leaders(321). Land value increments are captured more successfully from landowners and other stakeholders who perceive they are receiving greater benefits from a public intervention than those accruing from business as usual. Value capture tools are more likely to succeed when used to solve a locally recognised problem(321). However, they also highlight the need to manage the risks of corruption, gentrification, and over-reliance on value capture. If not managed, these factors can create negative perceptions among citizens in many developing countries because of a lack of transparency and can displace lower-income households(317). Further, there may not be legislative provisions to recover the value through a tax or a fee. As experiences in Bogotá, Seoul, and Beijing have shown, the cost-benefits of LVC and TOD appear positive for cities who cannot afford the expensive upfront costs of rail, and who can pursue joint projects with real estate developers(224,322).

The research shows that LVC can provide a funding source for HVT measures. Because LVC requires strong government capacity, it is especially helpful in contexts with strong government institutions and strong land markets, but limited funds. This may not be the case for many cities in LICs, but more research is needed. LVC also does not function well where funds are frequently raised through long-term leases, as in China, where the government does not benefit from increases in land value due to fixed rents.

5.1.2.4.c. Private Sector Finance

A common finding is that for HVT projects, public funds do not meet infrastructure needs, especially in MICs and LICs. Yet, this finding does not align with the results of our findings from the **Capacity Assessment** interviews above. This suggests that in multiple LIC and MIC cities in Africa and South Asia, funding is adequate, but often not directed towards HVT. However, in funding constrained contexts, the World Resources Institute identifies three main reasons to involve the private sector in financing urban transport infrastructure and operation: operational expertise, financial capacity, and efficiency(323). This subsection

explores the role of private financing for HVT, focusing strongly on the MIC and LIC context (given the breadth of information about municipal finance in HICs).

Some researchers point out the need for solid institutional and legal frameworks to maximise the benefits of this type of partnership(324). A 2014 World Bank report looks at the role of institutional investors in financing transport infrastructure in LICs and MICs. The report finds that there are (more or less) favourable preconditions for successful private investor involvement, and different models work in different situations, depending on the development stage and institutional environment(325). In this sense, it is necessary to question the relevance of public–private partnerships in the case of LICs, which experience the paradox of not having enough economic resources to finance urban transport systems, while also not counting with basic institutional and legal structures to attract private investors.

Bonds represent a means of securing financing from a broad base of private and/or public sources. Typically, bonds are purchased from governments in exchange for a government promise of regular interest payments to the bondholder over a fixed amount of time. Recent initiatives, such as green bonds and climate bonds, have used independent certification processes to identify bonds that support environmental and social goals, which typically align with HVT goals and include HVT measures(326,327). Bonds constitute the most common capital market instrument used by local governments and their financing structures, especially through special purpose vehicles for the PPPs. China, India, Indonesia, Malaysia, the Philippines, and Thailand, among others, have successfully fostered urban PPP special purpose vehicles and have accessed capital markets (both debt and equity)(190). However, the limited availability of useful and reliable information published by municipal governments, especially in smaller cities, makes it difficult to value a city's creditworthiness and therefore impedes access to credit markets for borrowing to finance infrastructure. Private investors may not have expertise or experience in financing or lending at the municipal level. They might be unfamiliar with local policies and business environments, which may necessitate greater due diligence. There also may not be mandatory obligations to disclose the climate performance of urban transport or infrastructure projects; and, positive externalities of environmentally sustainable infrastructure may not be appropriated or taken into account by private sector investors and reflected in risk-reward profiles(237).

Private sector finance can increase funding availability in resource-constrained environments and also increase capacity. However, the research shows that obtaining such financing may paradoxically require higher levels of capacity to begin with. In LICs and MICs, private funding is often obtained through special purpose vehicles, as part of PPPs. We need more research on the positive and negative impact of private sector finance in the LIC context, and the potential and risks for improved access to private finance in terms of HVT.

5.1.2.4.d. Overseas Development Assistance

Overseas development assistance (ODA)—the provision of financing and transfers of aid from one official agency to a recipient country or territory, often for humanitarian or diplomatic reasons—is the subject of extensive academic studies and literature reviews on the pros and cons of aid and financing, especially in fields of health, agriculture, and economic growth. One feature of ODA is its concessional nature, whether loans have an element of grant funding or the interest rates are below market rate. However, we found no substantial references on the effectiveness of aid in transport or mobility. Some authors argue that where aid has not been effective enough, its absence would have been even worse; it needs a new assessment model to measure aid effectiveness and fight inequality(328,329).

ODA can be categorised by multilateral assistance and bilateral assistance(330). Multilateral assistance is composed of financing and grants from multilateral development banks, such as the World Bank or the Asia Development Bank, and international development agencies like the United Nations. Bilateral assistance is from a specific country, such as the United Kingdom's Department for International Development and JICA. In

a 2010 review, researchers found that most ODA in the transport sector supported highways, flyovers, and ring roads in urban areas(330). In 2012, however, the eight most prominent MDBs committed their entire transport budgets, $175 billion, to “more sustainable transport” at the United Nations Conference on Sustainable Development (a.k.a. Rio+20)(331). According to a 2017 self-assessment by the eight MDBs, they collectively committed $88 billion for more sustainable transport projects from 2012 through 2015, and average of $22 billion per year, significantly more than the $17.5 billion per year that was pledged. However, the 2015 assessment includes financing for 89 road projects and 12 airport projects as commitments to sustainable transport(332).

BRT provides a relevant lens to assess development aid in practice. In the LIC context, the Tanzanian government was the beneficiary of a $150 million loan from the World Bank to establish BRT in Dar es Salaam(333). The literature suggests that loans may be crucial to launching BRT in less wealthy African countries, but they are not a sustainable source of funding. Appropriate policy instruments may be necessary to pay back start-up loans and supplement farebox revenue, especially if fares are to remain equitable(224). It also behooves cities to avoid cutting corners in construction (e.g., buying shoddy vehicle, or shrinking trunk lines for the sake of saving financial or political capital). These shortcuts can reduce ridership and lessen TOD, ultimately undermining a programme’s financial sustainability(93).

Previously mentioned under the **Building and Engaging Political and Community Will** section, development agencies can have a coercive effect on transportation decision-making. Particularly, bilateral aid may benefit the donor country over the needs of the receiving country. In African cities, as seen in Nairobi, Chinese aid agencies and firms have invested in the construction of road infrastructure. Kenyan authorities favour the more immediate and direct solutions of Chinese actors over the solutions brought by other foreign institutions(334). We need more research into the relationship between aid and project decision-making.

The effectiveness of aid in the LIC context is well-studied, but not in relation to HVT. The limited research we found suggests that aid can be effective at launching HVT measures and may lead to higher quality projects. However, the continued success of aid-funded or financed measures depends on governments securing additional ongoing funding sources.

5.1.3. State of Knowledge Conclusions

This review of the literature on ‘enabling structures’ has identified key governance elements necessary for the successful planning and implementation of HVT systems. (See a summary of key findings in **Table 10**.) We have found that grey literature, particularly high-level policy documents, offers a simplified vision of the institutions and mechanisms that must be in place to achieve HVT. These include political and community will, good governance and institutions, and sufficient funding. Peer-reviewed literature offers a more nuanced vision and explores the difficulties experienced by actors seeking to implement HVT in different locales.

Key Findings Summary
Building and Engaging Political and Community Will
- A strong single vision backed by political will can catalyse HVT and align actions, but competing visions do the opposite; - Political will can be built through experiential learning (study tours), persuasive messengers (often mayors), and simplified messages. It is facilitated through a network of international advocates and technical experts. Technology helps spread good practices quickly through pictures and videos. More successful exchanges reflect the local context and experience; - Strong engagement leads to stronger outcomes and potentially increased public acceptance in HICs, but engagement does not guarantee success. Engagement and participation can also derail HVT projects. There is limited evidence of how this works in LICs and MICs.
Governance and Institutions
- The metropolitan and municipal levels are generally best for HVT implementation if they have the capacity, authority, and resources; - The role of national government is critical: providing political support, policy goals, institutional structures, coordination, funding and financing, regulations, and capacity building that empower sub-national and local levels; - Metropolitan governance is needed in urban areas that cross jurisdictional boundaries. This can be achieved in three main ways: amalgamation, 2-tier systems of governance, and informal coordination mechanisms like committees; - Contracting with the private sector for transit operations has generally been positive, but more research is needed in how best to contract with the private sector; - Generally, PPPs for megaprojects, like big infrastructure projects, have had a higher risk than anticipated, and government bears the burden of those risks.
Education: Knowledge, Capacity and Research
- Manuals biased towards auto-centric transportation, such as the HCM, seem to be the norm for many LICs and MICs, although the extent is not known. These have been integrated into decision-making frameworks and policies to the detriment of HVT; - New HVT-focused manuals and tools are being developed and promulgated. The extent of their dissemination and influence is unknown; - Capacity building is a potent agent of change, but little is known about effective means for capacity building and how to measure their impact; - New data may improve governance, as it becomes easier to access and use for planning and evaluation, but it cannot solve all planning and implementation challenges.
Funding and Financing
- Predictable and steady flows of revenue enable HVT—from planning to operations; - Government is the major source of transport funding and financing, primarily focusing on road. infrastructure, including highways and flyovers; - Land value capture may enable local governments to raise revenues, but it requires strong institutions and strong land markets; - Leveraging the private sector, either through PPPs or bonds, may increase financing option but requires higher government capacity; - ODA plays a catalysing role for HVT, but not a sustaining one.

Table 10: Summary of key findings from the Enabling Structures section

In terms of **political will**, we found that a long history of pro-automobile policies continues to influence decision-making. Yet that experience with high-quality HVT systems, whether locally or via study tours, can boost support for HVT measures. We found that vision for HVT can act as a guide or even a catalyst for HVT measure implementation, but other goals can trump this if the political support is not consistent. We also found that clear communication of HVT visions and goals, in terms that align with other local priorities, can help to build political will for HVT measure implementation. We found evidence that public participation has mostly enjoyed success in Europe, but given some skepticism about the process there, we are unsure of how such methods would perform in middle- and low-income countries. The question of how citizen engagement can contribute to HVT in settings vastly different that Europe remains open. We also found that engaging vulnerable groups, such as low-income residents and women, may be critical to designing HVT measures that address safety and equity issues effectively, but it does not guarantee success or assure their buy-in.

We explored the different aspects of **governance and institutions** related to creating successful HVT systems. Much of the literature agrees that municipal governments are uniquely suited to handle challenges related to sustainability and resilience. However, when their actions are coordinated, higher levels of government can provide guidance and capacity support to empower local governments only when real power is transferred. National governments can also facilitate coordination across jurisdictions in a metropolitan area. Metropolitan coordination is important for solving metropolitan transportation issues. Metropolitan governance structures can help ensure this, but only when they have sufficient power and resources. The literature also showed examples of successful informal coordination, but only in HICs. Strong institutions are shown to support measure implementation through planning and contracting. However, strong institutions are more expensive to maintain and less adaptable to changing conditions. Weak institutions often lead to informal systems, which are common in public transportation in Africa and South Asia. Scholars pointed out that both formal and informal public transport systems have advantages and disadvantages. There is no clear path forward on this issue.

Grey and peer-reviewed literature covered PPPs and other private engagement in-depth, albeit often from the HIC context (particularly the US and Europe). While the results of tendering public transportation provision have generally been positive in Europe, it is difficult to generalise this to other locales, given differences in public and private sector capacity. The literature shows that larger projects tend to vary from use projections, especially in terms of rail. There is less data on smaller projects, but they have been shown to be more consistently financially successful.

In terms of **education and capacity**, we found that many tools and guides in the transport field originated in the US and go against the goals of HVT. This is changing with new HVT-focused tools, but few are tailored to conditions in LICs. We encountered a dearth of literature on capacity building, a much-touted tool in grey literature policy documents. Even when we looked outside of the field of urban transportation, we did not encounter much literature on successful cases of capacity building or evaluations of the contributions of such endeavors to clients or end users. This is an area that needs to be explored further. New sources of data, such as ‘big data’ and ‘smart cities’ are shown to provide opportunities to improve planning, some of which are already being applied. However, new data sources also present new challenges—privacy issues and capacity constraints—which are particularly important in LICs and MICs. Similarly, the role of education as an enabling factor in HVT implementation requires additional research.

In terms of **funding**, while one examination found greater flexibility at the local level, it was also more complex. Many local governments lack the authority and/or capacity to collect revenue. National governments can supplement funding but often do so at the expense of local decision-making authority. New tools, such as LVC and private-sector financing, can expand funding levels, but they require higher levels of government capacity to pursue. We found that development aid is well studied as a funding source in other

areas but less so for transport. The literature we reviewed found that aid could catalyse new types of measures and lead to stronger designs, but it rarely provided sustained funding, and required an improved local capacity to raise revenue for ongoing operations.

In conclusion, our review has shown that ambitious goals and simple scripts for implementing HVT systems are a starting point for the hard work of creating change at the street level. Much of the peer-reviewed literature we found pointed to the importance of taking local context into account. We cannot overstate this lesson. Further, we would discourage researchers and practitioners from glossing over the complexity of achieving HVT systems. Consider this quote from Lindua et al., "implementing a successful BRT has never been and will probably never be an easy task!"(93)(p.6). We would extend this quote to all HVT measures, including initiatives for walking, cycling, compact development, and parking management.

5.1.4. Key Research Gaps and Opportunities

Though academic peer-reviewed literature and grey literature describes various enabling factors, key gaps in the state of knowledge remain. Of the 236 sources we reviewed for this chapter, only 125 were relevant to the report. Of the relevant papers, both HICs and MICs are well covered, with an emphasis on MICs. However, only five relevant papers (4%) examined the LIC context. The literature is generally well distributed around world regions, with 40 (32%) and 50 (40%) of the relevant papers examining sub-Saharan Africa and South Asia, respectively. Much of the relevant literature covers governance and institutions, building political will, and to a lesser extent funding and finance. There is a notable lack of research on education, capacity, and research. (**Table 11** shows the research relevant to the paper.) The numbers do not sum to 125, as some papers covered multiple regions or did not cover a specific country or region at all. We have identified the most important gaps below and structured according to the structure used above.

	STUDIES PER ECONOMIC REGION (WORLD BANK DEFINITIONS)			STUDIES PER GEOGRAPHIC REGION (WORLD BANK REGION DEFINITIONS)						
REPORT SUBSECTION	HIC	MIC	LIC	EAST ASIA & PACIC	EUROPE & CENTRAL ASIA	LATIN AMERICA & CARIBBEAN	MIDDLE EAST & NORTH AFRICA	NORTH AMERICA	SOUTH ASIA	SUB-SAHARAN AFRICA
Building and Engaging Political and Community Will	13	28	2	9	11	15	0	12	11	11
Governance and Institutions	31	46	2	26	18	21	1	16	19	17
Education: Knowledge, Capacity, and Research	0	9	0	3	1	4	0	1	6	4
Funding and Finance	13	21	1	16	5	12	0	8	14	8

Table 11. Summary of research relevant to this paper

We also mapped the locations of sources we found in this section, to provide a geographic overview (see **Figure 17** below). The map shows that the sources we found were concentrated in the largest countries (China, United States, India, Mexico, and Brazil) and HICs in western Europe, North America, and Australia.

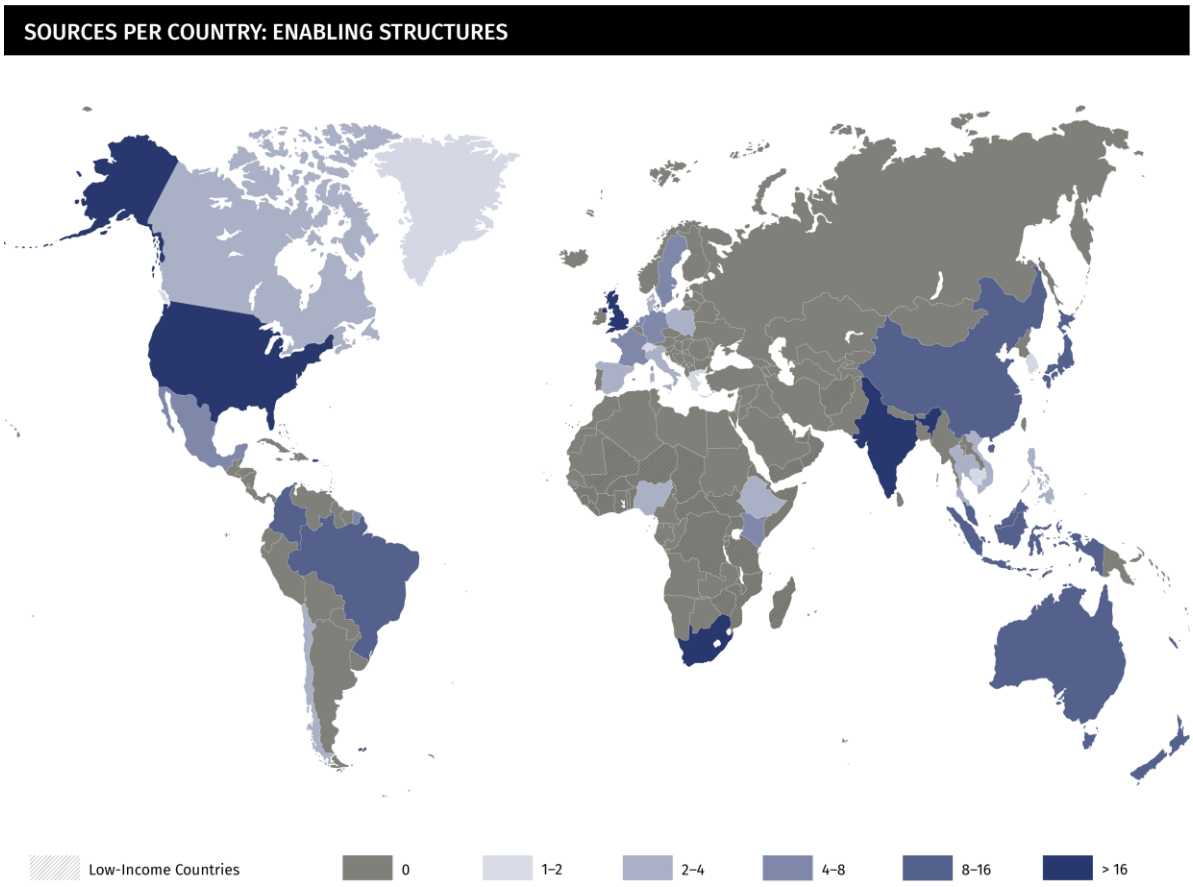


Figure 17. Locations of sources in this section. Source: Created by the authors

The key takeaway is that while enabling structures are critical for HVT, there is not enough research, especially in the context of LICs and MICs, on how exactly they support HVT measure implementation in LICs and MICs. In **Table 12** below, we summarise the key gaps we found from our research, followed by elaboration on the most critical ideas for future research.

Key Gaps Summary
Building Political and Community Will
- What role (positive and negative) do international aid agencies play in propagating measures? What impact do they have? - How does leadership work informally and formally to create successful HVT systems? - What makes an effective public participation process in LICs and MICs? What is the best role of government in this process and what skills are do governments need? - How can we effectively engage vulnerable communities?
Governance and Institutions
- What makes an effective institutional framework and what exists now in LICs and MICs? What role does devolution need to play and how? - How do institution building and institutional change happen in the face of a rapidly changing external environment? - How can we formalise transport service delivery and institutions? - How can we implement effective metropolitan governance in low-capacity regions? - What are the net costs and benefits of PPP after projects are finished? What are the institutional skills and structure needed for successful PPPs? - How are successful contracts for service provision structured, negotiated, and managed?
Education: Knowledge, Capacity, and Research
- How pervasive is the auto-centric HCM as a decision-making framework around the world? How can competing manuals and frameworks compete? - What areas most need capacity building—technical, managerial, consensus-building, facilitation—within different contexts and different levels of government and how? How can we measure effectiveness? - How well does the post-secondary curriculum address HVT? What gaps exist? - How can governments in capacity-constrained environments use data to achieve a HVT system without harming individual privacy?
Funding and Financing
- What are the best mechanisms for funding and financing to ensure the right outcomes in LICs, MICs, and other low-capacity environments? - What are the financial flows supporting HVT in LICs and MICs? How does a government undertake reforms for raising revenues? - How can the public sector leverage more financing options, such as land value capture? - What are the positive and negative impacts of private sector financing in LICs and MICs?

Table 12: A summary of key gaps in the literature review

5.1.4.1 Building and Engaging Political and Community Will

Role of Leadership

The existing literature underscores the role of leadership in creating formal and informal networks to mimic the behaviours of integrated agencies. There is limited research on how this is happening in public institutions characterised by siloed behavior. We also do not understand the importance of tacit knowledge and the role of politics and levers in decision-making, especially across multiple layers of government and different political parties.

Equity, Politics, and the Role of Citizen Involvement

The research on equity has either focused on a technocratic approach (upgrades and regularisation) or on an anthropological approach (micropolitics of negotiation of urban infrastructure and services), but not both. The politics of participatory planning can be opened up from daily negotiations to formally constituted platforms for including civil society, non-governmental, and community-based organisations. The politicisation of specific projects can have a negative effect on HVT projects or it can also slow down projects that undermine HVT.

While grey literature often recommends participatory approaches to achieve better results, we did not find evidence that this was the case in middle- and lower-income locales. Participatory planning is seen as an unqualified good—a way to be more inclusive and to better meet a diversity of needs. This is true in theory, but in practice the research is inconclusive on whether it delivers the intended outcomes. Although anecdotal, it is interesting that some lower-income cities heralded for urban transportation and land-use systems are not well known for using participatory means (e.g., Chinese cities, Singapore, Hong Kong, Curitiba). Thus, the relationship between participatory planning and HVT is unclear.

Simultaneously, 'street-level bureaucrats' (i.e., frontline workers or policy implementers in government agencies and communities at large) might benefit technically oriented research in the LICs of South Asia and Africa. They could help to understand cases where policy is implemented in unexpected or unintended ways and give insight on why policies are not implemented as intended(335).

5.1.4.2. Governance and Institutions

Institutional Structure for Urban Development and Transport Governance

While discussions on national, subnational and municipal governance and institutional integration were prevalent for East and South East Asia, with some discussions on metropolitan governance functions in OECD countries, there is little discussion on specific African countries and cities except Cape Town, South Africa (consolidation of land use and transport planning agencies). Similarly, there were very limited examples of measures from South Asian countries except for observations on the relationship of municipalities with national and subnational governments in India, and decentralisation impact on public transport in Karachi, Pakistan. It is also unclear how public institutions are trying to or should enable multiscalar, multisectoral, and territorial coordination for land-use and transport integration. Finally, the research we found was not conclusive about the role of metropolitan integration as a facilitator of HVT measures. There is disagreement among the literature about the impact of strong structures and the value of devolution.

Role of the Private Sector in LICs

The literature shows that the private sector is a common partner in providing investments and technical experience for transport services across countries of all income levels. More formal risk-sharing partnerships are still not common in LICs and MICs and the research indicates that it requires strong government capacity to succeed. Research on this theme focuses on HICs and emerging economies, including Hong Kong SAR and Japanese cities. A greater understanding of the processes of working with the private sector, including the informal sector, and the terms of engagement or contracts could assist other transit agencies in formulating PPPs. There is a particular need to better understand the institutional and financial conditions necessary to adapt to the PPP model in lower-income countries.

In addition, in LIC and MIC cities, the institutional arrangements of transit systems are predominantly studied from the planning and implementation phases, in which relationships and negotiations with private operators are most difficult for authorities. Although the processes of decision-making and coordination among actors at these stages has a strong impact on the efficiency of transit systems and their ability to retain HVT mode shares, there is little research on the governance of transit operation. Therefore, there is an

opportunity to analyse the (re)negotiation of contractual relationships and institutional arrangements in the operation of transit systems, as is increasingly done for BRT in Latin America.

5.1.4.3. Education

Implementation or Knowledge Gaps

One question is the distinction between implementation and knowledge gaps. We can say there is enough knowledge—in general and in specific regions—on how to move forward, assess specific conditions of a city, and act to improve transportation. However, implementation is lagging as governments attribute greater importance to other factors, such as political expedience, than knowledge itself.

Role of Capacity and Capacity Building as a Potent Agent of Change

Our experience is that many transportation engineers and related decision makers are trained with a singular technical goal to reduce congestion. This leading them to support measures that increase car speeds at the expense of HVT. There is limited empirical or case study research on staffing, capacity, and expertise—available and needed—for different types of cities, levels, ministries, departments, and agencies for effective policymaking, planning, and facilitating the implementation of land-use and transport integration. Further, implementation capacity may also need to be reframed beyond technical or technocratic knowledge to include other strategic expertise such as coordination, conflict management, and consensus building. Anecdotally, capacity building can improve the ability to make sound decisions. It can also be a potent agent of change since many actors can make daily decisions that do not rise to the political level. However, while we found literature on the effectiveness of capacity building to improve organisational governance, we could not find literature that examined the impact on the clients of those organisations.

5.1.4.4. Funding and Finance

Financing Urban Transport in Low-Income Countries

There is limited empirical research on how countries in South Asia and Africa undertake reforms to raise their revenues, practice asset management, manage intergovernmental transfers, receive loan financing, and access capital markets. What are the challenges and how can they be addressed within existing regulatory regimes? While there are references to the use of LVC instruments in developing countries, it is unclear how LICs can use instruments such as tax increment financing, vacant land taxes (which have the potential to check speculation), and congestion pricing. Further, conducting research, documenting and disseminating implementation experiences, and providing evidence about how value capture policies work on the ground are essential components to overcome the disjunction between rhetoric and practice.

Policy Implementation Process in Low-Income Countries

In addition, a more in-depth look at policy implementation in lower-income countries might reveal barriers that were not considered in this analysis. This could lead to dramatically different capacity-building strategies. We could select structural reforms for various contexts by better understanding the policy implementation, its hurdles, appropriate policies, and capacity-building efforts.

Related to this, although we encountered helpful research on policy transfer, much of this research focused on transfers within wealthy countries. We need more research on the possibility of transferring policies to, and within, LIC and MIC cities. Finally, we also need more information on the role of tools and guides in LICs and MICs, including the prevalence of LOS-based guidance, the prevalence of HVT-focused guidance, and the applicability of HVT-focused guidance developed in HICs.

5.2 AVOID — Land Use and Urban Development

According to the E-A-S-I approach, 'Avoid' refers to reducing unnecessary motorised travel. In practice. This means developing land uses that reduce the distances between homes and destinations. 'Avoid' also refers to efforts to discourage unnecessary travel, often called travel demand management (TDM). For this report, 'Avoid' refers to issues of urban land uses, built form, and physical infrastructure layout that impact the HVT system. Our focus on built form is based on the idea that the quality of urban spaces supports, prioritises, and works seamlessly with the appropriate transport modes to fulfil people's needs. This approach narrows the scope of 'Avoid' by not focusing on TDM (addressed in the **Shift** section) or innovations to reduce travel (discussed in the **Improve** section). Instead, we expand the focus of 'Avoid' to include built form measures that support mode shifts to HVT and equitable access for all.

5.2.1. Context

Population growth, migration, and urbanisation are projected to add 2.5 billion people to the world's urban population by 2050, with nearly 90% of the increase concentrated in Asia and Africa(336). Cities are expanding faster in land area than population. Worldwide, between 2000 and 2015, urban land expansion outpaced the growth of the urban population by a three-to-two margin(337). This expansion has decreased residential densities dramatically and resulted in urban sprawl and fragmentation(337,338). In the near future, most urban expansion will take place in lower-income countries(336). Population density is projected to decline in the core of large Indian cities but continue to grow in the urban periphery(81). Chinese cities are also experiencing a broad rural-urban fringe and outward growth(336).

Decreasing density undermines the capacity of cities to support efficient, high-volume public transport(1). Moreover, fast-growing cities in LICs and MICs are urbanising at the same rate as previous urbanisation waves, but without reducing poverty at the same level as those previous waves, leading to a growing number of slum dwellers. It is estimated that 56% of the sub-Saharan urban population lives in slums(1). In low-income countries like Mozambique, Sierra Leone, and Sudan this ratio exceeds 75%(339). Such growth results in inadequate shares of space allocated to streets, urban transport, and open and public spaces. It also contributes to poor accessibility, long commutes, and declining public health.

Urban development in the 20th century (in North America, Europe, the Soviet bloc and Soviet-influenced countries) focused on lowering urban density and creating wide urban spaces. This was partly a response to the 19th century's overcrowded industrial cities. The vision was for fast car- and truck-based travel through urban areas. The resulting system diminished the viability of public transit, the ease of walking and cycling in the city, and the access and mobility for people who would not or could not drive(340–342). HIC cities in North America suburbanised earlier, faster and became larger than those of Europe and East Asia which have a legacy of strong public transport systems. As a result, the latter regions are leading examples of the shift away from car dependency(343). Today, the conceptual framework for urban development and transport has returned to compact, walkable, and transit-oriented cities. Yet, the institutional and regulatory regime of laws, regulations, incentives, and practices that formally shape built forms and land uses in cities and countries around the world has lagged and perpetuated the 'automobility' paradigm.

5.2.2. State of Knowledge

The following section reports on the current state of knowledge for the **Avoid** section. We organised our research into three major themes. First, we discuss general principles for regulating land use and built form to support HVT and corresponding measures. Then we look at metropolitan-scale growth management and urban retrofit measures that aim to prevent sprawl and knit informal settlements into an HVT-supportive urban fabric. Finally, we assess land-use measures specific to urban freight. The structure is as follows:

1. Regulation of land use and built form;
2. Metropolitan compact growth and urban retrofit measures;

3. Land Use and urban freight.

5.2.2.1. Regulation of Land Use and Built Form

Land use and built form are essential factors of sustainable urban development centred on walking, cycling, and HVT. TOD and its principles encapsulate a comprehensive approach to coordinating land use. (We explore TOD at the metropolitan scale in the **Metropolitan Transit-Oriented Development Measures** section.) Institutions like the World Bank and ITDP have defined and agreed on TOD principles that many cities have pioneered. ITDP's "Eight Principles for Transport in Urban Life" and the World Bank's "3V Strategy" align on TOD principles including access to high-quality and high-capacity public transport; prioritising connectivity for pedestrians and cyclists, a vibrant mix of activities and people; human and economic densities at or above levels compatible with sustainable mass transit; the minimisation of space occupied by vehicles; and limiting demand for private vehicles. These are all supported by the resiliency of areas connected by transit(56,344). ITDP's TOD Standard uses these principles and detailed metrics as quantifiable and adaptable measures for sustainable urban development. This section reviews the literature on key standards, policies, and monitoring indicators deriving from TOD principles.

5.2.2.1.a. Land-Use Mix: Short Distance and Balanced Trip Origins and Destinations

The land-use mix refers to the residential, commercial, retail, industrial, and transportation uses that form the built environment in urban areas. Vast literature corroborates the role of land-use mix in supporting walking, cycling and transit travel modes, and its importance as a sustainable development goal(341,345,346). Land-use homogeneity generates motor vehicle trips, while accessible, fine-grained land-use patterns require less mobility(165,347,348). High levels of complementary mixed uses have a positive influence on walking(349). The following assessment examines how an optimal mixture of uses can reduce travel distances, support greater use of the HVT modes (walking, cycling, and public transport) and lower vehicle travel distances for urban freight.

Instruments to foster a more optimal land-use mix fall into three categories: (1) direct public investment in development, (2) statutory regulation of private sector development, and (3) incentives to private sector development(194). Direct public investment can take various forms, such as strategically locating public services, offices for government agencies or spaces to shelter anything from homeless people to community organisations, and incubating startup businesses. Investment in land banking can enable governments to take control of the land supply and specify the needed types of development. A statutory land-use code can mandate commercial ground floors or particular percentages of workspace versus residential floor area. Land use codes, known as zoning and land controls in different contexts, are underlying tools for spatial planning. Mixed-use land regulations aim to reduce trip distances by co-locating a variety of land uses in a single area. Targeted incentives can stimulate, rather than require, the private sector provision of certain land uses and services (otherwise missing) through tax abatements, valuable supplementary development rights, expedited or reduced-fee permitting, and localised public space improvements(350).

When government frameworks allow for negotiations with developers, through zoning variances in the US or development reviews in the UK, land and real estate markets offer more opportunities for public authorities to leverage benefits from developers. Skillful design measures, public participation, and careful monitoring of unintended effects are paramount to success. This will also help to avoid backlashes. For example, in Delhi, the unsuccessful implementation of mixed-use provisions in the Master Plan 2021 led to excessive commercialisation in residential neighbourhoods and increased traffic congestion due to inadequate infrastructure(351).

Fostering accessibility via fine-grained land-use mixes in contemporary urban development is challenging in many contexts. Obsolete regulatory frameworks that separate land uses through discrete zoning are frequent obstacles(352). Financial viability, profitability for market-based developers, and affordability for

users are also issues. Mainstream and low-end formal development largely gravitate towards single-use suburban projects that have less intricate design, construction, land purchase, assembly, financing, and marketing constraints(353). Nel recognised the issue with zoning in South Africa (MIC) and concluded that simpler and more flexible forms of land management are more suitable(354).

Many local and high-level governments (MIC and HIC) in Europe and the Americas reintroduced mixed use as an explicit goal in the 1990s(205,355–360). Multilateral organisations also shifted gears and recommended mixed-use development to be permitted as a default and restricted single-use zones to specific purposes, such as keeping noise, fumes, and hazardous industrial activities away from residential areas(361). However, achieving development with inclusive and people-oriented uses, beyond the high-end niches in the cores of cities worldwide, requires more than freeing the private sector. It requires proactive and specific public sector measures(352).

Following the “smart growth” theory, many US and European (HIC) cities have reformed their zoning codes to reverse induced sprawl(352). However, Indian (MIC) cities still use antiquated zoning laws that hinder sustainable development and mobility. Post-colonial zoning laws in Indian cities segregated land uses and resulted in more vehicle traffic due to longer commutes between jobs and residences(81). The land-use plans show land allocation but poorly reflect movement to work and other destinations. Consequently, transport planning is not the backbone of city development. Examples of poor land-use and transport coordination are visible in the relatively deserted new towns of Navi Mumbai and Dwarka in Delhi (204). In South Africa (MIC), national, provincial and local urban legislation use mixed-use and TOD as a lever to overcome a legacy of segregation and to limit sprawl(362). Cape Town, for example, prioritises mixed-use transit-accessible areas(363).

Kong et al. examine the ‘bottom-up’ development approach in Beijing (MIC), which develops ‘urban village’ enclaves with uncontrolled, informal densification of private low-cost rental housing units and unregulated small business. They find that this approach creates good job-housing patterns that limit the need to travel. Yet only communities with a high level of collective influence were able to deliver significant complementary transport investments(364). In another MIC context, Colmer points out that Indian urban sprawl, and the associated negative impact on HVT, is attributed to land-use regulation limiting development density(365). Discussions on mixed-use impact in sub-Saharan Africa are almost nonexistent. This is partially due to the limited influence national policies have on land management. Limited grey literature sources recognise the benefits of well-planned mixed-use, noting that land-use mixes occur haphazardly in African cities and urge better planning coordination to enable desirable and compatible uses within transit areas and residential communities(366). The literature also suggests that a mixture of use may have a positive impact on fostering HVT. With few academic studies on MICs and none found on LICs, there is a shortage of information on the transferability to LICs. There are many observations on the impact of poor land use codes, including a mix of uses in MICs and HICs. It is hard to devise observations on LICs where land use codes may not have been fully implemented.

Empirical studies, primarily in HICs and some MICs, confirm that mixed uses bear significant benefits on HVT. Complementary uses limit the need to travel long distances, increase the value of land, attract visitors, and can act as catalysts for market response and more concerted planning(367). Yet, direct financial benefits of mixed uses on HVT delivery are unknown, except for those linked to direct taxes from commercial uses that finance public transport. While LIC research is limited, evidence stresses the challenge of transferring traditional zoning-based approaches to regulate land use in LICs.

5.2.2.1.b. People Mix: Inclusionary Housing and Anti-Displacement Measures

Social integration is a pillar of sustainable development; equitable access and mobility via HVT are defining elements(368). However, there is an established link between HVT measures and displacement. A review by

Luederitz et al. points out that dense, pedestrian-oriented neighborhoods in New York and Vancouver, Canada, have led to displacement pressure(369). Multiple sources describe the terms 'involuntary displacement' and 'induced displacement', with the former referring to the forced removal of residents for the sake of development and the latter referring to a gradual change in the land values, and subsequently, change in socioeconomic makeup of the area(370).

A particular challenge for urbanising countries is addressing informal and semi-informal settlements without creating displacement. Poor land use and transport coordination results in spatial segregation and accessibility disruptions put extreme socio-economic burdens on lower-income residents. This gives rise to motor vehicle-dependent sprawl, which reinforces social isolation, segregation, and entrenched poverty(165). For example, travel to labour markets consume as much as 25% of daily wages in Mexico City(202). However, these same groups are particularly vulnerable to displacement. The United Nations reports that evictions linked to arbitrary displacement are related to the absence of legally secure tenure, which is an essential element of the right to adequate housing(371).

MICs have also developed measures to mitigate displacement. In 2007, India (MIC) established compensation measures for land acquisition and provisions for social impact based on assessment measures(372). Kenya (MIC) recently upgraded its land acquisition and displacement framework to mitigate the impact of renewal projects, such as those being implemented as part of the Nairobi Urban Transport Master Plan(373). To protect informal and very low-income residents, Thailand (MIC) has used collective land titles from the Baan Mankong Program which funds procurement of the programme and upgrade efforts. The bestowment of the collective land title requires the community to keep its land for at least 15 years to maintain benefits to the poor(374). Community land trusts are used across the regions as an effective security and a community capacity building tool. They allow communities to retain permanent ownership of the land and housing. They also often allow communities to lobby for amenities and improvements. Caño Martín Peña, formerly an informal settlement in San Juan, Puerto Rico is one example(375).

For involuntary displacement, it is becoming standard to compensate and/or resettle displaced populations. Many lending institutions have adopted compensation measures to support LIC nations. Olivier-Smith points out that there is an issue with compensation measures based solely on the evaluation of physical and economic traits of the affected communities. Values like a choice to stay and community ties ultimately constitute community socioeconomic resiliency(376).

While measures may have limited efficacy short of political–economic transformation, deliberate public regulations requiring mixed-income and demographic integration can mitigate the segregation effects of market-based development(377). Inclusive housing measures can leverage increasing land prices and minimise induced displacement by allowing existing and new residents access to affordable housing(378). Locating affordable housing in proximity to good transit is proven to lower the combined costs of housing and transportation of the beneficiaries(379,380). Some authors argue that higher density and unit size limitation contribute to housing affordability. This is of particular concern in LICs, where apparent TOD densification through increased floor-area ratio (FAR), the usable building area relative to land area, can paradoxically lead to lower population and job intensity. This is due to vastly increased space consumption per capita, as large-unit developments for higher-income residents displace low- to middle-income residents(367).

In São Paulo, Brazil (MIC) the 2015 Comprehensive Plan sets a basic free development FAR of 1.0–2.0 (depending on site and use) but allows developers to purchase additional building rights up to FAR 4.0, with the money used to fund public infrastructure and social housing projects, including slum rehabilitation(198). Other examples include the HICs of Hong Kong SAR and Singapore, where ambitious social housing measures include close cooperation between housing, urban planning, and transit agencies to develop subsidised

housing adjacent to HVT stations(381). The success of inclusive housing regulations in Singapore is possible because the state owns four-fifths of the land and determines the deployment of substantial public financing(382).

HICs that want to encourage the provision of below-market price units by the private sector have developed several techniques. These are generally divided into mandatory requirements and bonus incentives. We can link financing for affordable housing to the implementation of TOD projects in MICs and HICs that includes methods like land banking and LVC. (See **Land Value Capture** section.)

Social housing is relatively rare in Taiwan (0.12% of the housing stock) compared to Hong Kong (30%), the UK (18%) or Japan (6.1%). Taiwan also has not adopted housing measures apart from housing subsidy programmes, available to individuals and households of specific occupational status (e.g., civil servants)(383). This yields an uneven supply and demand of affordable housing. The share of the rental housing stock is 10%, as it is mostly supplied illegally to avoid higher property taxes, pushing many disadvantaged groups out of the equation(384). Social housing in the Netherlands constitutes the largest share in the EU (about 32%). The system uses an innovative public–private partnership model in which private not-for-profit organisations, supervised by the national government, provide below-market housing(385).

It is important to remember that the successful application of inclusive housing measures works mainly in strong housing markets, like the US, where developers can offset the increased costs by passing it on to the price of market-rate units(386). As neighborhood improvements drive up property values, the inclusion of low-income residents is at risk without adequate protective measures in place. The induced displacement—gentrification—is an observed phenomenon(387).

Given the link between many HVT measures and displacement, it is important to consider complementary HVT measures to prevent displacement and to create a more equitable distribution of HVT benefits, especially for the most vulnerable groups. The numerous measures described above have been widely applied in HICs and MICs, but less often in LICs. By integrating mixed-income and low-income development in transit areas, society gains socioeconomic benefits, including higher public transport ridership.

5.2.2.1.c. Adequate and Appropriate Density

Urban density refers to the residents, jobs or other trip generators per area in cities. Adequate and appropriate densities are those that support HVT but limit negative externalities. Density by itself does not guarantee HVT system efficiency unless complemented by appropriate mixes of land use, compact layouts concentrating residences and employment near rapid transit, and active measures to prioritise walking and cycling over the use of motor vehicles(346,388). However, sufficient density is required to support high-efficiency, frequent, reliable, high-coverage, HVT-based transit. It is also necessary for the investment in pedestrian public spaces which provides access to stations and increases walking and cycling(165).

Standard thresholds of density that support reliable public transport are elusive. Actual levels depend on complex contextual factors, including income levels, transit technologies and operational models, mode shares, street layouts, building layouts, building design, and parking. These can only be addressed locally through advanced modelling techniques. Rough estimations in the literature range from as low as 35 residents and jobs per hectare to as high as 150 persons per hectare for a frequent and well-connected public transport service(342,389). In the HIC context, TransLink, the Transit Authority of Metro Vancouver, Canada, suggests 27–48 housing units per hectare to support 10- to 15-minute frequencies of public transport(390).

The density of residents, jobs or other trip generators only support sustainable access and the mobility system when located close enough to stations to have a positive impact on HVT ridership. Density and mode share comparisons of different US cities by Kenworthy and Laube showed that a subset of urban areas,

averaging 50 persons per hectare, correlated with 40% transit trips and 18.4% combined walking and cycling trips. Much lower densities of 14.2 persons per hectare correlated with only 9% public transport and 4.6% walking and cycling trips(390).

It is a challenge to optimise urban density. Densification is often keenly resisted by established communities, especially by low-rise, car-oriented suburban communities that are not dense enough to sustain public transit(391). Angel's spatial analysis shows that cities expand in area by an average of 3% per year. Angel argues that de-densification is an irresistible historical trend and, despite occasional 'nail house' resistance, urban redevelopment and high-rise suburbanisation are popular in China (MIC) and have vastly increased average floor space per person in recent decades(337). Howley et al., however, argue that more than high density itself, the opposition to density stems from environmental degradation: traffic congestion, noise, air pollution, overtaxing of existing services and facilities, and disruptions to community life and identity(392).

There is a strong consensus in the HVT literature about the environmental, social and economic development benefits of urban density. Density correlates to low ownership of private vehicles, vehicle kilometres travelled, low-energy consumption for transport, and high provision and usage of pedestrian and transit infrastructure(341,342,348).

On the other hand, limitations on building densities may lead to sprawl, as in the case of Bangalore(165). By supporting public transport coverage, frequency and efficiency, and all else being equal, urban density benefits disadvantaged groups who depend on affordable transit to access opportunities, goods, and services(165). Urban densities also promote urban vitality and make sustainable and equitable walking and cycling trips more attractive and safe(166).

The literature shows that density is an important function enabling the concentration of land uses, people, and activities to support HVT. However, there is not a consensus around specific density thresholds to support HVT modes. In addition, many social challenges exist for creating dense cities in HICs and MICs. We could not find much research on density in the LIC context.

5.2.2.1.d. Connected street network

Experts believe that a well-connected street network is important to supporting access via HVT modes and other HVT goals. A key reference on this topic was Ewing and Cervero, who produced a meta-analysis of existing empirical studies(346). A general finding is that street connectivity positively affects the propensity to walk and use other modes of HVT, as do other built environment characteristics. Only one study in this meta-analysis is from a city in South America, which does not include any LICs(393). It finds that measures of good street connectivity relate to decreased automobile ownership and use in Santiago, Chile (HIC). Recent studies have found consistent evidence that street connectivity affects pedestrian volumes(394,395). In Latin America, Guerra et al. study Mexican (MIC) cities and find that measures of street density and other built environment characteristics have an impact on automobile use similar in magnitude to income, which is regularly identified as the main determinant of car travel(396). Multiple studies have found that well-connected street grids around stations, mixed land uses, and other environmental supports for walking correlate with higher station-level boardings(381,397,398). Overall, these findings underpin the importance of the street network in supporting walking and transit use.

In contrast, self-selection—people choosing their location according to the availability of infrastructure—may account for some impact of infrastructure on HVT modes. In Rajkot, India (MIC), researchers found that residential self-selection influenced the relationship between the built environment and travel(399). This issue has been considered in numerous studies (see Ewing et al. 2010). Lin et al. control for it by relying on the fact that in China (MIC), people have limited freedom to choose their location and find that after accounting for residential location, the impact of walkability on travel behaviour is reduced(400).

Grey literature provides a series of recommendations to improve the street network. ITDP offers a tool to understand and measure walkability(401). It recommends first improving block density at the city level to ensure that the basic foundation for walkability is there. UN-Habitat incorporates measures of street connectivity into the infrastructure dimension of its broader City Prosperity Index, designed to measure a city's productivity, quality of life, equity, environmental sustainability, and governance(402).

Evidence from HICs and MICs generally shows that well-connected street network is a key driver of HVT, as it corresponds to increased travel by walking, cycling and public transport, and decreased car use. However, self-selection may account for some of this effect. More research is needed into self-selection and the impact in LICs.

5.2.2.1.e. Urban Design: Enhancing Walking and Cycling

Good urban design can support the HVT mode of walking and cycling. The literature investigating this relationship identifies short travel distances and people-friendly urban design as the main enablers for walking and cycling(403,404). While walking is the dominant form of transportation in the LIC context of sub-Saharan African cities—75% of daily commuters walk wherever they need to go—this is out of necessity and not a choice (ASME). On the other hand, walking and cycling are unpopular in the wealthier city of Karachi (MIC), because of safety problems caused by poor design, lack of security, and air pollution caused by congestion(312). Subsequently, pedestrians account for over 50% of road fatalities in Karachi.

Urban design factors aim to create an environment where walking is efficient, safe and even desirable. These factors include safe walkways and crossings, short block dimensions that keep detour factors low, and a street environment vibrant with active and porous frontage(405). Other factors that are more related to comfort, such as measures for weather protection, also help increase walking mode share(116). Frontage that is active at night, along with functional street lighting, is critical to personal safety and the walkability of public space, particularly for women(406). For cycling, researchers also find that keeping detours low can be important. In HICs, researchers generally find that an increase in trip distance results in a lower cycling mode share(202,407). In addition to the design, researchers find that enforcement measures to keep sidewalks and bicycle paths clear of vehicles and vendors also influence walking and cycling rates(201).

In HICs, various levels of government have integrated design guidelines for pedestrian infrastructure into policies and land use building codes. In the US, the Departments of Transportation of New York City and Chicago, as well as the National Association of City Transportation Officials (NACTO), have released their own street design manuals emphasising traffic calming and urban design solutions for pedestrians and cyclists(264–266). In the UK, the Ministry of Housing, Communities and Local Government has a national planning framework with a goal to promote healthy communities. This provides local planning authorities with a set of recommendations on active street frontages to facilitate interaction between community members. These guidelines may not be adopted as regulation; however, several communities regulate street-level use and design of frontages to achieve a better pedestrian experience. On the local level, cities like Seattle and San Francisco adopted design standards reflected in land-use codes. In Singapore, the design standards even consider tropical weather. The Center for Liveable Cities points out that there is a sharp decline in people's willingness to walk beyond 400 m given Singapore's tropical climate(408). Toa Payoh, Singapore, is an example of a well-designed, pedestrian-friendly satellite town where greenery and shading protect pedestrian walkways from the sun and elements. In India (MIC), cities such as Coimbatore and Pune have adopted specific and high-standard manuals for the design of streets(409). In Africa, which includes mostly MICs and LICs, UN-Habitat and ITDP developed an HVT-focused street design guide for the local context(410). WRI and NACTO have also developed design guidance with a global focus(411,412).

The literature refers to connectivity, fine-grained land-use patterns, safety, and quality of walkways are the design criteria that increase the walk mode share(413). Evidence abounds that small blocks are key to

improving the connectivity and walking mode share. Cervero et al. found the likelihood of residents of a short-block neighbourhood walking 30 minutes or more per day is 220% higher than residents of a neighbourhood with low connectivity in Bogotá, Colombia (MIC)(201). A small block area of Shanghai, China (MIC), averaged about one-half the household car ownership rate of those living in a superblock district(202). In Ahmedabad, also within a MIC, neighbourhoods with a moderate average block area of 1.2 hectares had a 36% walking mode share, while that of neighbourhoods with four-hectare average blocks was only 13%(68). Engaging, permeable and active street frontages also enhance walk mode share, related to the fine grain land use pattern for reduced automobile trips. Active frontages also attract pedestrians because of perceived safety(266). There is a lack of knowledge on the specific impact and case studies of cities that measured the increase in pedestrian movement and walk mode after implementing measures to increase the activity of frontages. Traffic safety is also a key feature and driver of urban design, and we address this in more detail in the **Road Safety Measures** section.

Urban design measures influence walking in many contexts, except in very low-income populations where few alternatives to walking exist. We found less evidence for the relationship between urban design and cycling, although pro-cycling measures have been implemented in a number of settings. Measures that increase walking are varied but include design specifications for walkways and the public realm and short blocks that support short and varied trips. These measures can be successful if enforced or incentivised.

5.2.2.1.f. Off-Street Parking

Conventional urban parking regulations involve minimum parking requirements for developments and the construction of off-street parking facilities. Many studies have shown that this approach results in the provision of excess parking, which imposes additional costs—economic, social and environmental. These impacts can include higher development costs and hidden subsidies for car usage that induce car travel, sprawl, sub-optimal land use, greater congestion, and increased emissions(414,415). Parking requirements impose expenses on renters regardless of their demand for spaces, which reduces housing affordability, especially for low-income households, which tend to own fewer vehicles and face higher parking costs as a percentage of rent(303). In terms of land use patterns, conventional parking regulations can significantly impact and constrain economic development, but the opportunity cost of land is often overlooked(303). A study of two New York City neighbourhoods strongly suggests that supplying more residential off-street parking generates more car trips(416).

In the US (HIC) off-street parking requirements for different land uses rarely reflect demands, as planners typically copy parking codes from other cities(417). From the literature, middle- and lower-income countries are implementing similar minimum parking requirements to encourage the construction of more off-street parking to address issues of traffic and congestion. In cities such as Bangkok, Jakarta, Kuala Lumpur and Manila there are still conventional minimum parking requirements that promote car ownership and use but do not solve on-street parking problems(418,419). In Harbin, China, a study found that 40% of all parking in the Daoli district takes place informally on walkways, despite ample parking accessible in off-street underground facilities. Drivers consistently parked on walkways because the most visible parking garages filled up and created a false perception that parking was unavailable(420). A case study of Ilorin, Nigeria, highlighted the absence of clearly designated areas for parking in many cities across the country. It found that parking problems contributed to significant delays at intersections in Ilorin. The researchers recommended discouraging on-street parking and building more off-street parking facilities(421).

Enforcement issues and illegal surface parking are significant and may result from poor land and parking management, weak enforcement, and even corruption. The Seoul Municipal Government blames illegal parking issues on an insufficient supply of spaces since Korea's Building Act does not have parking minimums for multi-unit housing. However, the number of parking spots in Seoul has grown to 3.9 million as of 2016,

and there are only about 3 million cars registered in the city (422). In Bogotá, informal parking in forbidden areas on streets and in public spaces is pervasive, yet there is inadequate political will and police capacity to enforce parking violations. Bogotá and other Latin American cities have informal parking markets in which "caretakers" charge for spaces, providing self-regulation beyond government management, but these systems can be corrupt(423).

Thinking about off-street parking has shifted from a supply issue to a management issue(424). It is possible to accomplish better management of off-street parking through land-use regulation. This may limit parking spots depending on land use, with greater limits on commercial and residential parking in transit-accessible areas(425). For off-street parking in residential developments, researchers and experts recommend eliminating minimum parking requirements, establishing parking maximums, reducing parking near mass transit, implementing shared parking systems, capping parking in specific areas, and incorporating parking in smart growth measures(303,414). Developing and reforming parking regulations increase parking system efficiency, reduces excess supply and resulting demand, encourages the use of alternative transport modes, decreases vehicle use, and allows for more compact development(303). Parking must also be priced appropriately, including charging fair market prices for the use of off-street facilities(415). ITDP points out that managing parking demand is best achieved by putting one entity in charge of the overall supply (both on- and off-street), and allowing it to alter prices based on parking demand(414).

Recently, cities in Europe, North America, South America, and South-East Asia have implemented off-street parking reforms. In Tokyo, for example, there is a market-oriented parking system with ubiquitous pricing. Mexico City recently abolished parking minimum requirements and established maximums just above the previous minimums. The city also implemented an incremental fee for each parking space built within 50-100% of the maximum limit and will use this revenue for public transit improvements(378). Singapore also revised its parking regulations and, in 2019, the government will enact range-based parking provision standards that vary parking construction limits according to location and land use(426).

Cost-based pricing can reduce parking demand by 10–30% compared with free parking(303). Varying pricing for off-street parking spaces, using integrated data from multiple locations, can offset demand from more central areas to less desired areas, as observed in San Francisco and Barcelona(414). Higher parking costs have also been associated with an increase in public transit usage in larger cities(427). Portland, Oregon, reduced parking minimums in dense areas near transit caused the use of public transportation to jump by 20–25% in the early 1970s and by 48% in the mid-1990s(423). Not all schemes have shown such impact. London implemented its parking reform following a national agenda calling for the reformation of transportation, replacing parking minimums with maximums. Guao and Ren observed that the maximum requirement had little impact on the market overall, but they recommend accompanying measures such as fees or more restrictive maximums in transit zones(428).

The literature shows that requirements for off-street parking have a variety of negative effects on HVT goal of equity, access, efficiency, and the environment, and do not meet their goal of addressing traffic and congestion. Measures curbing the amount of off-street parking have evolved from encouraging parking supply to providing only essential limited parking, especially in transport-accessible areas. After reviewing various quantitative studies, we found no adequate method of estimating parking demand in areas with HVT options. In HIC studies of off-street parking reforms, some found that the measures led to increased transit ridership, while other studies found that they had little impact on the housing market. We found little research in MICs and LICs.

5.2.2.2. Metropolitan Compact Growth and Urban Retrofit Measures

This subsection reviews the recent literature on the methods, standards, and other practical tools that may help to end or significantly reduce suburban sprawl; and retrofit and integrate existing urban structures to

better support HVT. These measures facilitate key physical urban structures that enable, support and prioritise walking, cycling, and public transit, as opposed to car-oriented suburban sprawl. Metropolitan-scale measures require coordination across the urban area, discussed in the **Metropolitan Governance and Coordination** section above.

The term suburban sprawl refers to scattered development, low-density continuous development, quasi-urbanisation, and 'haphazard' or even (high-density but walk and transit-disconnected) unplanned growth(429). In the scattered environments (often single land use) that characterise sprawl, a decent way of life depends on having access to motor vehicles. For this research, we will focus on sprawl from the perspective of urban form on the metropolitan scale, and the characteristics that hinder accessibility to human development opportunities, goods, and services.

The common denominator of sprawl is that it is enabled by the availability of motor vehicles. A key propeller of sprawl is the land speculation opportunities that motorisation provides and, in contrast, the general lack of adequate regulations due to the spatial–jurisdictional fragmentation in metropolitan areas(199,430). The impacts of sprawl on the economic efficiency, public health, and governance of metropolitan areas are covered by vast literature. These implications are useful to review before discussing the issues of transport and land use in the expansion areas of fast-growing cities.

Suburban sprawl impacts the economic efficiency of cities owing to higher operating costs in fuel expenditures and road maintenance, and to the loss of productivity associated with low-volume motorised traffic congestion(165). Empirical studies highlight the negative effect of sprawl-induced commute times on labour markets and city productivity(431). Sprawl also impacts social equity chiefly because, among other factors, lower-income groups reside in areas that are the most affordable and typically also the most poorly connected to urban infrastructure and transport grids. These same groups also have less access to individualised means of transportation(432).

This section shows the widespread nature of sprawl and the negative impact it creates in terms of access, equity, efficiency, and enabling HVT-based urban mobility. The theory also points to the need for anti-sprawl measures and broad institutional structures capable of administering them across municipal jurisdictions. With LICs and MICs experiencing most urban growth and generally containing weaker governance structures (see **Capacity Assessment** section), they appear to have the greatest potential for sprawl. In the next section, we review specific measures found in various contexts used to curb sprawl directly or indirectly.

Since urban expansion in quickly expanding cities is often rapid and disorderly, it is important to study methods and planning tools from around the world that are effective in curbing sprawl. Well-known methods covered in the literature vary by context and scale of approach. These include sub/exurban growth containment policies, urban master plans, and Transit-Oriented Development measures among other measures that apply at the metropolitan scale.

5.2.2.2.a. Sub/Ex-Urban Growth Containment Measures

Sub/ex-urban growth containment refers to use of physical strategies like greenbelts and urban growth boundaries that physically limit the progression of urban expansion(433). Angel notes that growth containment is suitable in some cities, where population growth has subsided and where densities are already too low to sustain public transport, but unsuitable where population growth is significant and where higher densities and lower levels of car ownership can sustain public transport(337). Deal argues that the premise of growth management measures, like growth containment related to HVT, relies on integration between plans (transport and land use), agencies, and investment choices often undertaken at the local level(434).

Growth boundaries have been adopted mostly in HICs. This includes North American cities where urban population growth is slower than in rapidly urbanising regions. Yet, good integration is contingent on the inclusion of mobility and land use plans(434). Some European, Asian, and South American cities have also applied them. A few studies investigate the success of the measure in different contexts, especially as it relates to enabling land use and HVT integration. A study of 95 metropolitan areas in the US (MIC) concludes that jurisdictions with growth management strategies showed a statistically significant improvement in the percentage of commuters using public transit(434). However, suburban growth boundaries have often resulted in counterproductive exurban development leapfrogging to more distant areas. Last, if suburban growth boundaries may limit the physical expansion of a city's footprint, they do not in themselves integrate land use and transport, as pointed out in the analysis of cities like Hangzhou, Liverpool, and Portland, Oregon(435).

Overall, growth boundaries have successfully increased transit use in HICs where urbanisation and population growth are not pressing. However, they have not been shown to induce more HVT-supportive land uses by themselves and may lead to a greater dispersion of development. These measures must accompany other planning and regulatory tools to enable HVT. Finally, we found little research in the MIC and LIC context, which is another key gap.

5.2.2.2.b. Urban Master Plan

An urban master plan is an intricate planning tool. It takes into account growth areas—typically a level of land-use and transport integration—combined with transportation or urban mobility plans. Master plans have evolved from mid-20th-century land use plans used across the US and European cities to 21st-century comprehensive plans used globally(436). Many cities use comprehensive plans that integrate transportation and mobility planning. In fact, integrative methods that consider approaches like travel choices and land-use patterns make urban master plans a successful tool for compact development and HVT.

The literature recognises that successful master plans, even in MICs and HICs, must consider changes like shifts in housing demand and travel patterns, and relevant strategies and adjustments must accompany them during implementation(437). To address the issues of rapid urbanisation, master plan methods in the LIC context need to be easy to implement(438). A 'smart growth' theory of land use has pushed for regulation to increase density, improve walkability, manage parking, and add a greater mix of uses(352).

HICs in Europe, the Americas, and Asia use traditional master plans with various levels of success. Some examples from MICs in Africa include Cape Town, South Africa, and Nairobi, Kenya(438). One of the well-known examples of integrative master plans is Stockholm's Comprehensive Plan. Since the 1950s it has laid out a strategy for growth based on the compact city and TOD(439). Because the backbone of urban development in Stockholm is public rail-based transport, as per the compact city growth goals, Stockholm, with the exception of some post-war suburban communities, evolved into a world-class example of HVT-supportive urban development(439).

In Santiago de Cali, Colombia, the Territorial Plan stipulated that the sub-centres of the city develop areas accessible to the MIO system (BRT system) and that it delineate the densification areas along the HVT system(440). The Strategic Plan for São Paulo also calls for increased land development along metro, rail, and BRT/bus corridors. It introduces Special Social Interest Zones that require construction to provide 60% of its area to low-income housing, locating low-income residents near transport(441,442). In contrast, the plan for Hexi New Tow in Nanjing, China, illustrates a missed opportunity to foster neighborhood development oriented around HVT. Instead, the plan draws on personal vehicle use, with metro lines extended at a later stage(443).

In the African context, comprehensive master plans have not been adequate tools for growth planning because of colonial-era legislation that focuses on redevelopment programmes instead of accommodating

the population in the urban extent(438). As such, preparing urban expansion areas for growth is not the focus of local planners in Africa, even though there is an urgent need. Other reasons include a lack of capacity and enforcement. One example is Nairobi where master plans and growth strategies have been developed since 1948 but never acted on. Nigerian municipal governments are required to prepare master plans even though these plans are rarely implemented. In many cases, the master plans are not even made for fear of confrontations inherent to the implementation process. In India, 70–80% of the built environment is inconsistent with master plans. Traditional master planning also cannot engage with informal development to embrace mixed use(81).

The literature on master plans covers both implementation extent and impact across contexts, including HICs, MICs, and LICs. The literature shows that master plans can successfully foster HVT, especially in the HIC context when they are adaptable to changing conditions. In the LIC context, in particular, the literature stresses that plans must be simple and easy to implement to achieve success. Examples of unimplemented master plans in LICs show that their efficacy depends on institutional capacity, political will, land use enforcement regulations, and integration with the informal sector.

5.2.2.2.c. Metropolitan Transit-Oriented Development Measures

Governments can apply TOD, which supports HVT modes, to city-wide strategies to guide new urban growth and execute specific projects in transit areas(378,444). TOD is a planning process that focuses housing, jobs, and other activities around frequent and high-capacity public transport through increased density, a mix of uses and activities, and excellent pedestrian infrastructure(90,344,445). TOD applies to a variety of contexts and scales, but factors like a strong vision supported by constituents, institutional setup, accompanying regulation, and real estate viability are crucial to its success(446). Principles for a walkable environment with connected street networks and accessible public transport underpin TOD and can help establish measures and guidelines to curb haphazard development and sprawl(378). The following examples of TOD measures show the possibility of a gradual shift towards HVT in cities.

Large-scale TOD applications date to the 19th century, when early urban development integrated the expansion of urban and suburban rail lines in Europe, North America, and Japan. This development continued into the post-World War II period. For example, Copenhagen's Finger Plan from 1947 set urban development goals based on the principle of compact urban development, which enabled land value capture mechanisms(447). Many countries in Europe (Sweden, Germany) and Asia (Japan, Hong Kong, Singapore) used a similar approach for compact growth that relied on rail and metro networks(446).

In the context of Asian HICs and Latin American MICs, there are both good practices and missed opportunities for tailoring land use regulations to enable TOD. Seoul, Korea's BRT corridors, supported by neighborhood betterment strategies, exemplify adequate regulatory and zoning reform(202). While many Chinese cities (MIC) are implementing TOD strategies, they fail to integrate mixed-use and pedestrian and bicycle-friendly environments. The case of Hexi New Tow in Nanjing illustrates missed opportunities for a truly integrated TOD(443). BRT implementation has spurred transit-oriented development in Latin American cities (mostly MICs). Measures for guided city growth through integrated land use, transportation, and environmental preservation were implemented as early as the 1960s in Curitiba, Brazil(448). Other city examples of updated regulation for urban transport corridors include Santiago de Cali, Colombia, and São Paulo, Brazil. Yet, as argued by Cervero and Dai, many cities still lack adequate regulations and investment to capitalise on high-quality TOD in the BRT corridors(322). Even Curitiba seems to have failed in the sphere of equitable housing, locating most of its low-income housing outside transit-accessible areas and even in floodplains, and Bogotá, Colombia did not maximise the density potential along its BRT lines with adequate upzoning for leveraged investment(202). In sub-Saharan Africa, South Africa's (MIC) TOD framework is a leading example of integrated planning for equitable access and guided growth. There, inclusive mixed-use

projects submitted for TOD zones are highly prioritised via fast track procurement. However, since the measure is fairly new, no measurable outcomes have been detected yet(363).

Despite many examples of TOD, the impact on automobile and HVT travel are harder to assess as they require specific measures like parking demand management, or depend on existing conditions like the level of congestion, type of road network, or capacity of HVT(449). In cities worldwide, the outcome of TOD measures is varied and highly dependent on the measures used(450). A study of four metropolitan areas in the US (Philadelphia/N.E. New Jersey; Portland, Oregon; metropolitan Washington, D.C.; and the East Bay of the San Francisco Bay Area) by Arrington and Cervero found that TOD produced considerably less traffic than conventional development. TOD households are twice as likely not to own a car than comparable non-TOD households. Additionally, TOD commuters used transit two to five times more than other commuters in the region(449).

The TOD concept has become a catalyst for spatial change in many HIC and MIC cities around the world, enabled by various measures. However, because of the variety of measures included within TOD, it is difficult to assess their impact when applied at the metropolitan scale. The few studies we found have positive results in the North American HIC context. We found few examples of deliberate TOD implementation in the MIC and LIC context and little research on its impact.

5.2.2.2.d. Street and Arterial Network Layout

A network of walkable local-access streets and adequately spaced and sized arterial boulevards that support transit can enable HVT-focused growth to limit sprawl, even in rapid-growth contexts. Arterial networks can be organised to maximise safety and access, to provide space for urban design features—trees and landscaping—that support walking, and to ensure that street cross-sections allow space for dedicated lanes for all HVT modes.

As described above (see **Urban Design: Enhancing Walking and Cycling**) a fine-grain street network supports higher rates of walking. In addition, a study of 24 California cities found that a gridded street network was associated with less driving and more walking and cycling(451). A person living in an area with a dense street network was 50% more likely to walk(201). After comparing types of street networks, Litman concluded that hierarchical but fragmented networks reduce accessibility as they channel traffic to a few major arterials, even for short travel. This layout is functional only if continuous pedestrian and cycle paths are extended(452). In Bangkok (MIC), the lack of street connectivity and HVT-supportive arterial coverage contributed to the widespread use of motorcycle taxis and to the rise of ride-hailing enabled by new apps(202). Ibrahim and Alattar found that low-connectivity of the street network in Cairo's new satellite towns, compared to earlier development patterns, contributed to car orientation, weak neighbourhood-based social networks, and poor accessibility for lower-income residents(453).

Discussions about standards to facilitate a pedestrian network typically revolve around accessibility and connectivity. Two main attributes of pedestrian networks are walkway segments (defined by block edges) and intersections (defined by the area where blocks intersect). ITDP recommends that blocks between pedestrian connections should not exceed 150 m in order to minimise pedestrian detours and maximise the effective reach (as opposed to geometric radius) of transit station walksheds. We also recommend finer mesh pedestrian networks (50 m to 70 m) for high activity areas(378,454,455). (See link to right-of-ways and HVT in **Right-of-Way Dedicated to HVT**.)

A network of well-spaced arterials can allow for maximum transit coverage of developed land. However, arterial spacing specifications lack standardisation. For example, UN-Habitat recommends 1 km to 1.5 km of space between transit arterials and from 800 m to 1 km in another(389,456). ITDP suggests 1 km is the maximum distance people will walk to transit stations, and recommends locating most intensive trip

generators, including residential buildings, within a 500 m walk of quality transit(378). Angel also recommends a 1-km spacing rule(438).

With regard to arterial cross sections, case studies compiled by UN-Habitat show widths ranging from 30 m to as wide as 80 m for those that integrate greenways and cycle infrastructure(457). ITDP recommends 47 m to 52 m for complete urban boulevards including high capacity BRT (with passing lanes at stations), two lanes of general traffic in each direction, protected cycleways, shade trees and landscaping, and ample clear pedestrian walkways(458).

We found multiple examples of street networks that do not support HVT. Including all streets, UN-Habitat reports a 25–30% share of the public right-of-way out of the total land area is standard in the urban areas of high-income countries. It recommends this as a minimum standard. In African cities, however, streets account for less than 7% of the land, often due to rapid, unplanned growth. For example, in Douala, Cameroon (MIC), the street network has remained unchanged for the past 20 years despite the doubling of the population and manifold increase in the number of vehicles and urban sprawl(430). In the US, the design standards in urban fringes and suburbia favored hierarchical streets and cul-de-sacs, limiting connectivity and hindering walking and cycling(451). Cervero reports that Bangkok, Thailand (MIC), lacks road hierarchy and continuity; as a result, a fishbone network forces all types of traffic into saturated thoroughfares, causing informal motorcycle taxis to become the default transport system(202). (See **Right-of-Way Dedicated to HVT** for more discussion of space allocation within streets.)

Overall, we found only a few examples of HVT-focused street and arterial network standards. Some reports of local street network implementation before urbanisation include a case study of Villa El Salvador, a neighbourhood in Lima, Peru (MIC). This study exemplifies a quick and thoughtful municipal response to informal land settlement by squatters. Here, the city implemented a gridded plan featuring arterials equipped with greenways and enough width to carry transport infrastructure(457). The Urban Expansion Initiative deployed by New York University's Marron Institute encouraged four Ethiopian (LIC) cities to draft their local development plans and to extend their administrative boundaries to have full control of the growing metro area. They devised a special revolving fund to capture the value of land converted to urban use and used this to cover the cost of reserving land for arterial roads(438).

Overall, dense, gridded street patterns contribute to better access and efficiency and a larger share of walking and cycling modes, but this research is limited to HICs. While there is much guidance on the layout and design of street and arterial networks, less is known about the impact, particularly in MICs and LICs. In a few LIC and MIC cases, governments implemented street networks in rapidly growing cities before the onset of urbanisation to facilitate orderly growth, the provision of an arterial network and HVT corridors.

5.2.2.2.e. Land Readjustment Measures

Land readjustment measures include the modification of the shape and conditions (often the formalisation of tenure) of property lots and the addition or improvement of public infrastructures, such as continuous public streets. These changes may cause an increase in land value due to improved access and formality, addressing HVT goals of access and equity. The opposite of land expropriation, land readjustment involves a public or private agency managing the process of negotiations and compensation with the landowners(459).

Forms of this tool have been implemented across HIC, MIC, LIC and various geographic regions. HICs in Europe (e.g., Germany), Asia (e.g., Japan), and Latin America have used land readjustment to grapple with the effects of rapid population growth. Land pooling and readjustment in HICs like Hong Kong SAR, Japan, Seoul, and Germany have also helped to garner land for infrastructure and land banks(318). As the approach was successful in high-income countries, it expanded to LICs and MICs in the 1980s and 1990s. Gujarat, India implemented town planning schemes (i.e., land pooling and readjustment) to create street networks, land for public services, amenities, and affordable housing in greenfield areas(169,198,318). In sub-Saharan Africa,

land readjustment involves tenure formalisation because land occupation may be informal and highly top-down(460).

Tangible results of the town planning scheme are observable in Ahmedabad, where improved and dense roadway networks lead to shorter average trip distances than in other Indian cities(461). Since land readjustments often include tenure formalisation, they allow municipalities to garner tax revenue and promote home ownership and more sustainable development. In Rwanda, for example, large-scale land titling and readjustment of the country's land has unlocked a fivefold increase in land-related tax revenues from 2011 to 2013. In Lima, it increased the rate of housing investments by over 60%(462).

Land readjustment is a widely practiced measure. It is used at various levels for land preparation and assembly, often preceding other measures that foster orderly growth, compact development, and implementation of HVT. This tool is especially effective in areas where formal urbanisation has not occurred but where the potential for growth is high.

5.2.2.2.f. Resilience Planning

Effective land-use regulation is an essential tool for resilience planning because it can guide development from hazardous areas. It can also cluster density so it is more resilient and efficient than sprawling cities. The absence of integrated land use and transport planning prevents the creation of compact, efficient cities that can support sustainable mass transit modes and concentrated emergency services for expanding urban populations(463,464). The New Urbanism planning theory, which promotes compact, transit-oriented development, allows for building in safe locations while protecting ecologically sensitive regions. Yet, long-term strategies must supplement these codes to mitigate hazards rooted in adaptive plans that integrate transport and use(463).

Resilience in plans and regulations is not always well articulated or enforced. For example, in the US, the federal government has had a long history of weak support for planning and strong support for intensive development in areas prone to natural hazards(463). One example of a transport plan considering resiliency measures is Seattle's Freight Master Plan which identifies alternative routes for its freight movement, for use in the event of road construction, crashes, and extreme weather events(465).

Urban transportation and land-use resilience plans often fail to address equity, exacerbating socio-spatial inequalities. This can occur when interventions such as land use regulations and infrastructure projects disproportionately displace or negatively affect low-income communities. Furthermore, municipalities may omit disadvantaged communities from the planning process and prioritise the protection of more economically valuable places and populations(466).

Integrating resilience into long-term land use and transport planning is a necessary function of city planning. While there are countries and cities employing land-use regulation to prevent building in hazardous areas, they often limit it to rigid land use codes. We found very little in the LIC context. We found few sources in the literature on the impact of including resilience in the planning of urban development at a broader scale.

5.2.2.3. Land Use and Urban Freight

Although urban freight spans multiple aspects of urban transport, this section focuses on its connection to land-use measures, specifically the location and scale of distribution centres, and to a much lesser extent, its interaction with urban design. Service and regulatory implications of urban freight are discussed in the **Urban Freight Services and Regulations** section. Recent technological innovation in freight integration are discussed in the **Urban Freight Systems** section. The literature points to urban consolidation–distribution centres and off-hour delivery programmes as the two main measures relevant to integrated land use, transportation, and on-demand management in addressing "logistics sprawl" and "the historical trend towards spatial deconcentration of logistics terminals in metropolitan areas"(467).

In terms of LICs and MICs, one article briefly mentions freight as a contributor to traffic and congestion in urban areas but claims that "few developing cities plan for freight movements"(202)(p 14). Several grey literature reports from organisations delve into measures implemented in LICs and MICs in Asia, Africa, and Latin America(468,469). These reports show that in many LICs and MICs, freight planning tends to exist at the regional or national level. Initiatives at the urban level focus more on shifting to HVT modes and improving the eco-efficiency of vehicle fleets than system improvements (e.g., off-hour delivery and urban consolidation centres).

Distribution centres needed to store and transfer goods include centres along large truck routes, large regional hubs near rail or sea, and local last mile centres. In dense urban areas, consolidation centres near final delivery points can help reduce the number and size of trucks on the streets and potentially avoid duplication of trips by the competing carrier services. Research emphasises the importance of PPPs that involve private actors from the early planning stages and where the public sector provides funding for implementation to overcome high property costs in cities(470). Securing storage space is becoming a significant issue for cities where the fast and efficient distribution of goods relies on last mile distribution centres near city cores. The private sector is rushing to convert vacant spaces and warehouses into storage, amidst the scarcity and the high cost of land(471). From the government perspective, ordinances permitting mixed-use areas can also allow for multi-activity buildings including freight storage facility at ground floors(472).

It has become increasingly important for metropolitan areas to plan for freight infrastructure to integrate with the regional freight network and land uses. For countries that rely on rail infrastructure, railway links are a sustainable option for the distribution of urban freight. Cities can use multi-modal urban consolidation centres (where trains transport goods to a central location and then transfer them to low emissions vehicles for local delivery) to eliminate inefficient truck trips and capitalise on transit resources(473).

The 2008 Master Plan for Paris identifies 25 areas where logistic terminals were given priority for development or redevelopment to improve access(472). The Paris metropolitan area specified five categories of logistic terminals to create a denser network of distribution centres and to prevent logistic sprawl(474). In Tokyo, the Japanese Central Administration is running a "pocket loading" pilot using parking lots converted into loading areas(472).

In some cases, land-use regulations and building codes have regulated local freight distribution centres. For example, Tokyo has imposed off-street delivery area requirements for department stores and warehouses, and Barcelona mandates storage areas for food and beverage distributors(472). Curb space on public streets may also be used for freight loading and unloading, and we discuss this in greater detail in the **Curb Management** section.

As freight movement is growing in urban areas around the world, freight-related land uses will become more ubiquitous in the urban landscape. Yet our research implementing freight distribution centres only produced results in HICs. We found no impact assessments anywhere. This is a key gap in the knowledge of urban freight.

5.2.3. State of Knowledge Conclusions

The literature shows that the current course of car-centric urban development ("sprawl") has an extensive negative impact on the HVT system. Steps to enable HVT from a land use perspective will shape the future of mobility, especially in rapidly growing LIC and MIC cities. We see evidence of the prioritisation of personal vehicles in lower-income countries, and the rise of motorcycle taxis and on-demand services that result from a lack of access with walking, cycling, and transit and poor integration with land use. (We summarise our main conclusions in **Table 13** below.)

Key Findings Summary
Regulation of Land Use and Built Form
- Accessible, fine grain, mixed-use land patterns require less travel; - A complementary mix of uses supports increased walking; - HVT requires sufficient density, which correlates to higher walking and cycling, but does not guarantee HVT; - Urban design is a main enabler of walking and cycling; - Off-street parking requirements negatively affect all aspects of HVT.
Metropolitan Compact Growth and Urban Retrofit Measures
- Sprawl, leads to higher costs to cities, lower productivity, and less equity and is enabled by motor vehicles and propelled by land speculation and poor metropolitan governance; - Growth containment may work when growth is slow, but may exacerbate sprawl in high growth areas; - Urban master plans can support HVT in higher-income countries with higher capacity, but their effectiveness in LIC and MIC contexts is not clear; - A well-designed street network supports HVT. Characteristics of a good street network include regularly spaced arterials of appropriate widths (roughly 50 m) and a network of local access streets with short blocks (roughly 150m long); - Land readjustment measures are necessary before growth to help with tenure and potential tax revenue and after growth to implement an adequate street network.
Land Use and Urban Freight
- Freight is a contributor to congestion and sprawl and few cities in LICs and MICs are planning for freight at the urban level; - As on-demand freight rises, land use implications around the location of distribution centres will become more critical; without planning for this, it could lead to logistics sprawl; - Distribution centres near final destinations are needed and may require public-private collaboration to secure land and ensure this land use is allowable; these also need to link to regional freight delivery systems (i.e., multi-modal urban consolidation centres).

Table 13: Detailed summary of key findings

To support HVT, researchers generally agree on the benefits of land-use measures based on TOD principles, including a mixture of uses, inclusive housing, proper density, urban design that favors walking and cycling, dense and connected street networks, and appropriate regulation of off-street parking. These principles help enable HVT modes and are achieved by a variety of measures that more equitably distribute benefits. The challenge is how to define the right standards or thresholds for applying these principles in lower-income countries. The evidence for the effectiveness of measures supporting TOD principles is highly concentrated in HICs, especially in North America and Europe. The negative consequences of failing to achieve these measures are broadly distributed around the world.

As presented in the reviewed literature, the comprehensive planning and regulation typically found in HICs—rigid and complex master plans, growth regulation, and land use codes—may not always be suitable for rapid growth in areas characterised by a higher level of informal development and lower institutional capacities. In this context, effective plans combine simple and flexible land use and urban development measures, strong political will, and integration with the informal sector. Rapid response actions like land readjustment and upgradation of human settlements and infrastructure may be combined with equitable and anti-

displacement measures. The foundation of HVT is the street network—a level of arterial connections mixed with a fine grain grid of local access. In many lower-income countries, this very foundation is missing.

Finally, freight is an under-researched topic for LICs and MICs. Understanding how freight works in LICs, from last mile issues to distribution centres will be important to understand, especially as the nature of freight is changing with on-demand freight. This will have ramifications for land use planning as cities will need to plan for freight distribution (the new industrial areas of the city) in cities to avoid logistics sprawl.

5.2.4. Key Research Gaps and Opportunities

The following section describes key gaps in the research on land use measures enabling HVT. In some instances, the gaps in knowledge derived from a lack of quality peer-reviewed or grey literature. Of the 297 sources we reviewed for this chapter, only 140 were directly relevant to this report. Of those, only 17 (12%) examined the LIC context, and only 23 (16)% and 25 (18%) of papers examined South Asia and sub-Saharan Africa. Much of the literature covers cities in North America (40%) and East Asia and the Pacific (24%). (**Table 14** shows the research relevant to the paper.) The numbers do not sum to 140, as some papers covered multiple regions or did not cover a specific country or region at all. Thus there is a distinct opportunity to research land use measures in the sub-Saharan Africa and South Asia contexts, both of which include LICs. Most of the research we found focused on the regulation of land use and build form. While some focus was on compact growth measures, more likely needed. We found little research on urban freight and land use across all geographies.

	STUDIES PER ECONOMIC REGION (WORLD BANK DEFINITIONS)			STUDIES PER GEOGRAPHIC REGION (WORLD BANK REGION DEFINITIONS)						
REPORT SUBSECTION	HIC	MIC	LIC	EAST ASIA & PACIC	EUROPE & CENTRAL ASIA	LATIN AMERICA & CARIBBEAN	MIDDLE EAST & NORTH AFRICA	NORTH AMERICA	SOUTH ASIA	SUB-SAHARAN AFRICA
Regulation of Land Use and Built Form	58	36	2	20	9	12	1	41	13	10
Metropolitan Compact Growth and Urban Retrofit Measures	14	19	11	10	9	11	3	9	9	13
Land Use and Urban Design for Freight	13	2	1	3	7	0	0	6	1	2

Table 14: Summary of research relevant to the paper

We also mapped the locations of sources in this section, to provide a geographic assessment of sources (see **Figure 18** below). The map shows a heavy concentration of sources in many of the most populous countries (China, United States, India, and Brazil). We were surprised at the extent of literature coverage of Sub-saharan Africa and Latin America. We found very few sources in North Africa and the Middle East.

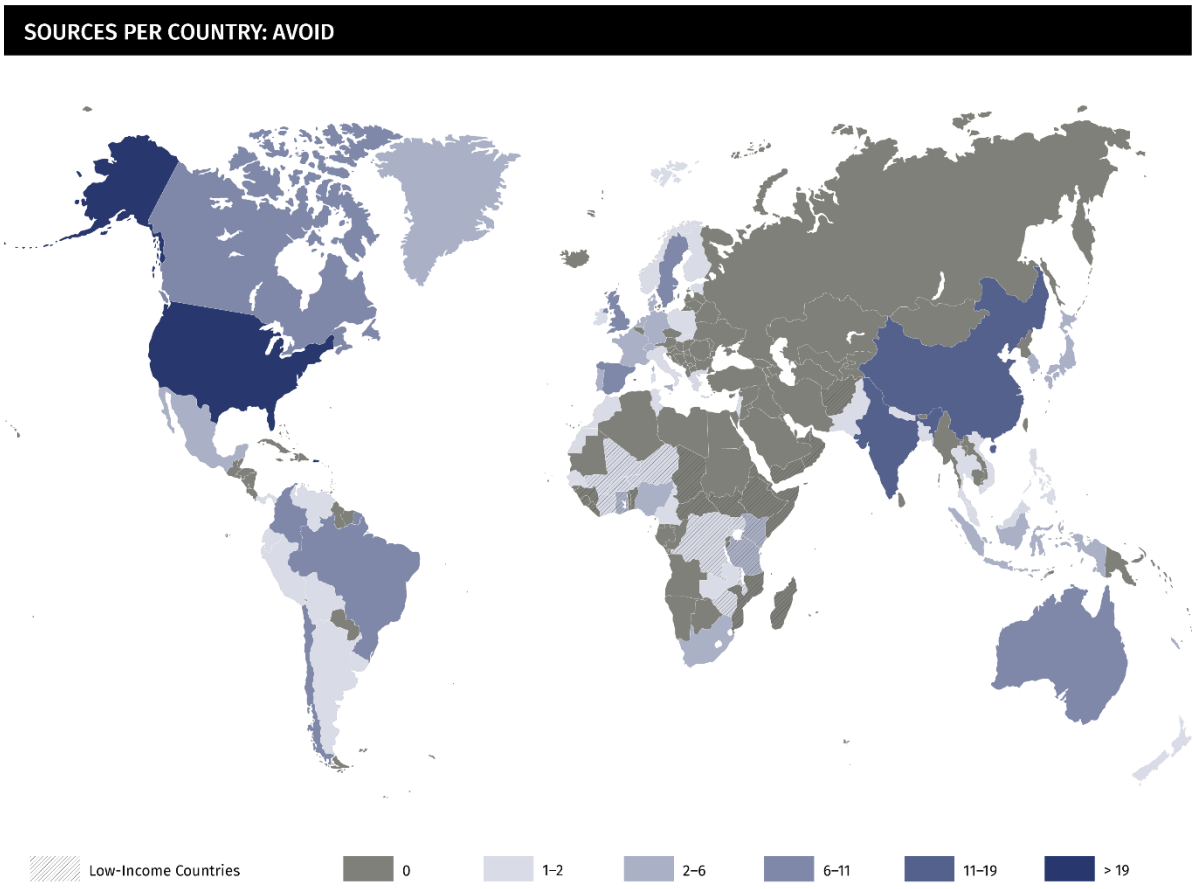


Figure 18. Distribution of Avoid sources. Source: Created by the authors

In addition to geographic gaps, the key areas that need to be covered from a research perspective are:

- Thresholds and standards for land use (mixed uses, density, off-street parking needs);
- Rapid assessment and planning/measures for rapid growth areas ;
- Thresholds and standards for street network density and design;
- How to harness or retrofit informal development for better growth and sustainable development;
- Freight distribution centres and networks in LICs and the role of the informal systems for distribution.

We provide a summary of key gaps in **Table 15** below, followed by a more detailed description of research needs.

Key Gaps Summary
Regulation of Land Use and Built Form
- What is the link between HVT and displacement, and how can it be mitigated? - What are the existing and potential planning mechanisms in SSA and lower-income cities? - What density and land use mixtures support HVT in different settings? - What amount of parking (if any) is necessary for different contexts?
Metropolitan Compact Growth and Urban Retrofit Measures
- What are effective anti-sprawl and growth containment measures in LICs and MICs? What institutions are needed to support them? - What planning mechanisms are used in LICs and MICs? How does planning work (or not work) in high growth areas? What lessons we can learn from areas that already experienced high growth? - What are effective simple planning mechanisms that are flexible and easy to implement?
Land Use and Urban Freight
- What are the appropriate mechanisms for freight planning in LICs and MICs – route planning, distribution centre planning? - What is the reality of freight delivery in LICs and MICs? How are informal freight measures, such as headloading to informal markets, used in LICs?

Table 15: Detailed summary of key gaps

5.2.4.1. Regulation of Land Use and Built Form

Mixed Land Uses in Low-Income Countries and Informal Settlements

Land-use regulation in the MICs of India and China singles out uses into large areas rather than fostering an internal mix. We found no measures to enable mixed uses in sub-Saharan Africa, where we believe there might be a lack of national measures to influence land management. The exception is Cape Town, South Africa, where mixed use became the main objective of the provincial and municipal development strategies. However, a brief internet search revealed that there are discussions on the urgent need for more coordinated land uses in response to haphazard development in African cities[9]. There is also the recognition that mixed-use development is an opportunity, but only if other planning aspects—such as improvements in walking and cycling, transport integration and alignments with density—support it. The informal commercial sector and the pre-existing commercial character of communities are usually not taken into account as integration opportunities in the studied literature. The informal economy plays a huge role in the core and fringe urban areas, as it may indicate a need for community facilities (open spaces, food centres and access to transport) and new travel patterns.

Although the peer-reviewed literature offers empirical studies illustrating that land-use mix reduces trip distances and induces more walking, the impact of mixed-use regulation established in specific cities has not been well studied. Examining actual changes in transport ridership, people density (jobs, visitors and residents) and the response of the real estate market to the adoption of land-use regulation would prove useful(165,349,475). Most studies on complementary uses are typically led by the real estate sector and covered in feasibility analyses focusing on market demand instead of complementarity informed by the needs and opportunities related to land uses, public transport and density (of residents, jobs, visitors and

[9] http://africancityplanner.com/mixed-land-use-isnt-random-land-use/

transients). Finally, the distinction between internal complementarity (within the development) and contextual complementarity is generally not emphasised in the literature.

Affordable Housing Incentives in Informal Settlements

With regard to affordable housing, measures found in HICs are nonexistent in sub-Saharan Africa. Housing affordability pertains typically to self-built housing, informal housing or housing provided by the state or private employers (very limited). Innovative ways and approaches to public-private partnerships and community involvement should be studied further. The literature typically covers incentive programmes and financing schemes for inclusive housing, but there are virtually no conversations on capacity building among the private sector. As stated by Acheampong et al., the scarcity of financing options for low-income households in Africa is well understood, but more research is needed to find sustainable and adaptable methods for the region(476).

Parking Measures

Some reports have been completed on the challenges of HVT supportive parking measures in LICs and MICs, but it is important to pursue research on parking reform specific to the types of countries that are experiencing a uniquely accelerated pace of growth(414,423). As noted by researchers, parking requirement ratios are not developed for specific contexts, rather, many have been transferred over from one city to another (especially in the US context). Although cities are implementing reforms to lower parking minimums, establish maximums or use charging methods, there is a lack in knowledge on the adequate assessment and survey methods on establishing the absolute “necessary” and essential amount of parking in cities, especially in transport corridors.

5.2.4.2. Metropolitan Compact Growth and Urban Retrofit Measures

Setting Density, Infrastructure and Accessibility Goals for Rapid Urban Expansion

Density, much like mixed use, has not been identified as a land-use regulation feature in sub-Saharan countries. There were adverse impacts of hyperdense development in Chinese cities connected to single land use and poor pedestrian connectivity, and misuse of density in Indian cities was driven by the market rather than concerted land use and transport planning. Empirical studies of correlations between population density (e.g., the European Commission’s Global Human Settlement mapping), transport infrastructure and service by mode and accessibility indexes are needed to guide policy on urban expansion and suburban densification towards HVT supportive densities(477). Some empirical studies yield helpful statements, but the impact of densification and other land-use measures on growth management need to be better understood.

Measures Curbing Rapid Urban Expansion in Low-Income Countries

Many planning tools applied in HICS, where growth is slower, may not be suitable in the context of LICs. Traditional master plans are comprehensive and require enforcement. Land-use regulation is challenging in contexts where land ownership is highly speculative. Simple rapid response tools may be more effective in tackling rapid growth(438). However, the lack of knowledge about emerging LIC planning practices and initiatives implies that more research is needed. LIC-specific tools, like upgrade programmes, need support from adequate policy reforms, institutional alignment, and capacity building. Owing to a lack of case studies, there is a lack of measurable impact of growth measures in LICs. Deeper assessment via interviews could help gauge what governments need to implement adequate measures for growth, including transport and land-use coordination. As Dowall points out, land-use regulation may lead to more spatial exclusion and rising housing costs(478). The traditional forms of regulating land that had an adverse effect in US cities and China are not always suitable for LICs and MICs.

Road Network Standards for Low-Income Countries and Informal Settlements

The key gap regarding arterial network specifications with relation to HVT is a lack of consensus on standards for properly connected networks that support HVT. Arterial network standards, with appropriate density thresholds for compact development, could prove useful as regulatory tools for rapidly growing cities, but only a few referenced case studies give any insight into global practices. Considering informal settlements, various reports refer to upgrade processes, but very few include road infrastructure and transport access as important aspects of the informal community upgrade programmes.

5.2.4.3. Land Use and Urban Freight

As described above, the scholarly literature on urban freight focused on the US, Europe, and Japan. Yet, there is a lack of information on the impact on HVT and land use deriving from planned freight networks and distribution centres. There is a lack of peer-reviewed, empirical knowledge of urban freight strategies in low- and middle-income cities and countries, especially in relation to system-wide efficiency improvements. There is also a gap in knowledge on informal freight transportation systems in LIC and MIC cities as examples of lower impact freight movement.

5.3. SHIFT — Transport Infrastructure, Services and Supporting Regulations

Traditionally, 'Shift' refers to improving trip efficiency by moving from inefficient and energy-consuming transport modes (private cars) towards modes that are safer, more efficient, affordable, and environmentally friendly (public transport, walking, and cycling)(6,11). This means changing urban modal shares to decrease the number of private motorised trips. In this report, 'Shift' refers to both increasing the efficiency and the quality of the HVT modes and improving them to retain and increase modal shares via infrastructure, transportation services, and the regulations that directly support them. Although a number of factors incentivise or deter the use of specific modes, it is possible to identify three key drivers that explain urban mobility patterns worldwide: urban form, income and the existence of sustainable mobility infrastructure and policies. Urban form is addressed in the **Avoid** section, but we feel it is important to mention that density and sprawl can play a crucial role in the success or failure of HVT. Our approach in this section focuses on sustainable mobility infrastructure and policies. This shifts the focus of sustainable mobility from looking at achieving efficiency to embracing the goals of HVT more broadly: improve access, enhance safety, address inequity, minimise environmental impact, and use resources efficiently. The shift to walking, cycling, and public transport serves as a proxy for the full set of HVT goals. Improving the efficiency of resource usage as per the definition of HVT in the beginning, is, however, still a main concern for HVT. In addition to improving access, HVT is a more resource-efficient baseline.

5.3.1. Context

Motorisation is steadily growing worldwide(27,479). The number of motorised vehicles in the world grew by 20% between 2010 and 2015, reaching 1.2 billion (see **Figure 19**). Seventy percent of these vehicles are private cars. If the trend continues, we expect this number to double by 2030(480). This growth is leading to social, economic and environmental losses due to increased traffic congestion, noise and air pollution, and road traffic crashes(27,303).

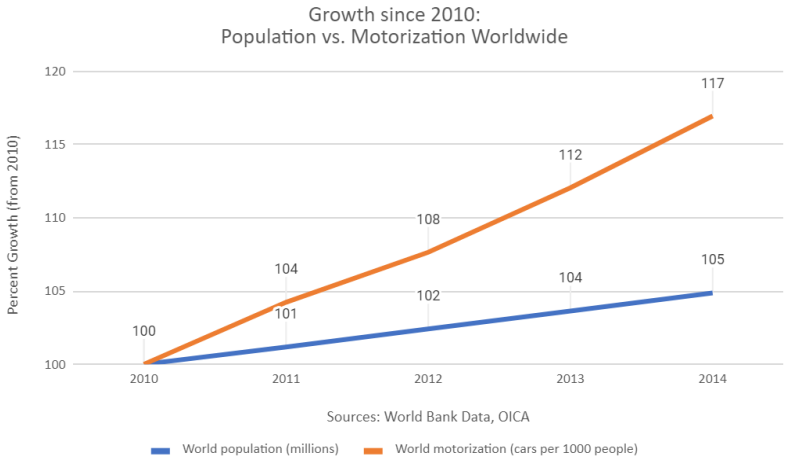


Figure 19. Growth in the number of motorised vehicles in the world since 2010

In addition, urban freight represents 20% to 30% of vehicle movement in cities generally, a figure which is steadily growing(42). Researchers project freight volumes to grow by 70% from 2015 to 2030(27).

Urban travel is not evenly distributed around the world. The Global Mobility Report describes significant differences between cities in HICs (where most daily urban trips are made by private motorised modes, mainly cars) and cities in MICs and LICs (where most of the trips are made by walking, cycling and a wide variety of public transport services, either formally structured or informally provided by private operators)(27). For cities in MICs and LICs, a high modal split for HVT does not mean that urban mobility systems are sustainable and efficient. Accessibility is often poor despite robust participation of sustainable modes, such as walking, cycling, and public transportation. This could translate into people leaving these modes when their income rises and they have other choices.

Nevertheless, HICs do not form a homogeneous group. In European and some Asian countries, such as Japan and Singapore, public transport is a high proportion of the urban modal split(94,481,482). In countries like the US, Canada, and Australia, public transport is a low portion of urban modal shares. Urban form, characterised by steady suburbanisation, is an important factor behind the high rates of car dependency in the cities of these countries(7).

Mobility trends follow different paths depending on the income level of countries. In LICs and MICs, economic growth and increasing income contribute to motorisation, but car ownership and use are stagnating in some European and North American cities (HIC)(7,202,482–484). (See **Figure 20**). According to UITP, motorisation in HICs grew by an annual average of 2.3% between 1995 and 2001; the annual average of growth has been 0.5% since 2001(479). Passenger travel shows similar trends from 2000 to 2015, increasing 1% in OECD countries (mostly HICs) and increasing 169% in non-OECD countries (mostly MIC and LICs)(485). Walking, cycling and public transport modes have the largest share of passenger transport in MICs and LICs, but there is a strong increase in the ownership and use of private motorised modes. As stated before, this is fuelled by economic growth, rising incomes, and the lack of consistent measures promoting sustainable modes(8,202,486). Thus, according to the UITP, cities in LICs and MICs saw a strong increase in private motorisation rates between 1995 and 2012 (4.6% average annual growth)(479). This trend is more acute in emerging economies like China, India, and Latin American countries(487,488). In India, even though walking, cycling and using public transport constitute 74% of all trips, the increase in household incomes and growth of industrial and commercial activity have triggered an exponential rise in the number of private motorised vehicles(489).

Motorcycle use has grown considerably in recent decades, and in many Asian, African and Latin American countries, it is the first step to increasing private motorisation(49,490). In their research on motorcycling in Thailand, Pongthanaisawan and Sorapipatana point out that when personal income reaches a certain threshold, people switch from motorcycles to cars(491). Although private motorised modes still have relatively small participation in modal shares, high levels of traffic congestion are commonplace in MICs and LICs. In addition, travel speeds are low and trips are increasingly time consuming. This is in part because of a lack of dense street networks, poor maintenance of street networks, and the inefficient or non-existent management of intersections(82).

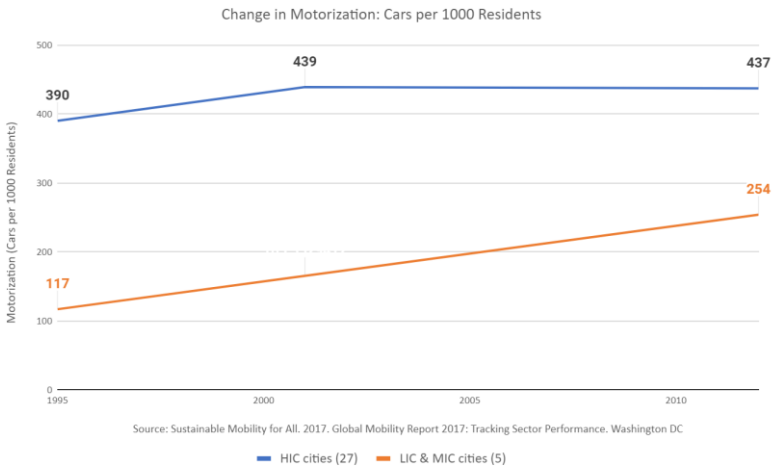


Figure 20. Number of cars per 1,000 residents

5.3.2. State of Knowledge

The following section reports on the state of knowledge on 'Shift'. In this section, we will review the state of knowledge on HVT measures, with a focus on walking, cycling, and public transport. We cover research around measures to increase the safety, quality, and energy and economic efficiency of HVT modes, with an aim to increase accessibility and the overall mode share for HVT. The findings cover measures used across the four themes of 'Shift' (see below) in LICs, MICs, and HICs (as available) and their impact. In several cases, opposing measures are discussed to inform the arguments that run counter to improvements in the quality of HVT modes.

- Infrastructure—addressing the provision of both strong networks and dedicated infrastructure for sustainable mobility;
- Modes and Services—looking at what conditions incentivise HVT;
- Travel Demand Management (TDM)—assessing means of limiting and managing private car use;
- Urban Freight Services and Regulations—focusing on freight route planning and last mile issues, with a look at informal freight movement.

We minimise overlap with other sections (**Enabling Structures**, **Avoid**, and **Improve**) as much as possible.

5.3.2.1. Infrastructure

We have identified infrastructure as a key driver of HVT based on the correlation between infrastructure spending and mode share. For example, Japan invested heavily in rail infrastructure and has relatively high rates of rail use the Netherlands invested heavily in cycling infrastructure and has high rates of cycling, and

the United States invested heavily in limited access roadways and has high rates of driving(492–494). This section looks at:

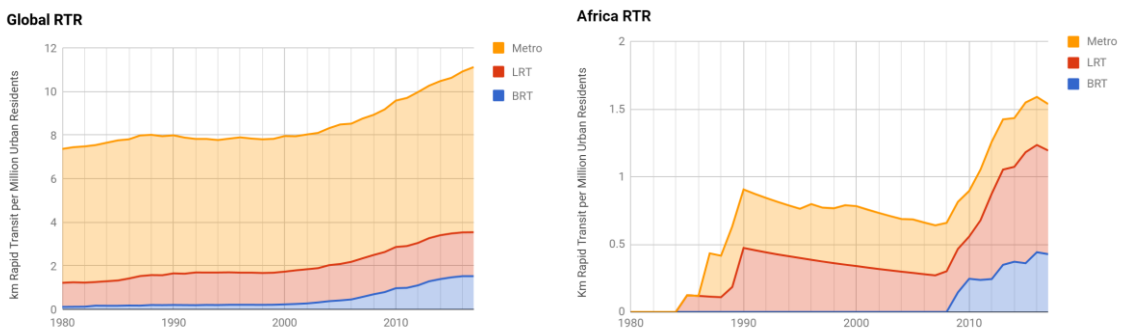
- Comprehensive high-capacity transit networks, including for rail and BRT;
- Dedicated right-of-way for HVT;
- Curb management;
- Urban roadway expansion and removal.

The foundational infrastructure needed for HVT is a well-connected, well-designed street network, characterised by a high ratio of intersection nodes to road links, that offers a grid of convenient and direct routes to destinations, and facilitates walking and cycling (see **Connected Street Network**). As we mention in the **Avoid** section, many lower-income cities are missing a sufficient street network—the basic requirement for HVT, let alone a well-connected or well-designed street network.

5.3.2.1.a. Comprehensive High-Capacity Transit Networks

Infrastructure for high-capacity transit networks is critical to HVT. We define high-capacity transit as heavy rail, light rail transit (LRT), and bus rapid transit (BRT). All require dedicated infrastructure and higher investments than systems with lower capacities. This section will focus on how well these systems meet HVT goals, with an emphasis on financial sustainability.

Rail continues to grow worldwide, particularly metro systems in Asia, while BRT has grown substantially in Latin America. Rapid transit ratios (RTR), which compare a country's urban population with its total length of rapid transit lines, are growing steadily across the world—although at different paces, and via different modes (see **Figure 21**). Since 1980, Latin America has only seen a marginal increase in its light rail (from 0 to 0.4 RTR) and heavy rail (from 3.4 to 4.4 RTR), while BRT has increased dramatically (from 0.6 to 4.9 RTR)(ITDP Database). By contrast, BRT has lagged in Asia over the same period while heavy rail has seen considerable growth. In China, heavy rail RTR grew from 0.6 to 9.0 RTR between 1980 and 2017, while its LRT and BRT only reached 0.6 and 1.3 RTRs, respectively. There has also been a rapid rise in the number of BRT systems in LIC and MIC cities, and some of the most advanced systems are now found in Latin America and Asia(495).



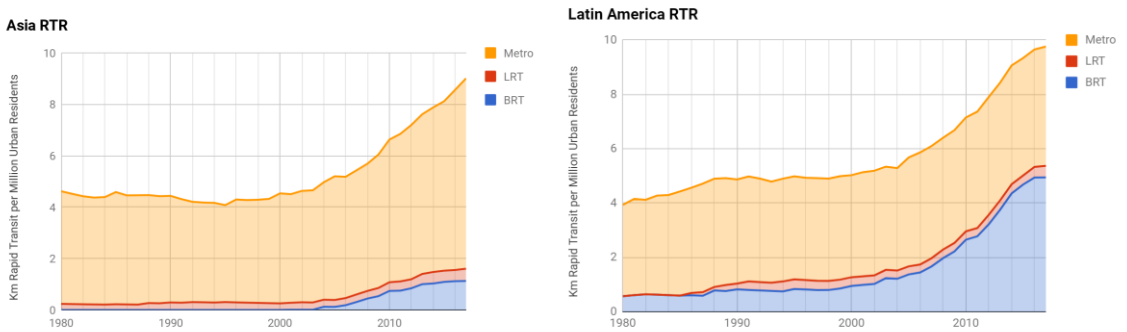


Figure 21. Rapid transit to resident ratios by region and mode. Source: ITDP 2018

The production of both peer-reviewed and grey literature on high-capacity transit networks appears to respond to national and regional trends. For instance, much of the literature on metro systems is produced in China, where construction of these systems skyrocketed in the last decade(445,446,496). Similarly, much research on BRT is produced in Latin America, where many of these systems have been implemented in recent years(8,73,93,225,497).

There is extensive literature on the technical aspects of urban rail network optimisation. Several reviews cover the financing, planning, design and operations of rail transit systems, although these focus on European, North American and, increasingly, Asian cities(496,498–502). Another aspect of rail research, including in LICs, examines the policy context of systems—whether rail networks are intended to stimulate growth, create equity, or catalyse sustainability. Others consider equity, showing that expansive heavy rail systems are ineffective for solving the mobility needs in middle-income cities, due to expense and time needed for construction when compared to other modes, such as BRT(458).

Regarding impact, Allport analyses the state of rail transit in lower-income countries and reviews empirical evidence to determine the nature of its role in the policymaking of LIC and MIC cities(503). Metro projects in these countries, Allport mentions, usually are planned poorly, lack a strategic vision, respond mostly to political objectives, focus insufficiently on financial sustainability and reduce the debate to “BRT vs Metro”.

Another strand of literature has focused on quantifying the impact of urban rail investments. That research has found positive impacts on land values, modal share, and environmental conditions; negative impacts have occurred when the infrastructure severs connections between people and destinations, reducing local accessibility(504). Studies from LIC and MIC cities are less common(505). In the MIC context, a study found that the extension of a line of the Mexico City metro led to increased transit use, land values and density in the neighbourhoods close to it. However, in contrast to those in higher-income countries, LIC investments in high-capacity public transportation are unlikely to offset the need for informal transportation, particularly for low- and moderate-income residents(505). Few studies have examined the accessibility impact of infrastructure investments in the LIC context.

The literature on network planning specifically for rail systems often analyses network types and provides decision-making toolkits to adapt the structures and capacities of systems to the specific urban form and demand of the cities(446,498–501). Among grey literature, a comprehensive evaluation of US rail systems indicates that “metropolitan areas with large, well-established rail transit systems have less traffic congestion, lower average per capita vehicle ownership and annual mileage, significantly higher per capita transit ridership, lower consumer expenditures on transportation, higher transit service cost recovery, and lower traffic death rates than otherwise comparable cities with less or no rail transit service(502).

Recent literature on BRT versus rail has focused on implementation, costs and benefits, the stigma of bus travel, political motivations, and the capacity of BRT to leverage TOD. Cervero and Dai (2014) note that BRT

systems have gained prominence worldwide as a cost-effective alternative to urban rail investments, and data shows a rapid expansion in BRT in the past 20 years, as evidenced above(322).

Currie and Delbosc compared BRT, LRT, and streetcars in HICs, finding that ridership and service levels are lowest among BRT, but that ridership is impacted more by vehicle capacity and service levels than transit mode(506). BRT is an HVT mode that, through certain approaches, is less expensive and quicker to construct than rail(270,507). Similarly, an assessment of Mexico City's BRT found benefits to ridership, safety, commute time, pollution reduction, and the public sector's ability to plan and manage key transportation services(508). Specifically, Flores Dewey depicts the success of BRT as both practical and political. It helped reduce reliance on informal jitneys that the city struggled to regulate and was "significantly less expensive than expanding the city's subway system"(508).

Given that BRT has shown it can have a similar capacity to light-rail at a third of the cost, Hensher challenges the widely assumed superiority of rail and the stigmas surrounding bus transit(509). Hensher suggests that cities are not doing their due diligence in cost-benefit analysis and that emotionally charged biases are winning over what is best for a community. Meanwhile, Tirachini et al. use a model to compare BRT, LRT, and heavy rail using data from Australian cities to establish the most efficient option given different variables (network density, frequency, speed)(510). They conclude that BRT is the optimal mode due to its lower costs, but that rail is the best option when it is faster than BRT.

Not all assessments favor BRT. In a review of Indian (MIC) urban rail systems, Rohit et al. maintain that investing in metros could be India's best opportunity to move towards an HVT development model. They identify land value capture measures as the most important element in financing and expanding these systems, although BRT has also been proven able to generate land value capture (See **Land Value Capture** section) in proportion to investment in many cities(79,275). From the economic perspective of planning, Tirachini et al. offer a comparative analysis of the cost for operators and users of light rail, heavy rail, and BRT in a radial public transport network(510). In most scenarios, BRT was the most cost-effective HVT mode of the three; however, rail (light or heavy) was the better option only if it surpassed the average BRT speed. The authors find that the advantage of rail speed is significant enough to overcome the lower costs, wait times, and superior access to buses.

The literature on the relationship between BRT investments and land uses often focuses on real estate impact(224,511–513). In general, they identify a positive correlation between implementing BRT corridors and land prices. For instance, in their analysis based on Bogotá's BRT, Rodriguez and Mojica identified that implementing a BRT corridor might lead to a 13% to 14% increase of property prices in its area of influence(512). Cervero and Kang came to a similar conclusion. They estimated land price premiums up to 10% for residences within 300 meters of BRT stations in Seoul and over 25% for retail and other non-residential uses along a 150-meter impact zone(495). Since the increase in land values may induce displacement of lower-income residents, anti-displacement measures should be considered in coordination. (See **People Mix: Inclusionary Housing and Anti-Displacement Measures** section.)

As for economic impact, investment in high-capacity transit systems has been summarised by grey literature publications UITP (2014) and peer-reviewed articles(514–517). In general, the existing literature agrees that investment in public transport sparks a chain reaction in economic activity that largely surpasses initial investments. A common finding is that while high-capacity transit projects are usually costly, they are significantly less expensive than the direct cost of congestion, which can seriously harm the productivity of cities. Gains from the investment in transit projects result in more local jobs and densification along the influence area of transit lines.

The literature on air quality impacts has mostly focused on older metro systems (Barcelona, Seoul, Athens, Oporto, Istanbul, Los Angeles, and Mexico City) that lack proper ventilation mechanisms(518–524). A

common finding is that passengers who use underground services are more exposed to particulate matter than those who use surface services. According to Martins et al., concentrations of the particulate matter with a diameter less than 2.5 µm largely depend on the quality of ventilation systems and on the operation and frequency of the trains(521). Particulate matter concentrations are lower inside the trains, when air-conditioning systems are operating properly, than on the platforms. Concentrations on platforms highly depend on train frequency. Among studies focused on the particulate matter with a diameter less than 10 µm, Jung et al. point out that mass concentration levels are highest in tunnels and decrease as the distance of sampling locations from the tunnel increase(520).

Multiple papers have focused on the challenges of implementing BRT systems in LICs and MICs. Several systems suffer problems (overcrowding in buses and stations, rapid deterioration of buses, low frequencies, etc.) resulting from poor planning, implementation and operation due to financial, institutional and regulatory constraints(525). Similarly, Nguyen and Pojani look at five case studies in Vietnam, India, Thailand, Nigeria, and Peru, stressing the importance of elements such as the institutional and legislative context, political leadership and commitment, and management of competing modes(91). In Indian cities where the central government strongly supported mass transit in the last decade, studies showed the negative role played by the lack of decisive leadership and institutional weaknesses. This is well-illustrated by the case of Delhi's BRT—dismantled in 2016—whose implementation difficulties were due to concurring factors such as the legal war waged by the elites for more driving space and initial planning decisions. This eventually led to a national debate on the viability of BRT systems in India(79,91,526).

Wood uses South Africa to demonstrate how BRT implementation can require "a learning process that is lengthy and drawn out, incremental and at times delayed," especially in "transnational policy flows and policy adoption"(109). South African cities were drawn to the Bogotá model for its ability to incorporate existing transit operators into its new BRT system, but the transition was challenging in the South African context. A 2009 report from the South African Cities Network on Sustainable Public Transport states that the national Public Transport infrastructure and Systems (PTIS) grant and its successors have been the main financial instruments supporting transport infrastructure in South African cities, including BRT. It is not unusual to have national funding support for infrastructure. The operating authorities only recover 30-50% of direct operating costs from BRT farebox revenues. (More research around the role of the informal operators and BRT is found in the **Informal Transit** section.)

Reviews of BRT implementation include India, China, and Africa, and have examined both existing and planned systems(79,109,224,526–531). A common finding of these studies is that recent BRT growth has produced large positive impact that includes decreased travel times, reduced emissions, and fewer road crash victims. In these countries, BRT usually brings professional operation, rational network planning, system legibility, financial sustainability, multimodal integration into systems lacking these important organising principles(532).

As rail networks are expanding in low- and middle-income countries, so is the literature covering them(503,505,511,533,534). Their sustainability, financial and political feasibility, and the impact on the urban form (especially in contrast to BRT) is being debated. But knowledge gaps persist, especially among LICs. BRT has emerged as a rapidly expanding, quality, and affordable HVT option for cities of LICs and MICs. The institutional context, available planning mechanisms, and financial models have a huge influence on a BRT system's success. Regional variation in each context needs to be addressed. In LICs, informal transit is often the only service available, and when BRTs open, they are the first formal transit system managed by the government. Therefore, we need more research to understand how this transition can strengthen institutions and operators, and create a more viable foundation for transit system growth. Further research into why different modes have flourished in different regions and which aspects of planning correlate with

transit network success could be helpful. We need more research to understand what investment to make from an infrastructure point of view. This will help local stakeholders ascertain when to use which form of high-capacity transit from both a political (policy goals, policy incentives, political objectives) and technical (cost, capacity, implementation considerations) perspective. While the literature suggests that BRT may be a more cost-effective solution that can scale more quickly, rail may have a larger impact in terms of land values and density. Generally, there is a lack of information on accessibility in the LIC and MIC context.

5.3.2.1.b. Right-of-Way Dedicated to HVT

We previously discussed efficient street and arterial networks as a system (see **Connected Street Network**). In this section, we examine empirical evidence of the role and need for dedicated infrastructure for sustainable modes, including how public right-of-way is distributed (bus lanes, bike lanes, rail corridors, shared streets, etc.), and the impact of dedicated right-of-way on modal share.

Academic literature gives a lot of attention to the allocation of street space. Transport modelling techniques and empirical methods are widely used to calculate the economic, social, and environmental impact of allocating space to specific modes. It is also used to determine the optimal allocation of street space in different urban contexts(535,536). These studies find that bus-only lanes, cycle tracks, high-occupancy vehicle (HOV) lanes, rail corridors, and shared streets can provide benefits to increase efficiency, accessibility, equity and road safety, while decreasing the environmental impact of travel on traffic lanes vulnerable to congestion(184). A study of BRT systems found that, in some cases, buses can achieve a performance similar to higher-order public transit and reap considerable economic, social and environmental benefits; but a BRT system's success highly depends on the integrity of dedicated lanes and its prioritisation within the right-of-way(537). Grey literature regularly concludes that there is a need to allocate increasing amounts of space to more efficient and equitable modes of transport, particularly public transportation and active travel(6,27,62,378). In terms of equity, dedicated lanes for public transport carry an important significance because in LICs a large percentage of the population cannot afford a car(184).

The existence of exclusive right-of-way infrastructure, such as urban rail or BRT, is linked to increased land values in several cities in HICs and LICs. This is due to the increased accessibility new infrastructure provides(397,495,505). Non-academic literature focused on LICs and MICs has advocated for the adoption of BRT systems, and this may have contributed to the expansion in the number of systems in this region(6,27,62,270). The impacts of BRT infrastructure are also being evaluated by peer-reviewed literature. Bocarejo et al. also find that land value is tied to BRT, and that BRT has led to higher densities around the transit corridor(538). Right-of-way is also linked to increased access, although this is not always distributed equitably. In an assessment of the impact of Rio de Janeiro's Olympic Games-led BRT expansion, Pereira uses open data and software to measure changes in accessibility levels and finds that the gains were concentrated in higher-income neighbourhoods(278). Dedicated bus lanes also help to increase the efficiency of bus systems more broadly. Basso et al. find that in Santiago the optimal allocation of bus-only lanes is about one-third of the capacity of the street network(536). In Nairobi, allocating bus and exclusive paratransit lanes was a key recommendation, according to the results of a macroscopic evidence-based model(539).

In the case of walking and cycling, there are both peer-reviewed and grey literature publications that indicate the positive relationship between the existence of cycling and walking trips and infrastructure for these modes, specifically showing an increase of bicycles in modal share proportionate to the length of the bicycle lane network(201,458,482,540,541). Pendakur finds that cycling and walking infrastructure are deeply neglected in LICs and MICs(184). Among the key issues he identifies is the lack of separation between people walking and cycling and higher speed motorised modes, inadequate traffic management, and a dangerous mix of modes in the streets that increase traffic fatalities. Reports from development agencies and NGOs

consistently argue that better infrastructure would help to protect vulnerable road users in LIC cities, propose measures and design guidelines to increase pedestrian and cyclist safety(6,62).

Anecdotally, incomplete walking networks lacking dedicated sidewalk space are pervasive in lower-income countries. Where they do exist, maintenance of sidewalks is often poor. Crossings are part of the dedicated infrastructure that should be considered in walking environments(542). Many countries in South and Southeast Asia completely neglect the crossing environment and it is nearly impossible to cross the street due to the volume of motorcycles, cars, and other vehicles. Cycling needs a dedicated infrastructure in areas where speeds are high. One of the biggest barriers to cycling is the perceived danger of cycling next to cars and motorcycles. A dedicated infrastructure can help overcome this perception and increase ridership(482).

The literature on high-occupancy vehicle (HOV) lanes mostly focuses on North American HIC cities, where they were implemented with varying degrees of success. A review of HOV measures in the US finds that their potential to reduce congestion and emission is highly context-dependent(543). The increasing availability of anonymised traffic speed data from mobile phones is facilitating the study of HOV lanes and other measures. Hanna et al. use this data to measure the city-wide effects of HOV lane restrictions in the MIC context of Jakarta and find that they greatly improve traffic conditions(544).

Dedicated infrastructure for buses, rail, walking, and cycling are the main forms of infrastructure that have been studied broadly, and they generally support HVT goals. In lower-income countries, there is a lack of dedicated infrastructure for these modes. In the future, LIC cities may seek other forms of dedicated infrastructure to address the changing landscapes of mobility, as pointed out in case studies of lane separation for motorcycles in Kuala Lumpur and cycle rickshaws in Bangalore(545). These may warrant more study to understand the effectiveness and impact. A dedicated right-of-way for HVT must be secure in order for the system and networks to thrive and increase HVT mode share.

5.3.2.1.c. Urban Roadway Expansion and Removal

In this section, we refer to urban roadways as road infrastructure exclusively built for vehicles travelling at high speeds, which correspond to private motorised transport modes such as freight vehicles, automobiles, and motorcycles (i.e., limited access highways). This review focuses on the trends of expanding and removing roadways in cities.

Transportation planning is beginning a paradigm shift. It is moving away from equating efficiency with fast vehicle travel and considering other impacts—multimodality, accessibility, among others—and of the pernicious effects of urban sprawl driven by roadway expansion which are evidenced worldwide (see **Metropolitan Compact Growth and Urban Retrofit Measures**). The literature shows how LIC cities are experiencing the negative effects of roadway expansion. For example, in Kathmandu, one of the fastest urbanising metropolitan regions of South Asia, the central government responded to traffic congestion with road expansion, which worsened vehicle traffic and travel conditions for all road users(546). Yet, there is some literature emphasising the benefits of expanding roadways in urban settings. To be clear, some cities require street expansion (not limited access highways though) when there is not a sufficiently well-connected network (see **Connected Street Network**).

Among HICs, some widely cited grey literature in the US underestimates the costs of congestion and the benefits of roadway expansion by not taking into account the most recent literature on the topic(18). This pattern is strongest in Asia and Africa. A Taipei-based study uses a mathematical model to determine optimal investment in road expansion to meet traffic demand from a central business district to satellite cities(547). In African cities, as the case of Nairobi shows, Chinese aid and firms have increasingly invested in the construction of road infrastructure; Kenyan authorities favour the more immediate and direct answers that Chinese actors bring to them compared to other foreign institutions(334). A 2015 Africa Transport Policy Program (SATPP) review of transport measures in Ethiopia, Benin, and Burkina Faso (LICs) and Gabon, Ghana,

and Zambia (MICs) found that road sector spending comprised between 75 and 95% or more of all transport sector public expenditures in those sub-Saharan countries. We did not find studies on the impact of these road construction projects in the LIC and MIC context. LICs and MICs continue to look to flyovers and highways to solve the problems of congestion, while there is little evidence that these will solve traffic problems and some evidence that increasing roadway capacity induces additional car travel(548–551).

While some LIC cities seek to expand roadways, transportation policy in HICs is trending in the other direction(552). A new generation of policymakers and urbanists are advocating for the removal of urban expressways altogether to promote multimodality and correct negative impact on the environment and urban social fabric(553). The literature describes urban expressway removal in the US—with high-profile successes in San Francisco, New York City, and Milwaukee, among others—as the result of a dramatic shift in urban priorities, from moving people as fast as possible to creating urban space for housing, recreation, community development, and green space(554). It also highlights that removing an urban expressway creates public land for development, generating revenue and increasing adjacent land value; it is also cheaper than renovation or replacement, reintegrates socially and economically isolated districts, and reduces pollution(555). In one famous case outside the US, Seoul removed its elevated expressway to reveal a natural stream underneath, adding a park and bike path. The new public amenity boosted real estate value along the corridor and lowered summer temperatures by 3-6˚C(495). Media outlets have reported that Seoul has developed a broader plan to remove or repurpose automobile overpasses throughout the city, removing 15 expressway between 2002 and 2014(556,557). While Seoul's new park is a sustainability success story, cities concerned about capacity can also substitute a beautified at-grade boulevard with connections to side streets and achieve commensurate benefits. Instead of outright removal, cities like Boston, Dallas, and Madrid have 'decked' their expressways, converting them to tunnels with space for parks or development above. The literature also suggests that fears of exacerbating congestion by removing expressways are unfounded. A study of post-removal traffic patterns in San Francisco and Milwaukee reveals that a combination of traffic redistribution, shifts to HVT modes, and reduction in vehicle volume are more likely to occur(558).

Urban expressway removal is usually precipitated by structural decay, a sudden window of opportunity (like damage from a natural disaster), and/or a shift in political priorities away from car-centric mobility(559). In most successful cases, local government support is strong and initiated by the mayor(555). This change in US urban transport policy is remarkable, considering its long history of prioritising private vehicle infrastructure and consumerism. After nearly a century of motorisation, car ownership is stagnating in many US cities and the limited value of urban expressways is becoming apparent(483,555,559,560). In Europe, where motorisation is also high but stagnating in some cities, Paris and Madrid have swapped portions of expressways for public space for similar reasons(561).

The literature suggests that roadway expansion contributes to congestion and sprawl, but there still seems to be a bias for using roadways to ease congestion. This lag is something to be explored, whether it is because the models used to calculate costs and benefits are outdated and what are the political pressures that drive this decision-making. While flyovers and highway expansion are occurring in LIC cities, highway removals are occurring with more frequency in HIC cities. Documenting the lessons from cities that have decided they no longer need highways to alleviate congestion may help with decision-making elsewhere. Specifically, it may help LICs avoid investing in expensive infrastructure they later want to remove. With increasingly available open-source and mobile data collected through smartphones (see **Integrative Technologies, Data, and Platforms**), there is an opportunity to study these gaps in LIC and MIC cities.

5.3.2.2. Modes and Services

This section addresses the characteristics and impact of modes and services in the transport network. It reviews academic and grey literature that analyse measures that influence the use of HVT modes (walking, cycling, and public transport services). Given its high modal share in LICs, informal transport is also considered in the analysis. Although informal services are often highly polluting, their higher occupancy and lower energy consumption per passenger-kilometre make them more sustainable compared to private cars(6). Finally, this section looks briefly at TDM measures and strategies to increase HVT modes.

5.3.2.2.a. Walking

Walking is the oldest and most accessible form of transportation and is still widespread in cities. Motorised modes thrived in the 20th century, leading to a profound change in infrastructure and street networks, with walking was often considered a residual mode of transport, treated as an impediment to automobile movement (see **Guides and Tools**). However, walking remains integral to HVT systems, often in combination with other modes. There are also equity implications for walking, as it is often the first or only choice for poor and vulnerable populations. Walking has an environmental impact close to zero and offers great flexibility in terms of timetables and route design. As previously mentioned (see **Connected Street Network**, **Urban Design: Enhancing Walking and Cycling** and **Right-of-Way Dedicated to HVT**), having dense networks, dedicated infrastructure, and urban design for walking increases mode share when people have real choices.

There is extensive literature and diverse perspectives regarding walking. Academic and grey literature recognise two main approaches. The first approach focuses on enabling walking by analysing infrastructure supplies, institutional capacity, regulations, rural-urban transitions and the recognition of both walking with utilitarian purposes(562–565). The second approach focuses on maintaining and increasing walking levels, considering enforcement regulations, emergent mobility options, travel behaviour and a vision of integrated mobility systems(201). These approaches also apply to cycling (see the next section, **Cycling**). In sub-Saharan Africa and South Asia, the subjects we interviewed described a lack of institutional understanding of and priority for walking, (see **Capacity Assessment** section). This deficiency results in inadequate attention to walking and therefore a significant deficiency in quality infrastructure. This relates to injuries and deaths caused by traffic(562). As road traffic crashes may disproportionately affect the poor, safety is one of the key topics in walking studies. (See **Road Safety Measures** below for an in-depth discussion on the issue.)

The documents we reviewed showed a stark difference between walking in HICs and LICs. In LICs, many residents have few affordable options apart from walking. This leads to high mode shares despite poorly designed and poorly connected streets. In Bangladesh, a large percentage of pedestrian trips are longer than 5 km, a walking distance rarely seen in other contexts(562). In LIC and MIC cities, such as Nairobi, slum residents walk largely because they cannot afford the motorised options(566). In Nairobi alone, walking comprises about 45% of all trips(48). Walking accounts for most traffic casualties in South African cities, towns, and villages. This suggests a need for interventions to alleviate poor walking conditions. Additionally, car ownership may not always be inversely tied to walking rates. In some central cities in the MIC context of China, residents who own cars or have a shorter home-to-work commute travel more by walking or spend less time on daily travel(563). Increasingly, guides have been developed to improve street design for walking, including in LICs and MICs. (See **Guides and Tools**.)

High-income cities, however, are increasingly pursuing initiatives that support modal shifts towards sustainable modes of transport and aiming to reduce adverse environmental impact associated with car dependency(565). In the US, there has been a shift away from car-centric planning in the federally supported transport projects towards accommodation of pedestrian and bicycle infrastructure(413). In Africa, there is an interest in reshaping walking and cycling plans and design by implementing strategies such as low-speed zones, complete streets, and the inclusion of universal design(410,564).

Gender is another central factor influencing walking. Globally, and particularly in LICs, women walk more than men because they lack access to vehicles (including bicycles) and money(562,567). Thus, poor walking conditions affect women more than men. Particularly in LICs and MICs, women are discouraged from walking (and cycling) by the disorderly occupation of public space by informal vendors, as well as poor lighting, lack of activity on the street, and insufficient maintenance of public space(401,567). More research on how users experience and use space in the city, especially when walking, is warranted; older people and children may need more places to sit, caregivers may need different considerations, etc.

In all of this, measures to improve walking conditions are important not only to increase their use but to improve conditions for those with few mode choices, especially in LICs. Women in LICS are sensitive to the walking environment and walk more because of a lack of options. Road safety for walking is a significant emerging issue. It is covered in more depth in the **Road Safety Measures** section below.

5.3.2.2.b. Cycling

Similar to walking, cycling has relatively low costs, creates minimal environmental impact, and enables flexible travel times and routes, given good conditions. Several academic and grey literature documents support the potential of using cycling in combination with other modes(378,404,407). Cycling can address first-mile gaps, especially if there is cycle parking or bike share options at the destinations(287). Supportive conditions for cycling include a connected street network (see **Connected Street Network**) supportive urban design (see **Urban Design: Enhancing Walking and Cycling**) and dedicated street space (see **Right-of-Way Dedicated to HVT**). As mentioned above, the subjects we interviewed in South Asia and sub-Saharan Africa described a lack of understanding and vision for HVT (including cycling) among decision makers to be a key barrier to HVT measures; however, the study participants also mentioned that cycling had important potential in cities in these regions (see **Capacity Assessment** section). This section focuses on cycling for passenger transport. For a more detailed look at the use of bicycles, tricycles and other human-powered vehicles for freight movement, please see **Urban Freight Services and Regulations** below.

In Asia, the correlation between the cycling industry and cycling modal shares have also been studied. The Interface for Cycling Expertise (2008) shows that China and India have a relatively high cycling modal share, a strong local bicycle manufacturing industry, and a high percentage of bicycle ownership. Large Chinese cities with a higher per-person income than Indian cities have a higher modal share of bicycles than Indian megacities. Taiwan has a strong bicycle manufacturing industry, but unlike China, it has low rates of both bicycle usage and ownership(562).

The process to implement cycling measures—in both MICs and LICs—has been slow and sometimes fragmented. According to Vanderschuren and Baufeldt, the infrastructure provision remains poor in the urban areas in Cape Town, despite the development of plans and regulations. Building cycling facilities is often not enough to drive cycling(568). It needs to be followed up with infrastructure maintenance plans and education programmes on the proper use of these facilities, as well as law enforcement strategies that ensure that facilities are used by cyclists only. These include education, awareness and adequate penalties to motorists to change the negative attitude and disrespect of motorised road users towards cycling facilities and cyclists(568). In South Africa, the lack of local awareness, data, research and funding, as well weak design and implementation strategies fail to address the needs of all cyclists, even when technical guidelines are available for cities(568,569). Technical guides are becoming more available in LICs and MICs (see **Guides and Tools**).

In terms of gender, women cycle less than men due to a high perception of risk, the lack of access to bicycles, cultural perceptions that women should not ride bicycles, and that women perform multiple trips throughout the day (grocery shopping, accompanying children to school, visiting family members) that may be difficult on a bicycle(567). A gendered study of urban travel in India (MIC), revealed that women constitute only 4% of

cyclist commuters(570). Some MICs have successfully encouraged women to bicycle more. In Mexico City, women made up 38% of the Ecobibi bikeshare users, although they accounted for 20% of cycle mode share before the program began(571). It is unclear what changes led to this shift.

Bikeshare has grown exponentially worldwide since the third generation of bikeshare systems started appearing in the late 1990s and early 2000s. In the past couple of years, dockless bikeshare has spread quickly throughout China with 10 million bikes in operation on the streets of China by May 2017. More information about bikeshare can be found in the **Integrated Technology, Data, and Platforms** section. While there is not a lot of peer-reviewed literature about either phenomenon, grey literature suggests that this is increasing mode share for cycling and even taking trips from cars (in China).

The literature shows that besides cycle infrastructure, growth in cycling requires better infrastructure design, increased education, enforcement, and promotion. In the MIC and LIC context, these are often lacking. There are significantly lower rates of cycling for women than, but new services, such as bikeshare have accompanied growth in cycling rates overall and growth in women as a percentage of people cycling, although it is not clear why. We need more research to understand this relationship.

5.3.2.2.c. Road Safety Measures

This section reviews road safety measures that comprise any type of effort to reduce the number of road traffic collisions that involve at least one vehicle or reduce the seriousness of injuries. The use of HVT modes depends significantly on road safety conditions because people who can choose other modes are less likely to walk, cycle or use public transportation when conditions are unsafe(51).

On a global scale, despite an international Decade of Action for Road Safety, road traffic deaths continue to increase, with 1.35 million people killed in 2016. However, the rate of deaths relative to population appears to have stabilised (see **Figure 22**). The World Health Organization projects that Sustainable Development Goal Target 3.6, to halve the number of road deaths by 2020, will not be achieved(51). While road traffic fatalities decreased 50% from 1970 to 2005 in OECD countries (mostly HICs), LICs and MICs suffered the burden of road traffic injuries(572). For LICs and MICs, road safety conditions have not improved during the rapid increase in motorisation(573). Regional rates of road traffic deaths are highest in Africa and Southeast Asia. Road traffic injuries are also more predominant among vulnerable road users such as pedestrians and bicyclists and represent the leading cause of death among children and young adults aged 5 to 29 years, making road safety a central challenge in the child health agenda. This disproportionate burden on active road users is heavier in Africa, which has the highest proportion of pedestrian and cyclist fatalities (44% of the African total). Motorcyclists have the most fatalities In Southeast Asia and the Western Pacific(51,573).

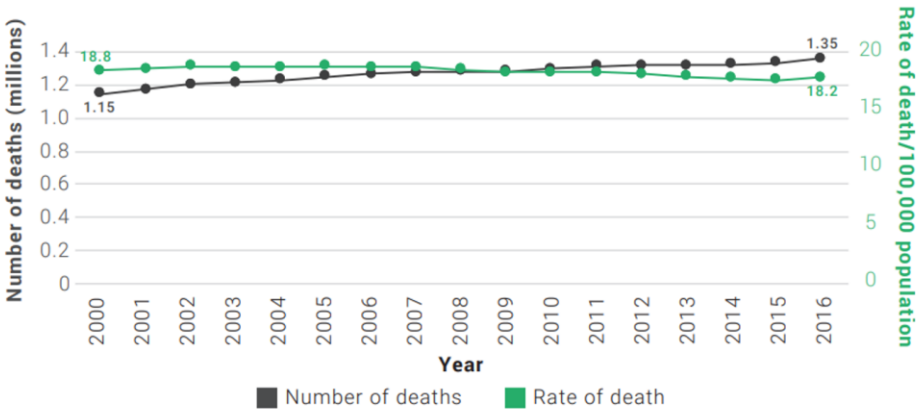


Figure 22. Global road deaths. Source: WHO Global Status Report on Road Safety 2018

Recent research into traffic safety has focused on safe systems. This approach originated in the Vision Zero policy first implemented by the Swedish government in the late 1990s. This policy advocates for building road systems that tolerate human error instead of "blaming the victim"(98). Since then, other national and local governments, mostly in HICs, have adopted this safety philosophy. For instance, the OECD advocates for a shift from a traditional approach concerned about road user behaviour to a safe system approach which "addresses all elements of the road transport system in an integrated way to ensure crash energy levels are below what would cause fatal or serious injury"(572) (p.24). In the US, over twenty cities have adopted the Vision Zero policy, working simultaneously on law enforcement, road design, and education to promote systemic road safety improvement(574). (See **Visions for HVT** for more information on Vision Zero.)

Grey literature emphasises that measures under the safe system paradigm are also fit for MICs and LICs. A study demonstrated the cost-effectiveness of strategies that applied law enforcement (such as wearing motorcycle helmets, speeding or drinking and driving) to reduce the burden of road traffic injuries in sub-Saharan Africa and Southeast Asia(51,572). Latin American cities (e.g., Mexico City and Bogotá) recently adopted the Vision Zero policy. Local governments have followed the road safety pillars declared in the Decade of Action for Road Safety. These include increasing government capacity for managing safety (safer roads, streets, vehicles, users, and adequate post-crash responses). In Mexico City, Vision Zero has contributed to the reduction of road traffic deaths—estimated at a 21% reduction between 2015 and 2018, a stronger pace than the national level(410).

Regarding specific road safety programmes, the literature has discussed the importance of reducing vehicle speed—the leading risk factor of road traffic crashes—on roads and evaluated the effectiveness of associated measures. In LICs and MICs, speed management is arguably a crucial challenge for decision makers and practitioners seeking to reduce the burden of road traffic injuries on vulnerable road users(51). Enforcement measures to reduce vehicle speed, such as speed cameras, have mostly been evaluated and implemented in HICs(575–577). A review of 35 studies showed that speed cameras were effective at reducing road traffic injuries and deaths (most results ranging from -14 to -25% crashes in the speed camera areas). More high-quality research is needed in MICs and LICs to validate this conclusion and to verify that they are more effective at the city level than at individual locations where they may displace speeding to nearby areas(575). In locations with weak enforcement, physical designs, such as narrowing road space, extending sidewalks at crossings (bulb-outs), and adding chicanes, may slow traffic speeds. New street design guides tailored to HVT in LICs and MICs suggest that more cities may be implementing these types of measures (see **Guides and Tools**).

This section presents evidence on the gravity of road traffic collisions and the measures that positively impact road safety. With pedestrians and cyclists, who tend to be poorer, bearing the burden of traffic injuries and deaths, measures to improve safety should have a positive impact on equity. There is little evidence on the extent to which such improvement may trigger a shift towards HVT modes, especially in LICs and MICs.

5.3.2.2.d. Public Transport Services

In this section, we will discuss public transport with a focus on structured public transit (formally regimented and regulated by public authorities). We discuss public transport infrastructure, including metro, BRT, and light rail, in more detail in the **Comprehensive High-Capacity Transit Networks** section above, and informal transit services in the **Informal Transit** section below. Public transport is a key component of HVT systems, but globally, its modal share is declining. Despite a twofold increase in supply between 1995 and 2012, urban population growth has outpaced transit networks. Since the industrial revolution, car traffic volume has increased tenfold, while public transport has registered little growth. In 2005, 16% of daily trips in urban areas worldwide were made by public transport, a third of the share of daily trips made by private motorised

vehicles(27,479). In the case of HICs, the modal share of public transport shows meaningful differences between regions and cities. Transit accounts for around 50% of motorised trips in some Asian and European cities, but in most North American cities it does not even reach 10%(479,480). In the case of MICs, the use of public and private motorised modes is more balanced. CAF estimates that 56.4% of all motorised trips in Latin America are made by public transport services(488). Most of these trips are made by standard buses and BRT, followed by minibuses and metro systems. For LICs, the modal share of structured public transport services is usually low and most motorised trips are made by a variety of unregulated informal transport services (minibuses, two- and three-wheelers)(45,49,202,419,578).

In Africa, a survey of 14 large cities found that all formerly had formal bus service with regulated fares provided by a government-owned monopoly operator. This system was established in the post-colonial period, however, since governments were unable to raise fares or provide subsidies, most publicly run systems and services deteriorated in quality, shrank in coverage, and eventually went out of business. Some cities now rely only on informal transit, others have reintroduced public bus service, but as of 2008 only Nairobi could maintain publicly run bus services without interruption(579). In India, only the largest cities (Mumbai, Chennai, Delhi, Kolkata, Pune, and Bangalore) have significant publicly run bus systems, while smaller cities only operate a few bus services or do not run bus service at all, relying on informal transit operations(580).

Researchers have found that the quality and affordability of transit services are key drivers of public transit mode share(482). Transport networks and accessibility were the most significant topics for structured public transport that emerged from the literature review. Regarding literature on transport networks, Guihaire and Hao provide a global review of what they call the two crucial steps of transit planning: the design and the scheduling of networks, which directly influences the quality of service and the economic sustainability of systems(581). The theme of accessibility and how it can contribute to better service is mostly addressed from a social equity perspective. One study indicates that the distribution of transport modes is a key factor in explaining the concentration of poverty in some urban areas(582). There is a notable lack of publications on accessibility and income in LICs from a transport perspective. When this topic is covered by the social sciences, it is not correlated with network planning processes and service improvements.

In terms of increasing demand once the networks are established, the literature focuses on user perception, modal choice, and preference of public transit. Most evidence is based on HICs, especially in European countries with consolidated public transport systems(583–591). A common finding is that comfort, service reliability, frequency and safety are identified as the most important public transport quality attributes from the passenger perspective. These attributes are key items to consider when promoting change in travel behaviour among car users. Studies by Cantwell et al., Li and Hensher, and Tirachini et al. identified crowding and long wait times as factors that negatively impact levels of satisfaction among users(592–594). Eboli and Mazzulla propose a customer satisfaction index to evaluate transit service quality(595).

Travel demand research in LICs has not delved into modal choice and preferences sufficiently; however, the literature suggests that demand patterns are considerably different. Lombard and Ninot evidence how the increasing demand for public transport (derived from urban population growth) cannot be met by shrinking conventional public transport companies(596,597). Demand in African cities is heavily conditioned by income; conventional public transport fares are too expensive for households with low-incomes and/or located in peripheral areas; further, structured public transport services are rare, especially in rush hours, which leads to demand that exceeds supply(53,598).

Research indicates that affordability is a key determinant for choice, especially in lower-income countries. Therefore, well-targeted and efficient public subsidies may be necessary to achieve adequate ridership for cities' most vulnerable populations. Peer-reviewed literature argues that public transit fares in many African

cities are socially regressive, and operator-based subsidies rarely reach riders, resulting in longer unaffordable trips for the poorest residents, limiting ridership(486). In higher-income countries, where authorities are also struggling with inefficient transit subsidies, solutions include competitive tendering, targeting desired beneficiaries through existing social service agencies, user-based subsidies (direct vouchers), and smart cards which reduce operating costs(599). But these HIC authorities have a much larger financial margin of error, and Cervero emphasises the importance of strong institutions—an obstacle for LICs and MICs. However, Cervero also gives the example of Peru, which circumvented this hindrance by selling discounted tickets directly in poor neighborhoods. Peru overcame operator-based subsidy flaws by paying paratransit operators the difference between regular fares and discounted tickets, plus an administrative fee. While perhaps using cumbersome methods, the measures successfully reach the intended populations, which is a constant struggle for subsidy programmes.

In Bogotá, Bocarejo and Oviedo found that instead of direct government subsidies, rider cross-subsidies can have a substantial impact on reaching the target population without compromising the operating budget(600). Equal fares for all are too expensive for the poor, but progressive fares tied to income creates huge gains in low-income accessibility, while barely reducing high-income ridership. Besides increasing ridership among the poor, it saves them money that can be used for other needs. Writing directly about fare accessibility in Africa, Dimitriou outlines the challenges with each subsidy approach: operator-based subsidies reduce fare for all riders, not just the poor, making them inefficient; meanwhile, LICs' poor institutions make identifying deserving beneficiaries through social service agencies quite difficult(601). In cities with high informality, the formally identified poor would reap the benefits—which is not bad, but it leaves out the substantially sized informal poor population. Building institutional capacity, and perhaps engaging the private sector in ITS services, may be crucial for efficient fare subsidies in LICs(76).

Much of the recent literature also focuses on public transport technology, concentrated in three main areas: vehicles (specifically the fuel they use and an analysis of the benefits provided by introducing electric vehicles), information systems, and payment methods. Regarding vehicle technologies, most of the recent literature centres on a cost-benefit analysis of replacing diesel buses with a hybrid, battery, electric or hydrogen cell-powered vehicles(602–605). Since **Theme 3: Low Carbon Transport** is focusing on this material, this review did not look into this.

A portion of recent peer-reviewed literature analyses the impacts of information systems, most of which focus on users' perceptions(606–608). For instance, Watkins et al. point out that riders without real-time information perceive wait time as longer than actual wait time. According to these authors, the aforementioned technologies accomplish their aim to optimise users' time: reported wait times were 30% lower for users with real-time information(609). As long wait times were mentioned in other research as a deterrent to using public transit, real time information may be a solution. More information on technological innovation for travel information and fare payment is found in the **Integrated Trip Planning** and **Integrated Payment Systems** sections.

The literature on payment methods usually evaluates the costs, benefits, feasibility of fare integration, and analyses impacts and opportunities resulting from the use of smart cards (610,611). A common finding is that smart card data has a lot of potential to describe the habits of public transport users, such as travel times, the number of transfers, and hourly trip distribution for all transit modes. This data will be useful for making public transport work better, leading to better access for users. Related to this topic, Thøgersen analyses the impact of fare promotions on travel behaviour. According to this analysis, providing a free month travel card generates an increase in transit ridership. Although this impact lessens after the promotion expires, the effect was still clear five months after the experiment began(612). What may need more study is the change in fare media technology and its impact on users. In lower-income countries, smartphones may not be as

ubiquitous and internet connectivity or costs of data may limit effectiveness. In cash-based societies where affordability may be the key driver of public transport use, the type of fare media technology may hinder people's ability to use the system.

Mobility benefits of investment in public transport systems have been addressed by, among others, Anderson, Beaudoin et al., and Beaudoin and Lawell(613–615). They found that increases in public transit supply can help to reduce congestion; however, the magnitude of this benefit depends on multiple factors related to the transit network characteristics and the quality of service(613–615). As Litman indicates, in many places transit exists mainly to satisfy the travel needs of non-drivers, who are usually the lowest income people(616). Hence, and to reduce congestion, public transport should attract discretionary travellers through the supply of high-quality public transport, defined by the author as "relatively fast, convenient, comfortable and integrated" (583)(p.30).

Research on environmental impact focuses on energy consumption, air quality, and greenhouse gas emissions(617–619). A common finding is that cities with a large share of transit ridership have lower energy consumption and greenhouse gas footprints than cities in which cars are the predominant mode.

The global rise of on-demand and technology-based services led by TNCs are a potential threat to traditional public transport services, but could serve as feeder services. More information on these services and their impact on public transport can be found in **Ridesourcing.**

The effective management of public transport services involves a number of government capacities, including technical skills, political will, institutional integration, and collaboration with private sector actors. More detail about these structures is found in the **Enabling Structures** section, specifically the **Informality** section, which reviews the transition from informal to formal operations. In both sub-Saharan Africa and South Asia, institutions are newly being built—from LAMATA, a transit agency in Lagos, Nigeria, CETUD in Dakar, Senegal, and DART Agency in Dar es Salaam, Tanzania(579). All of those examples are national-level transit agencies. BRT has been seen as an opportunity to establish these institutions. Best practices like Transport for London are a far stretch from LICs and MICs where there may be no or emerging transit agencies. In our interviews with stakeholders in India and sub-Saharan Africa (see **Capacity Assessment** section), a key finding was that sufficient ongoing funding is needed for formal transit operations, including funding for the institutions that manage those operations, as well as for covering part of the operations themselves. This reflects the collapse of formal bus operations across Africa in the post-colonial period.

The research shows that public transport modes are associated with all HVT goals, but that the effects vary based on the quality of service and the effective network. Public transport supply has not kept pace with urban growth. When there is supply, the key drivers of use are service quality and affordability. Service factors include comfort, reliability, frequency, and safety, with crowding and long wait times listed as deterrents to use. In LICs, many poor residents cannot afford public transit trips. User subsidies may be necessary and need to be better targeted to achieve promising results, but they require a high government capacity to aid the targeted beneficiary population effectively. In HICs, new technologies and approaches have shown promise, with fare promotions boosting ridership and real-time travel information reducing perceived wait times. Understanding the impact of technology and types of fare media in LIC and MIC needs more exploration.

5.3.2.2.e. Informal Transit

Informal transit is typically unscheduled and operates along a quasi-fixed route, although routing may change frequently(620). Informal transit services are usually run by unregulated or illegal operators. This provides employment options for poor or low-skilled workers, but the working conditions are usually poor, the wages are low, and there are no benefits(621,622). In MICs and LICs, informal transit provides most of the public transport services. It plays an essential role in providing access to opportunity(622,623). However, the

externalities and quality of informal transit raise questions about its long-term sustainability, especially as incomes rise and people choose other modes.

We commonly associate the origin and prevalence of informal transit with urban areas of LICs and MICs. These cities are characterised by monocentric urban forms, accelerated demographic dynamics, disorganised urban growth, and poor transport infrastructure. According to Ferro, informal transit includes drivers and vehicle owners, who are often part of associations or cooperatives(624). In these cities, informal transit services have emerged as the most viable mobility option and many people rely on them(624). It typically takes the form of midibuses, minibuses and smaller vehicles, such as 2- and 3-wheelers, and includes for example South Africa's minibus-taxis, Kenya's matatus, Tanzania's dala-dalas, Indonesia's Angkot and Bajaj, the Philippines' jeepneys and tricycles, Cambodia's motodops and remorks, Myanmar's sidecars, and Nepal's tempos(622,625). Informal transit has adapted rapidly to the needs of most urban dwellers who live in peripheral areas. Flexible modes such as minibuses or mototaxis can more efficiently cover areas with low travel demand(598).

These services are commonly unregistered and unregulated. Reviewed studies focus on two main issues: sector reform or restructuring and sector regulation and management(620,621,624,625). For Asian countries, Veng Kheang & Yai, Tetsuo identify four factors necessary to sustain the informal transit system: quality of service improvements, mass transit system integration, promotion of electric paratransit modes, and government support(622). Rahman et al. point to its insufficiency, while Phun and Yai present informal transit as an indispensable service in Asian LICs and MICs because of the lack of adequate mass transit systems(622,623). In African cities, Bruun and Behrens point to informal transit's flexibility and responsiveness as the key to its longevity(620).

Academic literature has focused on other externalities of informal transit and on the type of improvements that could manage them. In particular, Bruun and Behrens, Schalekamp, and Phun and Yai argue that externalities are related to road safety and poor quality of service for passengers, and that significant improvements to service quality can be made in the near- to medium-term(620,622,626). Summarised by Phun and Yai, an overview of the sustainability of informal transit services has been analysed by different authors in Asian LICs and MICs, from both the demand (mainly involving user perceptions such as satisfaction, service quality and behavioural intentions) and supply sides (focused on the drivers' quality of life and job performance, and government regulation)(622).

Informal transit is a service that fills gaps between private transport modes and mass transit systems (when available) but it also has the potential to increase accessibility for the urban poor(566). This may become more important as TNCs spread around the world. Salon and Gulyani found that even though 99% of residents in Nairobi reported that they had access to informal transit (matatus) for their daily commutes, one matatu fare represented a substantial portion of their daily expenses(566). While meeting the increasing demand for public transport, informal transit operators are mostly concerned by economic profitability which, with a lack of government regulation, has led them to maximise fares and primarily serve high-demand routes(178). This also means that informal transit operators often jockey for passengers, and use older, poorly maintained, and polluting vehicles. This negatively impacts user and labour experiences.

From a gender perspective, the analysis of informal transit systems shows deep equity concerns. In the slums of some African cities, even when equipped with informal transit routes, women's mobility is limited(566). Cervero points out that women must often endure the hardships of spatial isolation since many cannot afford informal transit and must remain close to home to raise children and carry out domestic work(202). Salon and Gulyani, who studied travel choices of the urban poor living in informal settlements in Nairobi, support this perspective. They highlight a gap in the public transport studies which assumes the possibility of being able to choose between modes of transport even when there is a large population that cannot afford

the informal paratransit options(566). Among adults, women not only suffer from the poverty gap in the ability to afford motorised transport but also have less mobility in general(566). The literature suggests that personal safety accessing and using informal transit is a key issue for women, especially at night. This may curtail women's use of transit(579,622). Finally, informal transit typically runs heavy in peak hours and can be almost nonexistent during off-peak hours(579). This affects women travelling outside of typical business hours or to places other than employment centres, such as domestic workers travelling to residential areas.

As mentioned in the **Comprehensive High Capacity Transit Networks** section, restructuring and reforming the existing informal industry is challenging. Several large cities in Africa have transitioned from informal transit to more structured models, mostly BRT, and more cities are planning similar transitions. According to Schalekamp, this will either displace or incorporate informal services. Authors such as Schalekamp and Behrens have noted the challenges of incorporating informal services that frequently lack accessible business plans and regulatory regimes into a formally structured scheme(625,626). According to Schalekamp and Behrens, in South Africa many national, regional and local informal transit associations have indicated their resistance to BRT because of insufficient consultation, an unclear future role in the system and employee redundancies(625). In addition, using the BRT scheme as the mechanism to drive reform in the informal sector, thousands of operators would have to formalise their businesses or merge into new or existing operator entities in order to participate in the new systems. Johannesburg had a long engagement process with the minibus operators to formalise the sector which proved both time- and resource-intensive(140).

A 2015 report by Martin Stucki for the Africa Transport Policy Program (SSATP) describes the struggle for African cities to reach transport sustainability, mentioning that informal transit is widespread but struggles to maintain financial viability(62). Stucki reinforces general convictions about transport sustainability in the African context, arguing that authorities must seek innovative fiscal mechanisms beyond farebox revenue and government subsidies. These include urban tolls, car and gas taxes, congestion pricing, land value capture (LVC), and a "workplace" tax on employers who own a certain number of parking spaces—plus earmarking these revenues for transport investment. But like Dimitriou and Suzuki (see **Right-of-Way Dedicated to HVT**), Stucki acknowledges the difficulty in implementing these tools in Africa given the limited institutional capacity.

Informal transport is widespread in the LIC and MIC context, providing a network of service or filling in gaps in the formal public transport network. Despite providing access to large swaths of the population, informal transport suffers from poor safety, a low-quality of service, environmental issues, and equity issues, especially around gender. It is unclear if such services can persist as populations gain enough wealth to choose other modes. As congestion and competition increases, informal transit financial/business models, which do not have big margins, will be increasingly threatened. Transitions to more formal public transport require strong institutions, good planning and design, and strong leadership for implementation and operation. The research shows that the transition from a relatively weak regulatory and institutional environment to a more formal, conventional public transport requires capacity building and investment in institutions and the operators, which takes time and money. The implementation of BRT may initiate that transition, but more research is needed to understand the conditions that will make it successful. The role of informal transit in the whole transportation system and the potential to fill the gap between high-capacity transit and walking and cycling, especially in light of the rise of TNCs, needs more exploration, especially the roles of smaller modes of shared informal transit, from boda-bodas (motorcycle taxis) to rickshaws to shared taxis.

5.3.2.2.f. Motorcycle Management

Motorcycles (a.k.a. Two-wheelers or motorbikes), motorised two-wheeled vehicles capable of similar speeds as automobiles, have been shown to be a growing mode of transportation in many LICs and MICs, but they

also produce many negative effects. In India, motorcycles accounted for 80% of private motor vehicle sales in 2004, with growth largely stemming from deregulation efforts in the 1990s, urbanisation, economic growth, and inadequate public transportation(627). In Asia, 200 million motorcycles were in use in 2010(628). Similarly, in Africa, trade liberalisation, urbanisation, economic growth, and inadequate public transportation have driven the growth in motorcycles. With poor orbital and secondary street networks in many African cities, traffic is often funneled into a few radial streets, leading to long delays. With narrow widths and low operating costs, motorcycles provide higher speed, door-to-door service, and greatly boost access. Some governments have distributed motorcycles as a poverty reduction strategy, like in Brazil. Vasconcellos, in analysing this policy, concluded that it ended up undermining the poverty reduction goal due to the impact of fatalities and injuries on low-income families(629). The collapse of formal public transportation services across Africa (see **Informal Transit** section above) has led to the rapid growth motorcycle taxis, often referred to as okada, bendskins, or boda bodas. In Kampala, motorcycles often make up 30 to 40% of vehicles on streets(630). In urban areas of India, motorcycles account for 27% of all road deaths, higher than any other mode(631). In Cambodia, Indonesia, and Malaysia (MICs), they account for over 60% of road deaths(628).

In addition to safety concerns, motorcycle use also raises concerns about noise pollution, barrier creation, and the difficulty of regulating motorcycles and their use of space. Despite high fuel efficiencies, motorcycles contribute to high levels of noise and air pollution, as shown in India and Brazil (MICs)(628,629,631). In Taiwan (HIC) and Vietnam (MIC), motorcycles are often parked on the sidewalk, obstructing the walking environment. However, in Malaysia, special motorcycle parking areas have been built in the carriageway to accommodate motorcycle parking. In the early 2000s, Taiwan began adopting similar parking bays to remove motorcycle parking from sidewalks(632).

To reduce motorcycle noise, Europe, India (MIC), and China (MIC) have all implemented noise regulations. Efforts to improve motorcycle safety include measures to reduce exposure to circumstances related to crashes. This includes regulations in the UK and Japan to limit the size of motorcycle engines(628). Malaysia (MIC) first introduced exclusive motorcycle lanes in the 1970s and has expanded them in the decades since, mostly along highways. A study showed that the lanes reduced motorcycle crashes by 25%(632). Another study looked at motorcycle lanes in two Indonesian (MIC) cities: Jakarta and Sragen. In the low-traffic streets of Sragen, researchers observed no encroachment of the motorcycle lanes. However, in the more congested streets of Jakarta, while cars encroached on all motorcycle lanes, they encroached the least on physically separated lanes(633).

Crash avoidance regulations relate to regulations requiring anti-lock brakes and daytime running lights. Finally, crash protection measures aim to reduce the severity of crashes. The UK, Japan, and Vietnam all require motorcycle users to wear helmets that meet minimum crash protection requirements. Regular inspection and maintenance requirements ensure that vehicles are suitable for road use(628).

Given the negative impact of motorcycle use, some research has examined the measures to shift motorcycle use to public transport, walking, and cycling. One study finds that the switch from motorcycle to public transport is more difficult than the switch from car to public transit(634). Conversely, a study in Thailand (MIC) found that motorcycle users were more likely to switch to BRT than car users. It also found that motorcycle users were more sensitive to the price of BRT, car users were more sensitive to the travel time(635). According to media reports, some cities in China, like Guangzhou, have banned motorcycle use all together since they have proven difficult to regulate(636).

The literature shows that motorcycles are a low-cost means of greatly improving access in cities. However, they generate many negative externalities, including high rates of injury and death, as well as pollution and noise where they are dominant. Many studies have examined efforts to mitigate these externalities through

countermeasures, such as vehicle engine restriction, braking standards, and even exclusive lanes. Other research has examined the potential to shift trips away from motorcycles, entirely, typically to BRT and other public transit modes, although the prospects are mixed. More research is needed on the effectiveness of measures to shift trips from motorcycle use without reducing access for low-income residents. Additional research is also needed on the relationship between motorcycles and cycling, good movement, and technology-driven on-demand services.

5.3.2.3. Travel Demand Management

Several authors have defined travel demand management (TDM) as a series of strategies to change people's travel behaviour (how, when and where people travel), to increase transportation system efficiency, and to achieve sustainable development public policy goals(303,423,637). Mobility management strategies prioritise the movement of people and goods over vehicles, specifically prioritising more efficient modes of transportation such as walking, cycling, public transportation, working remotely and carpooling(638). There is general agreement that TDM measures must include deterrents or 'push' measures that discourage the use of private motorised modes, and incentives or 'pull' measures that make HVT more attractive. TDM measures aimed at curbing excessive private car use include road pricing (congestion charging), traffic bans (limiting specific vehicles on specific roads and at specific times of day), street and highway network optimisation (implementation of HOV lanes, for instance), and parking management, which considers limiting the supply of parking spaces and charging for parking efficiently(303,415,639).

TDM measures were first adopted in HICs (Western Europe and Singapore are remarkable examples), where cities are more likely to have high-quality public transport networks, consolidated institutional frameworks, and resources to adopt measures that are perceived as socially and politically unpopular. Thus, most academic literature studies the effects of TDM measures in cities where they have been in place for decades. The studies focus on the assessment of their economic and environmental impacts and how the measures change user behaviour, taking into account detailed elements, such as perceptions of fairness and awareness of problems(640,641). In addition, a number of studies in both peer-reviewed and grey literature evaluate the feasibility of implementing these kinds of measures in cities that historically have adopted more car-oriented measures. For instance, Arnold et al. review road pricing programmes in Europe and Singapore to propose their adaptation for the US. Similarly, Weinberger et al. review parking measures in US cities and formulate recommendations on how to manage them, proposing different schemes and institutional arrangements available to policymakers when negotiating with private operators, developers and other key actors(424,642).

There is limited academic literature from MICs and LICs on TDM, but institutions, like the Inter-American Development Bank (IADB) and ITDP, are providing guidance and reports for curbing private motorised travel in these regions. These reports regularly propose contextualised recommendations for adapting TDM measures based on the experiences of HICs(423,643). The sparse peer-reviewed literature on this theme in LICs and MICs usually emphasises the difficulty of passing comprehensive legislation and adopting TDM measures (owing to the lack of resources and integrated policy visions)(644,645). However, the fact that most of the population uses active or public transportation can be an asset for policymakers, who could justify passing the cost of infrastructure building to the high-income population using private motorised modes. The guidebook elaborated by Ríos et al. for the Inter-American Development Bank provides a resource document for policymakers in Latin America(423). The guidebook emphasises the lessons from measures implemented in the region that increased congestion instead of reducing it, such as licence plate restrictions, urban highway construction, and excess parking supply. Recommendations for successful TDM measures include involving the private sector early on, building technical and implementation capacity, reviewing parking requirements, and securing financial resources for implementation. Only recently has it

been argued that the difficulty of increasing public transport mode share in LIC and MIC cities could be addressed with TDM strategies emphasising psycho-social variables, travel behaviour, travel chain attributes and quality of life. Yet, these discussions have existed for more than a decade in HICs(646,647).

Many parking management strategies may support TDM goals.(GIZ 2016) As discussed in **Curb Management**, pricing or limiting on-street parking supply is a viable tool to discourage the excessive use of private cars and the impact of its negative externalities(415). In a key example of a MIC city, Sañudo analyses parking policy trends and impacts in Mexico City and develops a set of key recommendations, like setting on-street parking charges and limiting the construction of off-street parking(648).

Another frequently studied TDM policy is congestion pricing. A review of the literature suggests that this mechanism has been successful in reducing congestion and emissions and in generating revenue streams for the government, but that cities interested in applying this policy should carefully consider its practicality(649,650). From its inception in Singapore (HIC), congestion charging has been increasingly discussed and studied by European-focused and Australasian cities. High-income cities such as London, Stockholm, and Durham (UK), have consolidated public transport systems and robust institutional frameworks that make such measures socially and politically feasible(651,652). In this sense, authors generally agree that it is important how policy revenue is spent. It is also important that such measures accompany TDM measures (namely parking management) and/or transit subsidies to maximise their potential to induce modal shifts and address equity concerns(536,639,653). Several trials have been unsuccessful in cities like Gothenburg and Hong Kong SAR, where peak hour pricing was discarded after six months owing to privacy concerns(639). The trial in Stockholm, however, was successful and the congestion charge remains in effect(654).

Existing congestion pricing systems, like those in London and Singapore, are static and do not respond to changing traffic conditions. They operate with license plate recognition cameras or radio beacons, which detect vehicles coming in and out of a defined area(655). Recent advances in mobile communications and digital technology, however, have facilitated highly accurate road pricing, which enables efficient time and location pricing of road use through dynamic road use charges(656,657). Academic literature has discussed dynamic road pricing extensively. There is a general agreement that mitigating congestion and other externalities is a rational and efficient solution(658). However, it has only recently become technologically practical to implement on a city scale. Singapore plans to deploy the world's most advanced electronic road pricing scheme in the early 2020s, which will involve installing a GPS device in every vehicle to evaluate actual use of the road network(657). Real-time data will allow the Land Transport Authority to develop simulations and adapt pricing based on changing conditions. GPS-enabled road pricing mechanisms have important privacy concerns, which can be dealt with by implementing anonymity mechanisms(657,659).

Congestion pricing is considered more effective at curbing congestion than traffic bans (i.e., license plate restrictions), but it is also more politically costly and complex to implement. While cities in HICs, like London, Stockholm, Milan, and Singapore, have implemented sophisticated congestion pricing plans, cities in other regions, like Latin America, have opted for simpler 'command and control' measures like traffic bans (e.g., the 'Pico y placa' license plate restriction programme in Bogotá and 'Hoy no circula'—"Do not drive today"—in Mexico City) to reduce air pollution. Mahendra analyses four Latin American cases and finds they have been unsuccessful in curbing congestion or vehicle ownership(645). Cantillo and Ortúzar point out that this policy is apparently effective only in the very short term (reduced travel costs and improved air quality), but ultimately does not achieve its objectives because it leads to the purchase of more cars (both new and used) by car-dependent people(660).

New mobility services, such as ride-hailing, can facilitate more efficient road pricing. This is similar to how TNCs implement surge pricing (flexible pricing) plans to set prices based on shifting demand and

supply(661,662). At least one city, São Paulo, has experimented with a regulation that charges ride-hailing trips directly for using the road infrastructure based on distance, time of day, place (city centre) and other characteristics of the trip—number of people riding, whether a female is driving or type of vehicle(663). Despite its potential to regulate road use efficiently, this regulation has been challenged in court and is currently suspended. It is likely the case will reach the Supreme Court(663).

Graham-Rowe et al. review 77 independent studies on the impact of TDM measures in HICs (mostly US cities) and find that evidence on the impact of car-reduction is much weaker than expected, thus more research is needed in this area(664). The evidence from LICs is weaker still, as there are few peer-reviewed empirical studies. Lowering speed limits as a tool to increase road safety has been widely studied, but the impact of lowering legal speeds with TDM purposes has received much less attention. (This measure is not usually implemented with this objective.) Yet lowering speed limits (or encouraging eco-driving) has been identified as a way to decrease fuel consumption(665).

Peer-reviewed literature shows that fuel prices influence HVT mode share. Creutzig points out that when fuel prices are high, public transit is more financially viable and thus more attractive to those who would otherwise use private motorised modes if fuel were inexpensive(666). Thus, fiscal measures, like increasing fuel taxes and eliminating fuel subsidies, are also tools to make drivers internalise the social costs of car travel and encourage the use of HVT. They are the second-best option to per-mile road charges(667). In LICs and MICS, however, fuel subsidies remain common. A review of the impact of fuel subsidies on household welfare in LICs and MICs—including African and Asian countries—found that they are inefficient, inequitable and fiscally costly, but that countries have struggled to move towards liberalised pricing due to institutional constraints such as national governments not allowing the authority to set prices(668). Fuel subsidies have contributed to the rapid rise in motorisation rates in LICs and MICs, which coupled with decreasing car prices have diminished the cost of owning a private car(667). A study of Malaysia found that the removal of fuel subsidies (due to a government budget crisis) led to drivers shifting to public transportation, suggesting that fuel taxes could be a useful tool to decrease excessive car travel in LICs(669). This measure, however, could generate resistance from drivers, which could make them politically infeasible. For example, a survey of drivers in Teheran found that fuel taxes are the least preferred TDM method(670).

Charges at the moment of purchase and registration limits are used to reduce the number of private vehicles on the road(671). Cities in Asia, like Singapore, have turned to higher vehicle registration fees and import taxes to manage car ownership and generate revenue, but these fees do not limit car use directly(94). In LICs and MICs like India, governments have intentionally favoured car-ownership, setting inexpensive registration fees, import duties, and licensing, increasing the affordability of car travel as a measure to maintain rapid economic growth(672). The situation is similar in Latin America(667). Despite following this model for decades, China is implementing aggressive measures to curb car use in its main cities(671). Beijing and Shanghai have implemented quotas on the number of vehicles that can be registered per year—Shanghai through an auction system where drivers bid to acquire a registration license and Beijing through a lottery system(673).

As motorisation increases along with the population in LIC and MIC cities, TDM measures can help regulate traffic congestion and generate revenue, which can fund HVT alternatives. But fees, bans, or caps (push mechanisms) placed on private vehicles without adequate HVT options to supplement travel may be rejected by constituents or it could lead to additional travel, as was seen with some license plate plans. Similarly, incentives will not attract the additional HVT ridership necessary if the options cannot satisfy commuters who can afford other options. In addition to quality HVT alternatives to private cars, such solutions imply a strong institutional framework to generate and enforce TDM regulations. But rapidly motorising LIC and MIC

cities can integrate TDM measures and leverage technological advances in a way that developed cities with an already-highly motorised environment cannot do as easily.

5.3.2.3.a. Curb Management

Academic and grey literature has covered the allocation of street curb space between competing uses. Curb space is a critical enabler of HVT since it is a place of conflict. The dominant topics are the management of on-street car parking, access for taxis and public transport, and urban freight. (We discuss off-street parking in detail in the **Avoid: Off-Street Parking** section). Research has increasingly pushed to integrate curb management into greater planning schemes and no longer view it as an isolated issue. Inefficient curb management can have grave repercussions on traffic and congestion, which can impede buses, make cycling and walking more dangerous, and stifle the economy by slowing down the workforce and freight deliveries. Curbside space can also be restructured to prioritise HVT passenger modes and freight delivery over private vehicles, generating revenue and promoting modal shifts. Thus, many case studies and modelling analysis have been carried out to determine the optimal design, allocation, and pricing of curb space(674–677). More recently, with the growth of transport network companies (TNCs) and the expectation of autonomous vehicles, new design and pricing practices focused on pick up and drop off (rather than parking) are being considered and researched(361,659).

On-street parking has been an important issue for cities. As motorisation advances it has become the focus of curb management. (See **Off-Street Parking**.) The academic literature on street parking has focused on quantifying the supply and demand for parking spaces and determining the optimum pricing and allocation of space to minimise social costs, such as congestion and time spent searching for a parking space(677). Academic literature covering on-street parking in LICs and MICs is growing. Das and Ahmed develop parking demand models for Kolkata in what they consider a pioneering study for the MIC context of India(678). They find that the demand for on-street parking exceeds supply, leading to traffic, noise, and pollution. They also propose parking management measures and transit improvements as solutions. Pricing is the main tool to balance supply and demand. Drivers consider the availability and cost of on-street and off-street parking when making travel decisions, so both should be managed, priced, and coordinated efficiently in a parking pricing-based TDM strategy(303). City governments frequently do not charge market rates for curb parking, so drivers will cruise to find a curb space instead of paying for off-street parking. This congests traffic, wastes fuel, increases air pollution, and causes traffic crashes(679). Based on Shoup's research, he recommends using pricing to achieve an 85% occupancy rate for on-street parking. (See **Regulation of Land Use and Built Form** for an in-depth discussion on off-street parking measures designed to offset car travel.)

In a rare analysis for an African city, Hamilton and Madiro call for an increase in parking spaces in the centre of Bulawayo, in the LIC of Zimbabwe. This is in contrast to the trend in literature from other world regions(680). Recent non-academic literature on HICs and LICs consistently proposes optimal practices in the management of on-street parking to create more livable urban streets and reduce car use. Tools include marking prohibited areas; designating spaces, associated facilities, and signs; limiting access to certain groups or modes; setting time limits; charging fees; and enforcement and monitoring(643).

Advanced solutions like dynamic performance-based pricing models have also been developed, mostly in HICs(677). A key example is SFPark in San Francisco, which provides drivers real-time information on pricing and availability of on-street and off-street parking, and has a demand-responsive pricing mechanism. It is linked to an increase in transit ridership and a decrease in congestion(681).

Another approach to regulating on-street parking is to designate parking for higher occupancy vehicles, like shared services such as van-pools or car sharing. Campuses (e.g., Cornell University) have designated carpooling and car-sharing parking spaces near major transport hubs in municipalities like Los Angeles to aid

the first and last-mile gap(682). Pilot solutions have been recorded in HIC cities like Los Angeles where carpooling and vanpooling parking spaces are used near campus transport hubs for last mile solutions(682).

In many cities in lower-income countries, parking management, specifically the use of parking meters, is not a widespread practice. Instead, street parking is managed through informal arrangements—often through parking mafias that charge for its use(667). Cities like Mexico City have experimented with defined zones with parking charges, but as of 2018 the programme had struggled to expand and remained limited(679). In South Asia, large cities like Mumbai have yet to incorporate parking fees as a measure to curb congestion and generate revenue(43).

More literature is evaluating the curb in terms of access by mobility services and not as a static zone for parking. Some cases, perhaps the situation in LICs, already have this 'multimodal curb' as the baseline, although it may be unmanaged, congested, and potentially unsafe. As mentioned above, the rise of TNCs and ongoing development of autonomous vehicles has created a new strand of literature concerning curb management, at the moment heavily focused on US cities. Xu et al. developed—in what they claim to be the first study to consider on-street parking and TNCs—a dynamic model to determine the optimal provision of street space to TNC passenger pickup and drop-off. Recommendations to integrate these trends successfully include turning on-street parking into 'flex-zones'—multipurpose curbside spaces—where many uses, such as the pick-up and drop-off of people and goods from TNCs, can be managed dynamically and also respond to changing circumstances(361,676).

A joint report from OECD and the International Transport Forum argues that there is enough competition for curb space that cities should not keep devoting most of it to private motor vehicle parking when this space could be freed up for pick-up and drop-off zones for passengers and freight(361). Some core recommendations proposed in the report include the establishment of street designations for new mobility services and the adaptation of street design standards for multimodal use. A study from Prague found that pick-up and drop-off trips generated by on-demand services constitute one-third of the share of total congestion, so a strategic location for idling vehicles and areas for pick-ups and drop-offs is necessary(683). Transport planners need to shift from treating these service spaces for drop-off and pickup as 'extra features' and integrate them into the planning and design process of new infrastructure(684). Karim points to the challenge added by the multiplication and fragmentation of mobility services operation and in allocating scarce public space, street space, curb access, and parking for these new modes(684).

Street design manuals and curb management recommendations are being developed by organisations like the National Association of City Transportation Officials (NACTO) to integrate autonomous vehicles and guarantee that the streets remain centred on sustainable urban transport(404). According to NACTO, cities should prepare for a parking-free future and consider several measures, such as proactively reallocating on-street parking for other uses or creating a digitally enabled dynamic management system to optimise curbside access(404). To date, we are unaware of where these have been tried or where a managed multimodal curb approach has been implemented.

Finally, the design and regulation of delivery zones are critical to the management of curb space and the prevention of traffic congestion. The literature has neglected freight parking in relation to passenger car parking even though the distribution of goods in cities is vital to local economies. However, interest is growing, and a rich range of tools is being applied to study the impact of freight parking measures(685). Urban freight parking studies have identified three major problems in the optimal distribution of goods: lack of off-street and on-street parking, illegal use of loading zones and disobeying time restrictions(675). Portland, Oregon's Performance Based Parking Management Manual suggests that truck loading areas be designated as "combination zones" to allow for different uses outside of defined delivery times. This ensures the efficient use of these spaces(686). Malik et al. analyse freight parking practices in two different contexts:

Gothenburg, Sweden and Delhi, India(675). They find that freight parking models are usually more complex than car parking models and require data that is harder to gather and validate. They also find that the feasibility of parking management techniques is highly context dependent. In the Ahmedabad (MIC), the issues related to freight management are a conflicting land-use mix, time and access restrictions for heavy goods, and a severe lack of parking space around heavy freight trip generation areas(68).

Curb management is a critical enabler of HVT and could be a way to help fund HVT through pricing. In many lower-income countries, the curb is poorly managed, managed by the informal sector or not managed at all. This means, however, that the curb space in many cities in LICs is inherently multimodal and should be studied to understand how to create more formal, self-regulating spaces for a multimodal curb. Conflict with freight and transit services dropping off passengers with parked vehicles is endemic, creating congestion and chaos at the curb. Literature suggests that curb management is necessary and achievable through pricing curb use and designating areas for motor vehicle parking, deliveries, transit, passenger drop-off/pick-up, and shared mobility service parking. Understanding curb management in cities where enforcement is low and informality is high is still needed, as well as access for freight, both last mile issues and parking. While the solutions discussed in this section may contribute to reducing the use of personal vehicles, it is unclear whether they reduce total vehicles kilometres travelled.

5.3.2.4. Urban Freight Services and Regulations

Urban freight is often overlooked in discussions about urban transportation. Yet a simple search of the phrase 'urban freight' in Google Scholar results in some 3,500 papers for the past five years alone. One main cross-cutting issue is sustainability, a term closely aligned with our definition of HVT. Urban freight is important to sustainability since it represents between 20% and 30% of vehicle kilometres in the urban area(42). This number is steadily growing. Overall freight movement are projected to grow by 70% from 2015 to 2030(27), although it is unclear how concentrated this will be in urban areas. This section discusses the relationship of urban freight as it relates to transportation infrastructure and services, with a specific focus on freight route planning, on-demand freight, intermediate and informal freight modes (such as headloading), and "last-mile" solutions as the most important issue for HVT systems in LICs and MICs. We did not specifically examine efforts to shift freight movement to trams and urban waterways. Land use implications of urban freight are discussed in the **Land Use and Urban Freight** section, and recent technological innovation in freight integration are discussed in the **Urban Freight Systems** section.

Behrends et al. conducted a literature review to define sustainable urban freight transport as a system that fulfils four objectives: 1) to ensure the accessibility offered by the transport system to all categories of freight transport; 2) to reduce air pollution, greenhouse gas emissions, waste and noise to levels with no negative impact on the health of residents or the environment; 3) to improve the resource and energy efficiency and cost-effectiveness of the transportation of goods, taking into account external costs; and 4) to contribute to the enhancement of the attractiveness and quality of the urban environment by reducing the number of traffic crashes and minimising the use of land without compromising the mobility of citizens(687).

Papers on urban freight often try to tackle the challenge of reducing its environmental impact while keeping or even increasing company profitability. A wide range of papers discuss this issue through the improvement of route efficiency and supply chain management, the use of electric vehicles or non-motorised last-mile modes, the use of information and communication technology, or the analysis of the impact of urban freight on sustainability itself(688–694).

Home delivery or door-to-door services are also a significant trend. A review of home delivery and its impact on urban freight transport by Johan Visser et al. in 2014 became one of the most cited urban freight research papers finding that increased home delivery may lead to greater overall vehicle travel but less car travel by consumers(695). Other areas of urban freight studied include freight modelling, rail and port-inter-modality,

freight transport in urban planning, and freight vehicle type. Extending existing transport and urban planning models with data from freight transport may help meet HVT goals in Gdynia, Poland(696).

Urban freight sits at the intersection between business activities and regulatory restrictions. Leonardi et al. present 15 effective measures for freight transport in Europe and their benefits in meeting the ever-growing requirements of city officials(688). The 15 innovative cases analysed in the study comprise six cases on consolidation centres and electric vehicles; three cases on information technology applications, fleet and loading management; and six cases on topics such as laboratory area, efficiency of retail deliveries, public–private cooperation, multi-use lanes and use of waterways.

Freight route planning includes identifying primary corridors within the municipal jurisdiction (Ontario Provincial Government, 2016) that can be achieved with comprehensive mobility plans that specify route restrictions and regional throughput(697). The Seattle Department of Transportation identified supply chains, system conditions and capacity issues of the complex freight system of the Seattle-Tacoma region. Additionally, the city's Freight Master Plan features classification of freight routes: limited access, major, minor, and last mile(465). DFID points to an array of examples of space allocation and adaptation that accommodate vehicle movement and the loading of goods. For example, some bus lanes in London and Paris permit use by delivery vehicles(472). According to our research, the only documentation of urban freight routing schemes was from HICs, and we found no assessment of their impact. Thus, this is a key gap in the literature.

Schemes aiming to limit freight movement during the most congested hours have improved efficiency in street space use and emissions while adding constraints on land uses and activities, particularly on storefront commercial operations. The literature highlights clear economic, productivity and pollution-reducing benefits. Holguín-Veras points out that freight road pricing and financial incentives to receivers can make implementing these measures more effective(698,699).

HICs dominate case study research, especially in Europe where regulations are well-enforced and freight operators can provide the data for analysis. Few peer-reviewed studies are available on urban freight in LICs, especially in Africa. Existing studies usually focus on the analysis of urban freight characteristics in a specific region. Ojekunle and Oluwole provided a geographical analysis of freight distribution and traffic flow patterns in south-western Nigeria(700). The study also revealed that rural freight transportation in the area is still bedevilled with challenges such as extortions by security agents, poor road condition and insecurity.

Headloading is a common freight practice for several goods (water, fuel, groceries, agricultural produce to and from markets) in urban and rural Africa, due to the lack of basic services, electricity, and affordable and efficient motorised transport modes. It also is most prominent among women and children as load-carrying is a domestic and feminine task(701). Peer-reviewed literature has recently explored the health and social effects of this transport activity. In an extensive review of literature on the health impact of pedestrian head-loading in sub-Saharan Africa, Porter et al. evidence that this transport pattern has a profound biomechanical maternal health and psychosocial impact on women and children(702). Multiple studies in African countries showed that load-carrying affects punctuality and concentration in school and causes pain and long-term injury(703,704). In a 2006 working paper, the World Bank identifies load-carrying as a key factor in the worsening of asymmetrical patterns of time use between men and women, and inequity. Similarly, Porter et al. argue that pedestrian load-carrying in Africa opens key policy challenges, such as adequate legislation to end children portage in commercial load-carrying, and improving the supply of services and the development of intermediate means of transport (IMT) such as wheelbarrows and carts for domestic load-carrying(702). Developing IMT may be a crucial measure to improve equity in Africa, as these transport means are traditionally left to men for commercial—and therefore paid—activities, as opposed to women(702,703). However, grey literature has few concrete policy recommendations. It is also worth noting that peer-

reviewed literature evidences the “feminisation of informal labour” phenomenon in sub-Saharan Africa, stressing that, contrary to neo-liberal claims of the importance of empowering women through the opening of informal market opportunities, women usually diversify into trade and informal labour as a survival strategy(705–707). However, no freight and transport solutions are linked to the alleviation of women’s poverty.

To align with the other sections of this study, we gave special attention to last-mile freight, with an emphasis on the use of non-motorised modes. Schliwa et al. investigate the potential of cargo cycles and more sustainable urban logistic systems(708). The paper raised the importance of local authorities in creating conditions that incentivise large logistics companies to integrate cargo cycles into their supply chain. This is in line with the research by Leonardi et al., who evaluate the success of a trial of a sustainable freight system called Bentobox, which uses a new locker bank for storing parcels and electrically assisted bicycles for final delivery(688). The experiment took place in a small residential and mixed-use business and retail area in a central borough of Berlin, a HIC city. Public and private support, and the flexibility of the distribution system in that area, were the main success factors for the experiment. Mahadevia and Ravi address cycle rickshaws and their potential to fill transportation demands in India(562,709). The study highlighted the benefits of cycle rickshaws, such as reducing pollution, eliminating fuel consumption, promoting low-cost travel, increasing the efficiency of the road space occupancy, and having the potential to increase employment and promote small-scale industries. In East, South and Southeast Asia, three-wheeled non-motorised vehicles have been a mainstay of goods and people transport for several decades. In Beijing, recycling is by far the most lucrative of the four utilitarian tricycle activities(710).

It is essential to include freight in the conversation about modal shifts, considering its sizeable share of transport trips made in cities. However, it is also necessary to understand what freight means in different contexts. While in HICs it may mean cargo on trains and fleets of trucks, in LICs it may also mean locally specific freight transport methods, like headloading. We should pay attention to these particularities and how they may create unique problems. Last-mile freight can innovative storage may not just improve business efficiency, but also have monumental transit-related impacts on commuting times and the environment.

5.3.3. State of Knowledge Conclusions

We assessed the state of knowledge of the **Shift** section in four areas: infrastructure, modes and services, travel demand management, and freight. (Key findings are summarised in **Table 16**.) Urban form, income, and the existence of HVT measures are the key drivers that explain urban mobility patterns. From this review, the foundation for HVT seems to be strong networks for walking, cycling, high capacity transit, and informal transit. In many LICs and MICs, this baseline is missing. High-quality infrastructure and services are next in importance, requiring strong institutions to enforce and manage. These can be supported by TDM measures to reduce car use. Motorcycles management is still an open question, as is how best to regulate and manage freight in LICs and MICs.

Key Findings Summary
Infrastructure
- Investment in HVT infrastructure corresponds to higher HVT mode share; - BRT may be able to scale more quickly and is a more cost-effective option than rail, but rail has higher operational speeds; - Investment in public transit generally induces greater economic activity than the initial investment, leading to increased transit use, higher densities, and higher land values; - Dedicated right-of-ways and network design are critical for higher HVT use; - Urban highway expansion leads to congestion and sprawl. Many HICs are removing highways, yet LICs and MICs are adding highways as a congestion mitigation measure.
Modes and Services
- Walking mode shares are high in many LICs and MICs, but walking and cycling conditions in these places are poor. Adequate infrastructure is needed to support walking and cycling; - Speed is the biggest factor in fatalities and injuries. A safe system approach, such as Vision Zero, allows for human error and has shown good results. This approach is spreading; - Public transport use is affected by network design and quality of service (reliability, frequency, safety, and comfort); in many LICs and MICs, affordability is the primary factor; - Subsidies are needed and warranted for public transport, even in LICs and MICs, but it is unclear how to apply them most effectively; - Informal transit is vital in LICs and MICs, but it suffer from poor safety, poor service, environmental issues, and equity issues; - Informal transit is a reflection of weak institutions and regulations; transforming this will require capacity building with both the public sector and the operators; - Women face personal security issues and potential violence when using transit or public space that may restrict their mobility or have them choose different options; - Motorcycle growth is high in LICs and MICs with many negative externalities. This partly due to inadequate public transit networks.
Travel Demand Management
- Congestion pricing reduces congestion and emissions while increasing revenue in HICs, but it is unclear how to apply it in MICs and LICs; license plate schemes, although easier to implement in LICs and MICs, have increased congestion over the long term; - HVT measures need to be in place for TDM measures to be successful; - Curb access management for parking, transit, taxis, and freight is critical to reducing congestion and increasing safety; Many LICs and MICs do not formally manage curb access; - Pricing is the main tool for managing on-street parking with the recommended target of 85% occupancy.
Urban Freight Services and Regulations
- Freight volumes are increasing, especially with the advent of on-demand freight services; - Last mile freight movement could be better served with intermediate modes, such as cargo bicycles; this happens informally in LICs and MICs and increasingly (and formally) in HICs; - Headloading as a form of freight movement is prevalent, yet problematic in LICs and MICs.

Table 16: Key findings from the Shift section

The state of knowledge on **infrastructure** looked at the different types of HVT infrastructure. Growth in high-capacity infrastructure is happening, but the factors that create long-term success need more research. Rail

network optimisation is being discussed worldwide, with a tendency to spur a 'BRT vs rail' debate in LICs and MICs. BRT may be able to scale more quickly and is now considered a cost effective option that brings many of the same benefits as rail. Rail has higher speeds. For both rail and bus-based public transport, network design is a key influencer of system use. Researchers find that dedicated right-of-ways (such as bus-only lanes, cycle lanes, high-occupancy lanes, rail corridors, and shared streets) lead to an increase in HVT. Urban roadway expansion has been directly linked to worse vehicle traffic and travel conditions for all road users. While some roadway expansion may be required to create connected roadway networks, in LICs and MICs, road expansion often accounts for the overwhelming amount of spending on transport, often in the form of flyovers and limited-access roads. At the same time, many HIC cities (mainly in the US and Europe) are removing expressways, with minimal negative effects. We need to better understand why many LIC and MIC cities continue to pursue roadway expansion policies not supported by research.

The literature on 'Shift' widely documents **modes and services,** and the conditions that incentivise HVT. The literature on walking and cycling is abundant, with these modes being growingly studied for their utilitarian purposes, in cities of all incomes aiming at respectively increasing and maintaining these modal shares. In LIC and MIC contexts, adequate infrastructure is the first need, with road safety receiving growing attention, especially where the burden of road traffic injuries and fatalities is heaviest, particularly for vulnerable road users. For road safety, two key avenues are being explored: designing safe systems that account for human error and slowing down vehicles, as speed is the biggest factor in fatalities. (More research is needed on how to achieve this in cities with weak enforcement.)

Structured public transport services are extensively analysed, with a different emphasis depending on the world region, in terms of planning, travel demand, technology, and the impact they generate. The drivers for user choice are the network design and the quality of the service. In LIC and MIC cities, similar attention has been given to informal transport—while stressing equity concerns. For both, affordability is key to understanding user behavior, with a need to figure out how to best target subsidies so that they reach the intended beneficiaries. Research has shown that informal transit services meet critical transport needs, but they often suffer from poor safety, low-quality of service, environmental issues, and equity issues, especially around gender. We need to better understand how to reform or restructure the existing informal industry, reduce externalities of the informal sector, and create new institutions (public) and business (private) to better support HVT.

There is a wealth of literature on **travel demand management**, mostly in HIC cities where its strategies have been long implemented and where strong public transit networks exist. Some TDM measures actually increased congestion, so understanding the most effective levers (i.e., fuel taxes) in relationship to politically viability (license plate schemes) and their impact will be important for making recommendations for LIC and MIC cities, where more research is needed. Curb management is also widely documented, with on-street parking—mainly of passenger cars—dominating the discussion, although TNCs and freight are now receiving more attention in HICs. The changing role of the curb and the success factors of moving from unregulated curbs to regulated curbs needs more analysis, especially in LIC and MIC contexts.

Finally, 'Shift' has been studied through the lens of **freight**, with a focus on understanding the changes in patterns of consumption and their impact on modal share. Freight, whose volume is increasing, is widely covered in the literature, mainly in HICs, and with a focus on how to reduce its environmental impact while keeping the sector profitable. Last-mile freight and sustainable urban logistics systems could also be found in the literature. More research on freight in LIC and MIC cities is needed, especially in the context of informality, gender, and access to markets, and the feminisation of the informal labour.

5.3.4. Key Research Gaps and Opportunities

The following section describes key gaps in the research on transportation infrastructure, services, and supporting measures, based on the literature reviewed. Of the 294 sources we reviewed for this chapter, 240 were directly relevant to the research. Of those, only 10 (4%) examined the LIC context, and only 28 (12%) and 35 (15%) of papers examined South Asia and sub-Saharan Africa, respectively. The literature appears to covers the range of topics in this section, with the notable exception of urban freight services and regulations. Research on TDM measures is limited in sub-Saharan Africa and South Asia, a research gap that should be filled. (**Table 17** shows the research relevant to the paper.) The numbers do not sum to 240, as some papers covered multiple regions or did not cover a specific country or region at all. Within the context of this chapter, we think there should be more research focused on LICs and more research on freight services and regulations.

	STUDIES PER ECONOMIC REGION (WORLD BANK DEFINITIONS)			STUDIES PER GEOGRAPHIC REGION (WORLD BANK REGION DEFINITIONS)						
REPORT SUBSECTION	HIC	MIC	LIC	EAST ASIA & PACIC	EUROPE & CENTRAL ASIA	LATIN AMERICA & CARIBBEAN	MIDDLE EAST & NORTH AFRICA	NORTH AMERICA	SOUTH ASIA	SUB-SAHARAN AFRICA
Infrastructure	26	36	4	22	8	17	0	12	12	10
Modes and Services	75	28	3	27	33	9	3	41	12	17
Travel Demand Management	39	11	1	7	13	5	0	25	4	3
Urban Freight Services and Regulations	1	6	2	1	1	1	0	0	0	5

Table 17. Summary of research relevant to this paper

We also mapped the locations of the sources we found in this section, to provide a geographic overview (see **Figure 23** below). In addition to a concentration of sources in the most populous countries (China, United States, India, and Brazil), we found sources in multiple LICs in Africa, and most countries in South America.

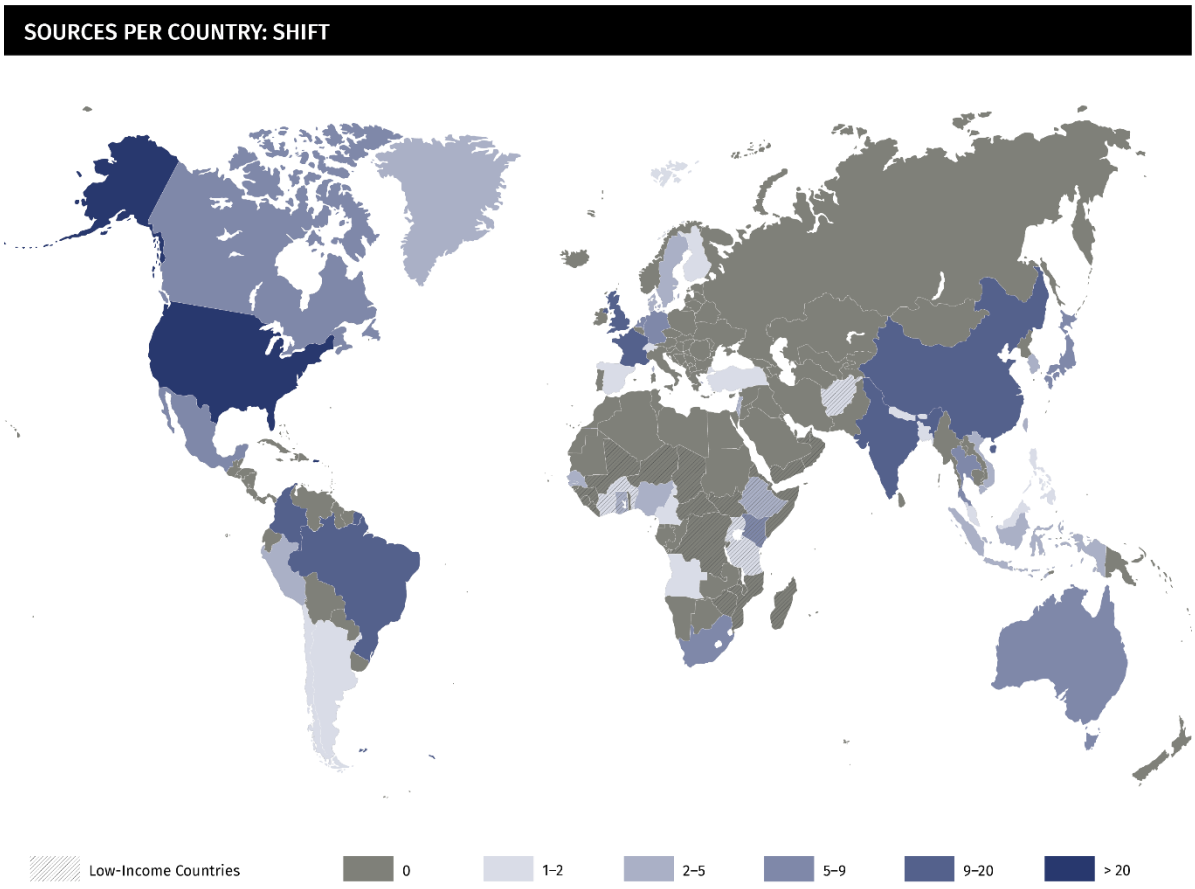


Figure 23. Distribution of Shift sources. Source: Created by the authors

A key issue gap in understanding is how to introduce new infrastructure and services in weaker institutional environments and how to transition to stronger systems, institutions, and operators, while embracing and elevating the good of the informal services and inherent multimodalism. (We present a summary of the key gaps in **Table 18** below.)

Key Gaps Summary
Infrastructure
- What are the factors that make successful high capacity transit systems over time and in different regions that address both planning and post-implementation issues? - What are effective measures for reducing congestion in LICs and MICs? - Why are cities still pursuing urban highways as a solution for congestion when the research does not support it? - How can we introduce new HVT infrastructure in LICs and MICs in a way that respects local context and ensures long-term success? - How does the street network structure influence the form of transport that dominates, especially in informal areas?
Modes and Services
- How has HVT (mode shares, trip lengths, trip purposes, vehicle kilometres travelled, etc.) changed over time? - How do different groups make travel decisions in LICs and MICs? - How do fare structure, media, and policy affect HVT modes in LICs and MICs? How can we target subsidies most effectively to reach intended beneficiaries? - What is the role of various informal and semi-formal services (including two- and three- wheelers) in HVT systems in LICs and MICs? - How can the informal transit service be improved within the regulatory and financial model constraints of those systems? How can they be transformed to provide structured public services, like BRT? - How can we create new institutions to manage public transit in LICs and MICs? How can we transform weak institutions into strong ones?
Travel Demand Management
- What are effective TDM measures in LICs and MICs? - How can we move from unregulated multimodal curb space to more regulated multimodal curb management in MICs and LICs?
Urban Freight
- How can we improve freight provision in LICs and MICs? How can route planning and last mile issues be addressed? - How are intermediate and non-motorised modes for freight delivery currently being used in LICs and MICs and how can they be used better for freight delivery? - With the feminisation of informal labour, how do gender dynamics affect the informal freight system and how are women moving goods? - What are effective strategies for curb management for freight?

Table 18: Key gaps in research from the Shift section

5.3.4.1. Infrastructure

Infrastructure in Low- and Middle-Income Countries

Unsurprisingly, there are large gaps in the availability of evidence from LICs and MICs in several of the topics reviewed. A key question is what are the success factors for different types of high-capacity infrastructure? Also, as rail and BRT systems are being built in the Global South, how can that infrastructure achieve HVT and ensure the right impact? Guidance on street network densities and coverage and how to increase that ratio would be good to understand as well. Similarly, while extensive research on the negative effects of private

motorised modes and on the removal of urban expressways in HIC cities, there is sparse equivalent research in rapidly motorising LICs, where this kind of infrastructure is being constructed. A large opportunity to study these gaps in LIC and MIC cities comes from increasingly available open-source and mobile data collected through smartphones.

Non-Dominant Infrastructure

Impact studies of various transport infrastructure are mostly concentrated in places where infrastructure is widespread. For example, studies on private vehicle travel and the impact of associated measures such as investments in highways are extensive in the US; rail-based systems have been more widely studied in Europe and more recently in large East Asian cities where these systems are expanding rapidly. Similarly, studies related to BRT systems mostly assess Latin American and Asian cities and explore the success factors of these systems, including the financing tools adequate to the regions' specificities such as LVC and TOD. A number of gaps exist in the study of infrastructure systems in places where they are emerging or less dominant. What needs to be in place to build new infrastructure where it has not been implemented before or implemented well (i.e., sidewalks)?

Advancing sustainable mobility in African and South Asian cities will require a proactive identification and analysis of measures that are being implemented, since adopting measures based on the experience of places where political, social and economic conditions are widely different can be ineffective. In this sense, there are high value research opportunities in the growing number of BRT and rail systems implemented in African cities like Dar es Salaam, Addis, Accra, and Marrakech (Morocco); the impact of the rapid rise in investment in car infrastructure in these regions; how to increase and maintain cycle and walking networks, and the adequate financial tools and processes needed to reach financial stability.

Transit Services in Informal Areas

We found little research assessing the challenges posed to transit services by the street networks in many peripheral and less formal parts of cities. These networks may be poorly connected, with streets that are unpaved, poorly maintained, frequently occupied by street vendors or too narrow to accommodate many transit vehicles.

5.3.4.2. Modes and Services

Walking and Cycling in Rural-Urban Transitions

Many quantitative reports of walking and cycling are not updated regularly; therefore, data is not easily comparable owing to the long time gaps. An element that remains understudied is the relationship between urban form and travel preferences throughout the process of rural-urban transition and the changes in the modal share because of migration flows. Also, owing to cycling's complexity and heterogeneity across diverse regions, there is no clear vision about how it integrates into LIC and MIC design, urban planning or policy.

Road Safety Measures in LICs

Regarding road safety in HICs, there is a range of research proving the effectiveness of speed management measures, such as speed cameras, and an increasing number of publications on integrated and locally implemented policies, such as Vision Zero. Yet, there is little research on solutions to control speed in LIC cities, especially the role of traffic calming. There is also limited research on complementary law enforcement, education, and road safety management, especially in cities with weak enforcement, to reduce the burden of road traffic injuries, which are heaviest in Asia and Africa.

Data and Technology for Intervention Monitoring and Mapping

Unfortunately, insufficient data are available to monitor the effect of many HVT interventions. Often, data such as vehicles ownership—both motorised and non-motorised—modal share, purposes of trips, average trip length, and vehicle kilometres travelled is lacking in studies and reports in LICs and MICs. This is

especially acute for walking and cycling. Little literature was found supporting the use of new technologies to map interventions and create a baseline to evaluate their progress.

Upgrading and Integrating Informal Transit Systems

Despite accounting for the overwhelming majority of public transport trips in many LICs and MICs, there is too little research on informal and semi-formal modes of public transportation, including services such as minibuses, motorcycle taxis, cycle rickshaws, autorickshaws, and jitneys. These paratransit systems are the lifeblood of many areas, offering an affordable service and the most viable mobility option for a great majority of the low- and middle-income population. However, there is an undeniable need to improve the access and the quality of service they provide. These informal services are often poorly understood, and the regulations appear to differ from one place to another, making improvements more challenging to develop.

In addition, it is an open question of how to improve the access and quality of service of informal transit. Current paratransit reforms often rely on a restructuring of the entire public transport system into a formal system. There are understudied opportunities to explore a transition to a hybrid system, a common approach in LICs and MICs. It is not clear that these types of incremental reform work or last. But it is also not clear that total restructuring to a formal system works or lasts. Understanding this transition better will be key. Is there a way to improve access and service quality of informal transit while transitioning to a structured system?

Also, there is a need to better understand the role of informal transit in a city with structured formal transport system—potentially serving different needs or acting as an integrated system. Informal transit systems offer an affordable service (in many cases are the most viable mobility option for most of the low- and middle-income population). It seems to be strategic to identify advantages or opportunities of the informal transit sector: (1) coverage in peripheral areas of cities commonly characterised by fast urban growth and a lack of public transport; (2) the provision of access to the urban poor, and (3) first and last mile connections. A more thorough assessment of these informal services could lead to a much more informed approach to maximising the benefits of existing services and institutions while minimising their downsides.

Enabling Structures for Modernising and Integrating Public Transport Systems

Modernising public transport services in MICs and LICs has proven to be extremely difficult. Both rails and BRTs, despite their initial success in rationalising dysfunctional transit operations, have had some failures in construction, operations, and maintenance, including low quality, deterioration of operations, overcrowding, and financial struggles. Although BRTs are faster and easier to implement than rail systems, not all the countries and cities are prepared to implement them. And for both, implementing new forms of transit service require new skills from the public sector. In addition, the physical, operational and fare integration of local or informal services with formal trunk corridors has also been challenging. The alternative comprehensive approach of integrating all the services (e.g., Santiago and Bogotá) has also been plagued by significant technical and financial problems that have severely affected the quality of services. Before implementing BRT or the comprehensive approach, it may be helpful to study the financial, institutional and organisational requirements a city needs to fulfil to integrate and modernise its public transport systems.

Managing and Regulating Motorised Two- and Three-Wheelers

The number of two and three wheelers is rapidly increasing in LICS and MICs, particularly in South Asia, Southeast Asia, and sub-Saharan Africa. However, apart from assessments of dedicated motorcycle lanes, we found little research about them. We specifically want to know how to regulate them, the impact they have on the walking and cycling environments, their relationship to public and high-volume transit, their role in the transportation ecosystem (as a shared mobility service versus private vehicle ownership), how they alter the experience of the city, access and gender issues, and how they may contribute to freight and the on-demand economy.

Incorporating On-Demand Shared Services into High-Volume Transport

The rapid growth of new on-demand services might decrease demand for public transport services, especially in some HICs where existing mass transit systems usually deal with low ridership. This situation could be highly critical for rail systems, whose infrastructure is not flexible or recyclable. In this sense, it is necessary to carry out further research on how these new services affect the modal share of the rest of the modes (especially the sustainable ones) and how to incorporate these services into a sustainable mobility policy.

Gender and Income In Middle- and Low-Income Countries

In the **Avoid** section, we discussed how poor transport and land use integration placed additional burdens on poor residents. In addition, specific constraints faced by women and lower-income populations in LICs and MICs in their daily mobility patterns are documented by peer-reviewed and grey literature. However, there is a lack of publications on the impact of income and gender on travel demand in low- and middle-income countries, especially in Africa and South Asia. This gap opens an opportunity to envision policy solutions for poverty alleviation and mobility improvement among women.

5.3.4.3. Travel Demand Management

Travel Demand Management User Behaviour Impact in Middle- and Low-Income Countries

TDM strategies and their impacts have been studied in European and Australasian cities and countries since they were first implemented. In LICs, the evidence on the impact of TDM measures to reduced motorised trips is still weak and opens several research opportunities. In LIC and MIC cities, there is growing research on the feasibility of their introduction, taking into account political scenarios and social factors. Even though much effort has been put on studying TDM strategies to retain public transit mode shares (the equivalent of the 'pull' strategies in HICs), there is a growing concern about how to discourage private motorised trips. There are still gaps in the research relative to user behaviour and how public authorities can best respond to it with TDM strategies that consider problem awareness methods, psycho-social variables, and social fairness.

Curb Management in LICs and MICs

Many LIC cities have, by default, multimodal curbs where freight, vending, transit, parking, walking and cycling intermingle. The challenge of moving to a regulated multimodal curb (first with parking and then to other modes and services) from an unregulated one needs more investigation. Also, the rise of on-demand services, both passenger and freight, raises the question of the role of and access to the curb more broadly.

5.3.4.4. Freight

Non-Motorised Freight

Anecdotally, non-motorised freight delivery accounts for a large portion of freight delivery in cities in lower-income countries. It includes deliveries by hand trucks, bicycles, tricycles, and other human-powered vehicles. These vehicles emit no pollution, employ many people in the transportation sector, and, except for headloading, seem to pose little safety risk to the public (unlike many other forms of freight delivery). Despite these positive effects, the sector is poorly researched and documented.

Curb Management for Freight Deliveries

Freight vehicles compete with passenger and public transport vehicles for space on crowded city streets; this situation is especially critical in LICs. TOD measures oriented to promote walking, cycling and the use of public transportation may make the delivery of goods more difficult in cities with limited street capacity and where parking is scarce. Dedicated bus and cycle lanes are good infrastructure solutions to promote sustainable mobility, but freight might be significant obstacles that hamper efficient urban supply chains. Peer-reviewed and grey literature seldom address street design and curb management to facilitate freight activities and promote sustainable urban transport. This gap is evident in MICs and LICs.

Urban Freight in Africa

The literature on urban freight in the African context is limited and highly focused on a few specific locations. The role of corruption in urban freight and what efforts have been successful in improving urban freight in the African context are two major gaps in understanding. Further, pedestrian load-carrying poses significant health risks and inequity to women and children, but there is little research on the viability and policy opportunities to apply intermediate means of transport in rural and urban Africa.

5.4. IMPROVE — Technology, Innovation and Integration

The **Improve** section characterises the state of knowledge related to user-focused, whole trip, and whole-system efficiency for urban HVT, with a focus on LICs. It is about moving people, moving freight and reducing travel demand through technology, innovation, and integration. We identified these areas based on their timeliness and relevance to the goals and directions of the overall project and the distinct (yet related) set of capacities they require. This approach to HVT moves beyond an energy- and fuel-based understanding of 'Improve', which focuses on improving vehicle efficiency(6). **Theme 3: Low Carbon Transport** will discuss the fuel and vehicle technology aspects of 'Improve'.

The team expanded the scope of 'Improve' in light of recent developments related to Mobility-as-a-Service (MaaS) and MaaS-like services and system innovations[10]. In this report, MaaS-like services and systems serve as the framework for working toward providing transportation as a whole system, seamlessly integrating the multiple elements and factors at play. MaaS-like is characterised as having multimodality, built around public transit and including some combination of bikeshare, carshare, and ridesourcing; broad expansion capacity; informal transport; goods movement; moving less; automation, etc. In addition, MaaS-like is characterised by integration (preferably seamless), technology enhancement, service orientation, user focus, and public-private business models(711,712). (**Figure 24** displays these elements and highlights their potential for improved HVT.)

[10] Over the past few decades, MaaS-like iterations have emerged under a variety of names, including Mobility-as-a-Service, New Mobility hub networks, Transportation-as-a-Service, combined mobility, connected mobility, eco-mobility, 'egg-laying wool-milk sow' (Bremen, Germany), shared mobility, integrated mobility, mobility on demand, multimodal transport, new mobility services, smart city mobility, etc.

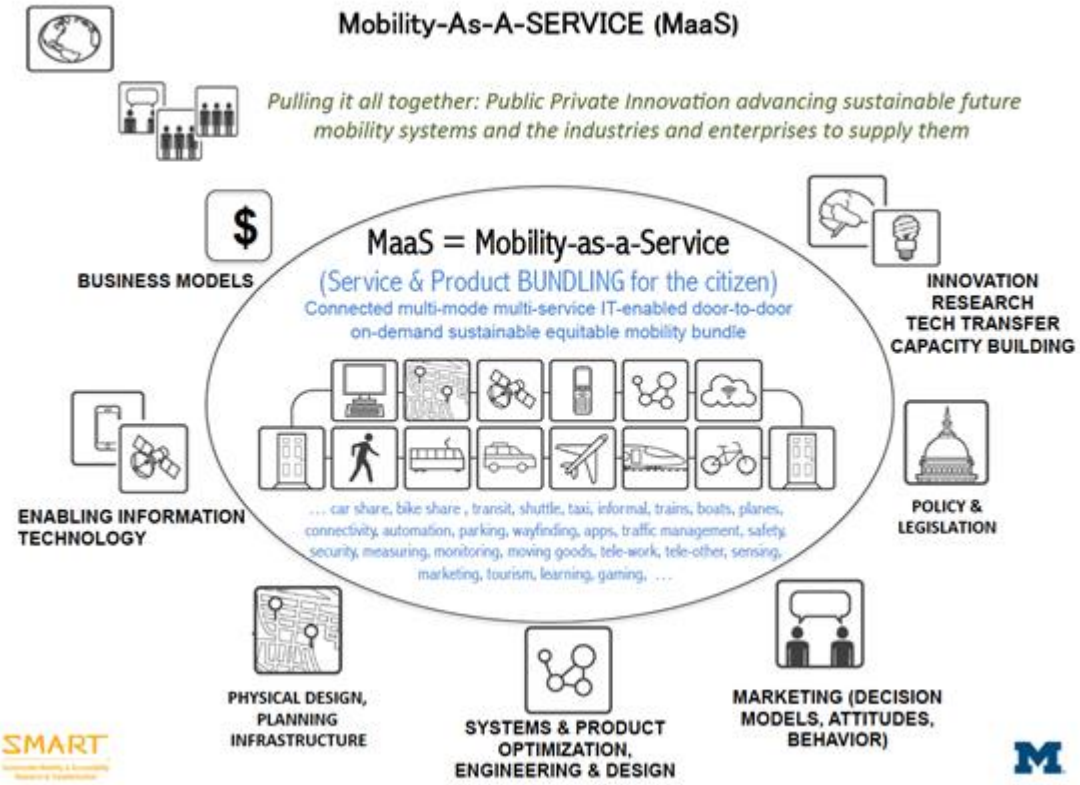


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Figure 24. MaaS framework (Zielinski, 2018)

We base work for this section on the combined experience of ITDP's project team and include:

- Exploration of the somewhat limited peer-reviewed MaaS-like literature relevant to HVT;[11]
- Scans of the fast-growing and diverse body of grey literature in the active global mobility space;[12]
- In-depth consultations and correspondence with global leaders in the field.[13]

The **Improve** section provides background on integrated, technology-enabled, user-focused mobility and MaaS-like approaches, and an in-depth state of knowledge of the key elements of 'Improve'. The section concludes with a summary of research gaps, and opportunities to inform future research and action of benefit to LICs.

[11] Search terms for this section include: Business Models, Combined Mobility, Connected Mobility, Connected Automated Mobility, Connected Transport, Integrated Mobility, Integrated Urban Mobility, Leapfrogging, Mobility-as-a-Service, Mobility Hub Networks, Mobility Innovation, Mobility On Demand, Multimodal mobility/transport, New Mobility Networks/Services/Systems, On Demand Transport, Policy Models, Reverse Innovation, Smart City Mobility, Smart Transportation/Mobility, Sustainable Transportation, Transportation-as-a-Service, VMT.

[12] See also, UM-SMART's "Un-bibliography" of literature and resources: http://mobi-platform.com/maas-resources

[13] We consulted with the following experts to identify literature sources and key concepts: Peter Adriaens (Center for Smart Infrastructure Finance, University of Michigan); Chris Ballinger (Mobi Open Blockchain Initiative);, Bruce Belzowski (Automotive Futures Group); Jeb Brugmann (100 Resilient Cities); Ceit Butler (George Brown College Blockchain Program); Adam Cohen (UC Berkeley); Benjamin de la Pena (Seattle Department of Transportation); Claire Enslin (Where Is My Transport); Efon Epanty (Fairfax County, VA); Danielle Guillen (Ateneo de Manila University); Bern Grush (Harmonize Mobility); Ralph Hall (Virginia Tech); Jackie Klopp (Columbia University); Holly Krambeck (the World Bank); Alan McKinnon (Kuehne Logistics University); Apiwat Ratanawaraha (Chulalongkorn University); Lauren Reid (Sidewalk Labs); Lake Sagaris (Pontificia Universidad Católica de Chile); Mimi Scheller (New Mobilities Research and Policy Center, Drexel University); and Kristin Schondorf Slanina (Thirdware Solution INC).

5.4.1. Context

Worldwide, transportation is adopting more technology- and data-enabled, seamlessly integrated, multimodal and on-demand mobility systems. Recent developments are helping a rapidly urbanising world access more nimble, technology-enabled, and profitable mobility markets. This creates an opportunity for HVT to become safer and more connected, sustainable, and equitable, albeit not yet predictable(713).

Within MaaS-like services, there are two meta-phenomena in play: (1) technology is outpacing policy, and (2) change (positive and negative) is occurring faster(713). More than ever, 'we don't know what we don't know', and it is becoming more difficult to pick winners and to predict (and prepare for) any specific future mobility path. The recent flurry of MaaS-like activity spans the globe, including work in LICs[14]. This activity often includes private sector participation or co-leadership, which can affect transparency, research and evaluation, accountability, and regulation.

The rapid pace of MaaS has shifted how many people conceive of transportation. It is moving from advancing transportation modes or services to meeting a multitude of user needs via a diversity of connected options. This shift is seen in government policies and declarations of user 'bills of rights', including the global MaaS Alliance passenger rights framework, the City of Toronto Pedestrian Charter, and the City of Seattle's New Mobility Playbook(714–716). In the private sector, Ford Motor Company and Volkswagen have rebranded themselves as mobility companies, offering a range of mobility-related services including carshare, bikeshare, and electric kick-scooters. Other carmakers and mobility-related manufacturers, such as Michelin, BMW, Toyota, and General Motors have followed suit, expanding their legacy products to embrace the potentials of mobility services and systems(717,718). MaaS-like narratives have also led to the following shifts:

- From disparate modes and services to connected multimodal systems;
- from tearing down, reinventing and rebuilding from scratch, to connecting and building on existing assets;
- From leaders facing disparate challenges to multi-sector leadership ecosystems developing holistic outcome-based solutions and systems;
- From "public costs" to public and private investments;
- From a centralised public infrastructure funding to a structure with innovative financing, optimised business models, and clustered mobility industry development opportunities;
- From traditional desk research to on the ground multi-sector research collaborations in real time(713,719).

Despite these shifts, the proactive, technology-enabled, integrated, multimodal MaaS approach has not become common practice.

5.4.2. State of Knowledge

The contexts above describe a vision of transportation that brings together all elements in the service of urban HVT with the user at the core. This **Improve** section describes the state of knowledge related to three pathways to accelerate HVT through technology, innovation, and integration. This will be done within the MaaS framework, looking at specific aspects of MaaS as they support HVT and the goals of access, equity, the environment, safety, and efficiency. These aspects include the technologies and platforms that support integrated systems; the new business, financial, and policy models needed to implement and regulate MaaS-

[14] See the MaaS Alliance; ITDP; ICLEI; ITS World Congress; World Economic Forum; OECD International Transport Forum; WRI Ross Center for Sustainable Cities; NACTO; New Cities Foundation; Next City.

like systems; and the networks of people and leaders that can support HVT in a rapidly changing environment:

1. Integrative Technologies, Data, and Platforms;
2. Innovative Business, Financial and Regulatory Approaches;
3. Leadership Ecosystems.

During this rapid evolution, when credible knowledge addressing whole-system mobility might become even more valuable, there may be a relative *decrease* in peer-reviewed academic research, not because of the rapid pace of change (although this is a significant factor), but because private sector movers can perceive academic research as too slow, too narrowly focused, and/or not sufficiently implementation- or commercial-oriented(713). In the following section, we keep this in mind as we look at grey literature and other sources to best understand this subject.

As mentioned above, MaaS-like services and systems work to provide transportation in an integrated, seamless, multimodal, technology-forward, user-focused, and service-oriented system. They draw on a range of public, private, hybrid business, and finance models. MaaS-like systems aim to facilitate access by combining multiple modes, schedules, and payment all in one platform.

Though MaaS has recently been in the spotlight, limited but diverse MaaS-like iterations have appeared in dialogues and on the ground for almost three decades. Examples include:

- Switzerland's early 'Mobility' system, which links carshare, trains, transit, and bikeshare, starting with carsharing as early as 1988(720);
- Bremen, Germany's 'Mobil Punkt' network of connection points, which links carshare, bikeshare and transit through integrated electronic wayfinding and fare payment, elegant physical design and signage, and entertaining marketing, later adding urban freight movement to the mix(721);
- Inspired by Bremen, Moving the Economy and the City of Toronto's small Mobility Hub Network pilot, helped plant the seeds for a regional multimodal network, multimodal fare card, integrated information systems, and a mobility innovation programme(722);
- In 2006, Ford Motor Company's partnered with the newly established SMART initiative at the University of Michigan to explore and advanced multimodal mobility markets in emerging economies and LICs(223,723,724).

Related to these on-the-ground examples, some systems-focused research also appeared. In 2002, the City of Toronto, with Canadian federal government funding, released a study assessing new industry, economic development and employment opportunities related to an emerging global New Mobility industry cluster. It is the first known global study on the topic(719). In 2006, another paper compared complex system approaches to New Mobility and the emerging New Mobility industry cluster. It called for a fundamental transformation of urban mobility systems consistent with a sustainable human future. These included harnessing emerging science, identifying 'tipping points' to guide the system evolution, developing integrated innovation and business models, providing diverse research opportunities; and growing a multidisciplinary global network(725).

Regarding equity, one goal of a MaaS-like system is to move towards a user-based transportation paradigm that focuses on providing access, not only to destinations but also to basic needs(726). This is in contrast to traditional infrastructure-based paradigms that focus on increasing mobility through the reduction of congestion, vehicle travel times, and vehicle miles traveled(711). Jittrapirom et al. suggest that the shift from ownership-based models to "access-based transportation" will help to make the system more equitable, and could expand access to historically underserved areas(711). However, MaaS could also contribute to

inequality, where premium packages or services—priority boarding, express service, etc.—are available to users who can afford to pay more(304). In addition, Pangbourne et al. question how quickly riders will be prioritised and charged if the transportation network were to reach capacity(727). Though these potential inequalities also occur in individual modes, we need more research on this topic.

Much of the relatively small body of academic peer-reviewed literature on integrated systems (specifically MaaS and MaaS-like) appears in Europe (Sweden, Finland, Austria, the Netherlands, Germany, and the UK)(713). Some emerging work also focuses on North America, South America, and the Philippines, and to a lesser degree on other emerging economies and LICs(711,728–732).

Overall, there is a dearth of research on how to design and implement MaaS in specific LIC contexts. Support for new mobility enterprises, particularly in emerging economies and in relation to the underserved, is also lacking. Efforts such as University of Michigan SMART's work (since 2007) with emerging economies and LIC cities to advance and implement technology-enabled integrated mobility systems, and the early creation of the Mobi Prize and platform, have contributed to the evolution of MaaS-like directions in those countries. (See the **Leadership Ecosystems** section below). However, car-based approaches to transportation planning and infrastructure along with siloed governance structures could challenge the capacities of LIC governments to implement integrated solutions effectively.

Another gap is a lack of research into any negative effects of MaaS. While a few researchers look at MaaS with a critical eye (most notably Pangbourne et al.), most frame it as an obvious and important direction for the transportation sector. While MaaS-like principles such as focusing on user needs and mode integration have widespread support among planners, the specific mechanisms of such systems are less clear. To date, amid the MaaS "buzz", the scant body of existing research focuses on the potential advantages than the potential challenges(711,727). In some cases, we treat negatives (such as the potential equity concerns highlighted earlier) as barriers to be overcome with little consideration of the overall value, potential, and challenge of MaaS across a range of settings. This could be due to newfound claims (not yet conclusive evidence) of the commercial and economic potential of MaaS-like efforts. The overarching goals of MaaS (integration, efficiency, sustainability, access to economic opportunity) are hard to contest, but their implementation and execution could present suboptimal outcomes depending on geography, policy, and other variables. We need more research in this area as MaaS expands.

Because MaaS-like services and components comprise many combinations of elements, it is important not only to assess the collective impact of the whole system but also the impact of individual components within the system. The sections below address current components of MaaS, with the assumption that MaaS as a system will continue to evolve and integrate new modes, services, and technologies as they become available. The impacts (positive and negative) of many of these components are noted below, particularly in the **Technology-Enabled Shared Mobility Services** sub-section.

5.4.2.1. Integrative Technologies, Data, and Platforms

We often refer to technology, big data, and platforms as 'the next transportation infrastructure,' in addition to the physical and energy infrastructures traditionally associated with transportation. Together, they have the capability to enhance individual components of the transport system and to better integrate the whole system. These developments warrant attention, investment, care and caution(733).

Technology and big data could have an important impact on transport in LICs, but there is a digital divide. While technologies like smartphones have become more accessible across LICs, supporting services like mobile data are still prohibitively expensive for many people. Personal computers and in-home internet access are also less common in LICs than in OECD countries. As such, mobile phones without internet access are still widely used. These devices do not allow users to access mobility services, like transport trip planners

or real-time schedules. Nor do they enable other services like online commerce or telemedicine, which could reduce the need for taking certain trips (see **Moving Less: Trip Reduction and Replacement**, below)(734). The literature has explored skill acquisition and the socioeconomic factors that influence technology adoption versus non-adoption (even when digital access is available)(735).

Efforts to address the 'digital divide' are important drivers of transportation's recent transformation worldwide. Erosion of the digital divide was initially evidenced by the widespread adoption of mobile phones in sub-Saharan Africa where mobile phones are used for more than simple communication, including safety and security, health, business and even economic development(736,737). With regard to mobility, mobile phones had an important impact on city planning and urban transportation in sub-Saharan African through the generation of big data. One example is Digital Matatus, an initiative in Nairobi that mapped the city's informal transport system using the geo-locative capabilities of mobile technology. This data was then converted to the standard General Transit Feed Specification (GTFS) format to make it available for use by third-party trip planning apps like Google Maps(294). This work facilitated the world's first known data-based map of an informal transportation network, creating better access for users. The Digital Matatus project used a bottom-up approach, enabling urban citizens to play a role in the planning of transport services(738).

Private-sector platforms and data collection efforts have also helped bridge the digital divide. The South African transportation data startup WhereIsMyTransport works with municipalities to improve transport systems and services through local data collection and generation(734). Efforts like these help to translate and contextualise concepts that can enable integrated HVT for lower capacity locations.[15] In a 2013 article about the Rockefeller Foundation initiative, "Catalyzing the New Mobility in Cities", De la Pena and Albright share examples of technology applications that have improved mobility for the urban underserved in emerging economies(739). Around the same time, online sites, platforms,[16] and awards related to smart and sustainable mobility entrepreneurship proliferated. These platforms addressed a prior information gap related to promising mobility-related services and technologies, and they have accelerated engagement and support for mobility technology innovation, including in LICs.

More broadly, technology is a proven catalyst of commercial value in urban mobility, particularly when applied to the sharing economy. Often this perception of commercial value may originate from the data or the promise of technology and not the provision of transportation services. This is clear with platforms like Uber and Lyft that have applied technology to the private vehicle-for-hire model and are helping to set the stage for MaaS-like services in some cities(451,740–743). Technology has also played an increasingly significant economic role both in LICs and HICs, opening the door to the 'gig economy' and offering new, flexible employment opportunities, but characterised by a lack of worker rights and protections, as well as under-employment. Examples of how technology drives commercialised transportation are outlined in the Rockefeller Foundation's "Catalyzing the New Mobility in Cities" report and more recently in a UNDP publication(713,744).

Protocols increasingly facilitate data sharing, transparency and use. Open data enables users to easily and directly interact with transportation information and payment using third-party mobile apps and websites. Open data has also proven critical for system-level integration of public and private transport modes; national and municipal governments are already moving toward requiring data transparency in transportation(745,746). In 2017, the Finnish national government adopted 'The Act on Transport Services,' which harmonised existing regulations of various transport modes and established standards for

[15] Additional efforts to expand access to transport services despite barriers posed by the digital divide include: Safeboda, Uganda; AftaRobot, South Africa; Digital Matatus, Kenya; Transport for Cairo, Cairo; Chalo, India; Flock Tracker, Mexico City; Maan Nassel, Jordan; and Viamo, Africa and South Asia (previously Voto Mobile).

[16] Examples of platforms and accelerators are available through the University of Michigan SMART Mobi Platform: http://mobi-platform.com/selected-listing-of-platforms-and-accelerators/

interoperability, digitalisation, and more efficient use of data generated by the transportation sector. Part of the regulations requires the Finnish Transport Agency to make anonymous service-use data publicly available. This data can help lower barriers to cohesive service delivery by enabling operators of combined services to merge tickets across modes and offer discounts that reflect how customers use different modes(746).

New mobility offerings—ridesourcing, dockless bikeshare, and scootershare—feature GPS-enabled devices that can generate a plethora of travel pattern data. Granular trip data can illuminate when and where people are using different modes, which is invaluable to cities as they decide where to site or improve infrastructure(747). It also underscores efforts between the public and private sectors to improve the functionality of these modes. For example, platforms such as SharedStreets enable city governments and TNCs (e.g., Uber and Lyft) to share standardised data using a common map and other open source tools, in order to better understand and manage curb space. Worldwide, buses are being equipped with GPS and automatic fare collection systems that have the potential to increase data for planning and evaluating services. Particularly, the use of automatic vehicle location (AVL) technology and automated passenger counters (APC) have enabled researchers to better understand bus operations(748–752). These systems are in operation in MICs such as Brazil and Mexico(497).

Significant opportunities exist for sufficiently funded and integrated technology endeavours to improve mobility in LICs. However, according to experts, traditional development funders have been slow to support the transformative, inclusive, and cost-effective role of data as an infrastructure to improve and integrate transit, walking, and cycling(753). Recent developments in LICs suggest that investment in integrated mobility technologies could allow for rapid growth in HVT. For example, bandwidth was frequently cited as a key barrier to success for mobility startups during University of Michigan SMART/Ford's mobility project strategic sessions in South Africa (2007-2011)(754).

Increased investment in both individual enabling technologies and supporting technology infrastructures and platforms could position LICs to advance their urban HVT systems significantly. This support could also enable innovation not only for local citizens and businesses but also for growing regional mobility industries and export economies, potentially leapfrogging wealthier nations. (Leapfrogging is the phenomenon of disruptive technologies and innovations that provide latecomers opportunities to enter the market and to skip certain trial-and-error phases, thereby accelerating their success)(719,755).

Leapfrog technologies may also catalyse and support reverse innovation, which occurs when products are developed specifically for low-resource and/or limited infrastructure markets, but end up being applicable and profitable as lower-cost goods in developed markets(756). Such products may be (a) developed by firms in emerging economies able to scale internationally on their own or partner with multinational companies to market their products, services, or business models to wealthier markets, or (b) developed by multinationals specifically for sale and use in resource-constrained contexts(757). The most celebrated example of reverse innovation in the transport sector is BRT, developed in Brazil (MIC) as a low-cost alternative to rail and now spreading to many HICs.

Blockchain is a rapidly developing technology that enables decentralised transactions and management of data. It provides security, transparency, and reliability, but no single organisation is in control of the transactions (also referred to as distributed ledgers)(758). In terms of use cases for mobility, blockchain may have applications in passenger transport integration, such as facilitating vehicle sharing, electrification, parking optimisation, and the connection of multiple mobility modes through one application accessed using a universal account(759). Blockchain could help shift the focus of transport systems from providing individual modes to a more integrated perspective of servicing user needs by offering a secure framework for public and private-sector operators to share and integrate data across transport modes(760). Small pilot

programmes applying blockchain to mobility are being launched. While most development in this space has been limited to HICs, LICs and MICs have the potential to benefit from blockchain, especially in terms of decentralisation and security. Leapfrogging opportunities for LIC and MIC cities may arise as higher-income cities test new applications of blockchain for mobility, and overcome barriers (e.g., the enormous amount of computational power needed to confirm blockchain transactions)(758).

Despite the potential of technology and big data to facilitate MaaS and HVT, they are not ends themselves. There are myriad risks arising from rapid technological development, most notably that it will not serve the user(761). In addition, there are risks around data generation, use, ownership, cybersecurity, management, currency, monetisation, and even weaponisation. The World Economic Forum's Center for the Fourth Industrial Revolution has researched the latter issues extensively. Data security is of specific importance in the context of transportation data. The rapid development of technology and its application to highly personal information, like people's travel patterns, raises serious privacy concerns. While mobility data generated from GPS-enabled services like TNCs and bikeshare can be extremely informative for city planning decisions, as mentioned above, it is among the most sensitive data collected from individuals. Montjoye et al. found that only four pieces of spatial data are needed to identify 95% of people in an anonymised database(762). While the situation may have evolved since 2013, this still raises concerns for MaaS platforms, which could host mobility data across multiple modes in one centralised location.

Recognising the wealth of opportunity presented by big data and HVT-enabling technologies, the use of data should be managed responsibly. OECD countries are developing approaches and measures to prevent harm. For example, Sidewalk Toronto, a collaboration between Sidewalk Labs (Google) and Waterfront Toronto, is working to develop a state-of-the-art data and privacy approach related to a major smart city redevelopment along Toronto's waterfront. It will combine urban design with new digital technologies to create sustainable, affordable people-centred neighbourhoods. A responsible data-use framework is proposed as part of the redevelopment plan to ensure that all data collection is purposeful, transparent and open(763). Other locations, especially LICs, could adapt aspects of this approach and combine it with smart city redevelopment. To date, few studies have emerged detailing the impact of these emerging technology and big data measures in LICs. There is a clear need for additional research as these measures mature and undergo more widespread implementation.

Adoption of HVT-enabling technologies can vary according to several factors, including understanding of the value and opportunity of technology applied to transportation; what technology and related infrastructure is necessary and available; what it can do; actual local needs; and priorities, politics and resources. The spectrum of application and uptake of technology in LIC transportation ranges from minimal to considerable development as described in the sub-sections below.

5.4.2.1.a. Technology-Enabled Shared Mobility Systems

HVT systems are composed of an array of traditional services, particularly public transit, addressed in the **Shift** section above. They can be supported by emerging, technology-enabled shared mobility services, such as ridesourcing (including ridehail and rideshare), bikeshare, and carshare. Shared mobility systems could coordinate these services across all modes, public and private, leading to resource and space efficiency benefits, and offering travelers flexibility in their mode choice, particularly for one-way and connecting trips. Multiple studies show that integrating shared mobility with transit facilitates more convenient and reliable multimodal travel and reduce VKT and greenhouse gas emissions(764–766).

Technology-enabled shared mobility has taken several forms. In LIC cities, it is helping to adapt on-demand transport services to informal or unplanned contexts. Kumar et al. highlight that informal shared transport systems, not dependent on technology, help bridge the HVT supply gap in parts of Indian cities that are not well covered by public transit(767). Gaps in the formal transport network are also filled by informal modes in

Africa. (See **Informal Transit** section above.) Some organised informal and private transport providers are offering on-demand services, as seen with minibuses in Johannesburg and matatus in Nigerian cities. We outlined an assessment of the modal-specific implementation of shared modes with the most promising impact on HVT in HIC and LIC contexts in the sub-sections below.

Nuttall et al. discuss the role of transport agencies in shaping the landscape of shared mobility systems as new forms of business and stakeholder engagement are becoming the norm in transport planning(768). Multi-modal mapping is one way that public transport and private shared mobility providers can help identify opportunities for integration, enabling cities to devise measures that achieve desired goals and avoid unwanted outcomes(732,769).

A number of studies, many from China, evaluated users' uptake of shared modes, and what elements governments and private companies should focus on expanding use, particularly in connection with transit. For example, Liu and Yang explored factors that influence Chinese users' adoption of shared mobility services, since attracting more users will expand potential benefits such as fewer carbon emissions. Results revealed that perceived usefulness and perceived ease of use of shared services are the main factors that lead to user adoption, and that trust and norms are also important(770). Another Chinese study looks at bikesharing from the point of view of the public, industry, media, and government. It finds that user interface design, social influences, and new media positively affect users' awareness of and attitude towards bikeshare and other shared modes(771). These design, communication, and user engagement elements will probably be critical to successful, broad-scale MaaS-related development.

The impact of shared mobility systems on low-income populations remains lower compared to the general population in the US, indicating an equity disparity(766). In New York City, between 2013 and 2016, the use of new mobility services in wealthy areas of Brooklyn and Queens, where frequent public transit is available, increased by 200%(772). It is unclear how these impacts differ in city centres versus peripheral areas or in LICs, MICs, and HICs.

While the literature widely covers shared mobility, the implications of technology-enabled shared mobility in LIC transportation systems as part of MaaS-like initiatives are not as well documented, particularly in Africa and Southeast Asia. Future research could focus on: the extent to which informal transport in LICs and MICs could transition to more formal shared mobility services (both benefits and potential challenges for users and operators if shared mobility services don't equal or surpass previous informal options); factors that could increase shared mobility as a replacement for personal vehicle trips; factors that might affect shared use replacing walking and cycling (sometimes healthier and safer options) as part of the overall system; how shared mobility could better connect to transit and the rest of the system; and a deeper evaluation of the equitable distribution of shared mobility services among the other connected options.

The technological advancement of each of the following modes is critical, but their harmonisation into a common user-focused platform will be paramount. The following subsections provide a general discussion of these services as individual modes.

Ridesourcing

The explosive growth of ridesourcing,[17] facilitated by TNCs, has prompted cities around the world to evaluate the best practices for integrating this industry into transport networks. (We often define TNCs as entities that match passengers with drivers in real time through a website or mobile app.) Around the time that TNC giants like Uber were scaling operations in the US (2011-2015), other TNCs emerged in MIC cities, notably Didi in China, Ola in India, Grab in Singapore, Gojek in Indonesia, and Bolt (formerly Taxify) in Kenya. Their

[17] For a comprehensive overview of definitions related to shared mobility, see SAE International's *Taxonomy and Definitions for Terms Related to Shared Mobility and Enabling Technologies* at https://www.sae.org/standards/content/j3163_201809/

business models closely mirror that of Uber and Lyft; similar to taxis, they provide point-to-point on-demand transportation service using primarily sedans.

However, Gojek connects users with motorbike taxis, known in Indonesia as “ojeks”. National transport regulations in Indonesia only apply to four-wheeled vehicles, allowing Gojek-supported motorbikes to skirt these rules and not directly compete with the taxi industry. Since its launch in 2015, Gojek has expanded to provide a range of on-demand services including grocery and prepared food delivery, logistics, digital payment, mobile phone credit top-ups, etc. Gojek drivers can double as delivery workers for the company’s array of services during off-peak hours, enabling them to earn more income(773). Interestingly, according to media reports, Uber offers connections in its app to boda-bodas (motorcycle taxis) in some places, like Nairobi(774).

Ridesourcing could support HVT by offering connections to transit, potentially reducing the need for car ownership over time, thereby shifting many car trips to more sustainable modes like transit, biking and walking. However, the literature on this theory is inconclusive. Several studies found that ridesourcing is pulling travelers away from transit, particularly buses, and contributing to congestion and increased rates of traffic-related deaths(775–777). UC Davis researchers find that ridesourcing, carsharing and vehicle automation have the potential to increase urban sprawl unless they are planned and regulated to support sustainable, compact development(5). A two-year exploration by the National Academy of Sciences in partnership with the Transportation Research Board found that innovative mobility services both positively impact (expand travel choices, enhance mobility for the elderly and non-car owners) and negatively impact (exacerbate the digital divide, erode the taxi market, and cannibalise transit riders, pedestrian and cyclists) on the transportation system. These services have the potential to change long-term travel and land-use patterns(778).

App-based ridesourcing is convenient and predictable for users. It can lead to increased use of these services over time, potentially eroding public transport, walking, and cycling. A study by Schaller in New York City showed that use of ridesource apps led to a 3% increase in total vehicle miles travelled in Manhattan between 2013 and 2016. Mode shift from public transport was even more pronounced in the first-ring districts where the use of ridesource apps grew by as much as 40–100% during that time(772). Researchers also found that ridesourcing can increase car travel, congestion, and privacy concerns(772,779). The level of convenience attained through the ridesourcing model depends upon having enough drivers available and optimally located to meet demand. This means that drivers are, at times, driving around waiting to be matched with passengers. These “empty” or “deadhead” miles are severely inefficient, contributing to overall VKT without transporting passengers(776).

In the United States, in particular, the growing concern about TNCs competing with public transport has triggered research on microtransit, defined by the U.S. Department of Transportation as “a privately owned and operated shared transportation system that can offer fixed routes and schedules, as well as flexible routes and on-demand scheduling. The vehicles generally include vans and buses”(780)(p.5). By moving a higher volume of people per vehicle, microtransit could be more aligned with HVT goals than TNCs. Grey literature emphasises that, in order to test microtransit as a public service successfully, public transit agencies should understand the challenges of incorporating the technology that supports these on-demand shared models, while putting the needs of users at the forefront of the service(781). New technology-driven microtransit services have begun operating in HICs. These include privately operated services, such as Via and Hamburg Moia and services operated by public transport agencies, such as Berlkonig in Berlin(782–784). It should be noted that services akin to microtransit exist in LICs and MICs in the form of informal transit services (see **Informal Transit**).

We need additional research on the impact of TNCs on overall VKT (besides congestion) in both high-income and low-income cities. A better understanding of the spatial and temporal effects of TNCs on the use of transit is also necessary. The impact of technology-based microtransit is also unclear in any context. We also need research to better understand the interaction between ridesourcing, taxis, and informal transit operators in LIC and MIC cities, and how to integrate these services to meet user demand.

Bikeshare

Bikeshare offers a practical, point-to-point, shared transportation option that reduces or removes many of the barriers to cycling and can help people to live car-free. Highly successful systems—Mexico City and China—often connect to transit and help to promote cycling as a viable and valuable transport option. Chinese cities have some of the highest usage rates of bikeshare and have significantly shifted mode share away from private vehicles(785).

Over the past decade, bikeshare systems have launched around the world, providing reliable, affordable alternatives to cars for short trips, and flexible connections to transit for longer trips. Recent modifications to the original station-based bikeshare model, such as GPS-enabled dockless bikes, shared electric bikes and shared electric kick scooters, present new opportunities to scale bikeshare and improve the spatial distribution of bikeshare systems, expanding mode shift and connectivity benefits. However, as these new mobility modes gain popularity, cities are being forced to navigate new environments, testing new regulatory approaches to better manage how private mobility companies operate in public space. In many cases, cities have learned from their experiences with TNCs. They are taking a more proactive and integrative approach to regulate emerging privately operated modes, and understand the potential for connections across these modes and with public transit(785). However, in some cases, challenges and uncertainty stem from the question of which level of government (national, state, municipal) has the authority to regulate and, ultimately, integrate these emerging modes.

The United Nations, World Bank, and other global agencies have partnered with local groups to launch shared transport projects like bikeshare in LICs, particularly in African cities. In 2016, Marrakech, Morocco, launched a bikeshare programme in coordination with the United Nations' annual climate change conference. The system signified a commitment to HVT as an action to reduce climate change, with bikeshare serving as a first-last mile feeder to and from higher-capacity transport. Also, with support from the UN, Nairobi University launched a small but notable bikeshare in 2017, and Mobike launched a dockless bikeshare programme on the UN's Nairobi compound in 2018(786). ITDP and UN-Habitat are working closely with city officials in Cairo to launch a bikeshare programme with other planned cycling and pedestrian improvements.

Bikeshare has been shown to reduce a number of barriers to cycling in LIC cities. Such barriers include access (upfront cost of purchasing a bike, availability of bikes for purchase), security (concerns about theft, nowhere to store), and reliability (time and cost of maintenance), among others(787). While the availability of bikeshare has been shown to decrease bus ridership slightly, it can increase heavy- and light-rail ridership(775). These findings show that a well-designed bikeshare system could contribute to an HVT system.

Dockless bikeshare systems, due to lower upfront capital costs compared to station-based systems and operating costs covered by private companies, could be more feasible for implementing bikeshare in lower-capacity locations(785). However, strong concerns from cities about vandalism and theft of the bikes, and street designs that are unfriendly to cyclists are barriers to implementing dockless bikeshare systems in some LIC cities, particularly in Africa.

User surveys and academic studies across HIC and MIC cities and regions quantify mode shift from cars to bikeshare which yields emissions reduction, air quality, and other co-benefits(788). However, Fishman et al.

find that, in London, the low substitution of bike trips for car trips (coupled with the use of trucks to re-balance bikeshare stations) contributed to a net increase in VKT(788). Surveys also show people use bikeshare to connect to and from transit stops, especially in cities where protected infrastructure and/or bicycle-friendly road networks surround transit nodes(789). In Cape Town, Jennings notes the conflict presented by public bikeshare business models relying on advertising revenue, use of credit cards for payment, and reliable internet access. This can restrict access to the urban poor who live on the outskirts of the city(790). The impact of bikeshare on HVT in LIC cities is less clear.

There is a growing body of literature focused on quantifying the benefit and impact of bikeshare in specific cities (often HIC). Yet few of these studies present a regionally representative analysis of impact. Despite cities' efforts to design bikeshare systems to bridge the first-mile and last-mile gaps to transit, it is still unclear, particularly in LICs, if this is effective. There also remains a gap in knowledge regarding bikeshare operating models, specifically whether public, private or a combination of the two yields systemwide benefits, particularly the ability to integrate bikeshare with transit and other modes.

Carshare

While informal carsharing has occurred for decades around the world, formalised carsharing facilitated by private companies is another shared mobility opportunity to reduce the need for car ownership. Carshare has two forms of operation: (a) shared vehicles offered as part of a fleet, priced by time or distance, for one-way or round trip (e.g., Zipcar, car2go, Zoomcar, GoFun) and (b) individual vehicle owners make their vehicles available for short rentals, often through a third-party booking platform (e.g., Getaround, GM's Maven). The availability of carsharing is linked to reduced rates of vehicle ownership by carshare users over time, which could cause greater use of non-car modes like transit, biking and walking(791).

National and local governments have shown interest in enacting measures that support carsharing. In China, carsharing has received strong governmental support in the form of designated parking spaces, charging infrastructure for electric shared cars, and direct operational subsidies(792). These interventions, in addition to low car ownership rates in China, have established carsharing as a highly used shared mode. Due to significantly lower operating costs and fleet size demands than one-way carsharing, round-trip carsharing (pickup and return at the same location) has been identified as the more feasible model to implement in LICs, at least at first(793). As with other shared modes, technological solutions that maximise the convenience of carshare in HICs have presented obstacles in some LIC settings. However, Lane et al. note that e-payment technology could a present a leapfrogging opportunity wherein LIC carshare users can use innovations like social media payment platforms (i.e., WeChat) and mobile app accounts (i.e., DiDi Dache) instead of credit cards(793).

Some quantitative surveys find that carsharing can reduce overall car ownership(772). It can even contribute to an increase in public transport use if designed to serve as a feeder as opposed to door-to-door service(794). Carsharing can reduce parking demand and free up land, including doorstep pickups and drop-offs, but requires appropriate policy levers for parking requirements and mode integration(684). Baptista et al. present a case study of Portugal's carsharing system as transport policy, based on a global analysis of over 400 cities. Overall, the results quantify the contribution of carsharing to HVT and highlight the positive effects of promoting a technological shift from gas to hybrid vehicles. Like the Karim study, Baptista et al. find that the benefits of carsharing systems are maximised by measures that target parking allocation (reducing or eliminating parking minimums and/or establishing parking maximums), integration with public transport, signage, and marketing of social and environmental benefits(795). In a study of carshare in Portland, Oregon, Katzev finds that about a quarter of users sold their personal vehicle, half decided not to purchase a car, and most users reported increasing their use of transit, biking, and walking(796). As of 2013, several carshare services had plans to launch in Africa, but their current status is not clear(797). We also identified three

carshare services in India: Drivezy, Myles, and Volercars, but we did not find any assessments of their use or impact. More research is needed on the use and impact of carsharing in LICs (particularly in Africa and India) and its connection to HVT.

Case studies on the impact of carsharing on vehicle ownership, VKT, and use of HVT have been well documented in North America, Europe, and China. We also found several theories about how carsharing might best apply to the LIC setting. However, the use and impact of carshare on HVT in LICs are not as well known. Usage rates in LICs compared to MICs and HICs, as well as use cases for both carshare operating models, could be topics for further research, in addition to assessing how and whether carsharing helps to enable HVT in LIC contexts.

5.4.2.1.b. Urban Freight Systems

While the bulk of the conversation and action surrounding MaaS-like initiatives concerns its impact on passenger transport, elements of MaaS approaches and related innovations could create efficiencies and improve urban freight systems. Urban freight movement is vital to national economies and the daily lives of urban residents, and it is complex, moving by foot, road, sea, and air. It is often facilitated by advanced technology and is inextricably linked to the entire transport system. Because the goods movement is commercial and competitive, it is often highly efficient. Furthermore, the supply chain lies at the nexus of technology, innovation, and integration, often sustained by stakeholder partnerships (public–private ecosystems), which engage diverse actors including freight-related companies, government agencies, NGOs and local startups and enterprises(798). This section examines recent technology-driven innovations in urban freight. Land use implications of urban freight are discussed in the **Land Use and Urban Freight** section, and service and regulatory implications of urban freight are discussed in the **Urban Freight Services and Regulations** section.

Much like with passenger transport, a MaaS system that includes urban freight could reduce emissions and congestion in urban areas(799). Conversely, there is a lot of integrative experience that could be transferred from the global freight supply chain experience to the creation of efficient technology-enabled, seamlessly connected, on-demand people movement. In the HIC context of Europe, examples like Austria's checkrobin.com enable fast, inexpensive delivery of private goods via an online platform. The service connects people who are already making a trip with packages that need to be delivered to locations along the route. The platform is open to both individuals and professional service providers such as taxi drivers(799). While implementing the movement of urban goods in a MaaS or MaaS-like system is still emerging, there is evidence that a MaaS approach to urban freight has created efficiencies in goods movement. This is true for the checkrobin.com example, which allows trips to serve both passengers and freight. In addition, the Smart Freight Centre is a global network of freight businesses that work to reduce emissions and improve efficiency through harmonised frameworks for emissions calculation; more efficient fleet energy management. The Smart Freight Center also works globally with the World Economic Forum to advance approaches to sustainable freight via a global forum to share best practices and new ideas.

Blockchain has been consistently identified as an opportunity to vastly improve the efficiency of freight transportation systems by optimising logistics and decentralising delivery networks(800). Since most freight operations are carried out by private firms, publicly available data related to freight operations is scarce, which limits research potential and the ability of municipal authorities to conduct informed planning and decision-making involving freight networks(801). There is potential for blockchain to address this challenge by providing secure datasets accessible by all parties within the supply chain. With blockchain, currently fragmented stakeholders would have access to shared, standardised data on shipments and transactions across the network.

Maersk, a global shipping company, piloted the use of blockchain for freight tracking in 2017. This gave the company and Dutch and United States customs agencies the ability to access a common database of shipping data that utilises digital signatures to reduce instances of inaccurately labeled shipments(350). Applied to an urban context, the ability to share a common dataset of trackable shipments between multiple stakeholders could help to identify operational integration opportunities between freight and passenger transport once shipments arrive in cities. This could facilitate the type of integration described by Chatterjee et al., in which the use of existing public transport modes for last-mile delivery of small- and medium-sized packages would offer advantages over the existing delivery networks in terms of energy efficiency, and emissions and congestion reductions(802). While this type of integration is rare in high and upper- and middle-income cities, LIC and MIC cities able to implement blockchain have an opportunity to leapfrog fragmented, inefficient urban freight systems that are already well-established in higher-income cities(801).

There is a relative dearth of research on MaaS-like urban freight systems operating in LICs. As populations (and related congestion) grow and economies evolve in LICs, better integration with the supply chain and people movement, combined with technology enablers and stakeholder ecosystems, may serve LICs if adapted to local assets and conditions. Additional research is needed on the design, implementation, and impact of integrated urban freight systems in LICs. This includes identifying barriers and capacity constraints. Given the existing capacity and governance constraints, research is also needed on the extent to which new mobility strategies and technologies (e.g., autonomous vehicles and drones) could facilitate integrated goods movement in LICs.

5.4.2.1.c. Integrated Trip Planning

Operators, governments and companies have optimised transport service planning, traffic demand management, congestion, and other dynamic pricing, and freight movement through the application of technology.

Trip planning, fare payment, multimodal service applications (“apps”) and traffic management have become critical facilitators of a more seamless trip for users. For example, trip planning mobile apps, like CityMapper and Transit, allow users to compare cost and time across different mode combinations—public transit, rideshare, personal bicycles, bikeshare, and personal cars—for their intended trip. Locations of free-floating modes offered by a variety of operators, such as dockless bikes, e-scooters and carshare (e.g., Car2go), are often available on a common map. In some cases, users can also purchase passes or pay directly within these appsb (e.g., passes are available on the Bikeshare Toronto Transit app. Many of these applications have integrated safety and security enhancements, including user data and privacy protections, as well as built-in review and rating functions that may increase confidence in the system.

While trip planning applications are prevalent in HICs, such as those in Europe and North America, there is evidence to suggest that they may be hard to implement in LICs and MICs. Apps such as CityMapper use the General Transit Feed Specification (GTFS) data standard to include public transport in their platform(803). However, a 2014 study in Mexico City (MIC) found that GTFS data was difficult to acquire for semi-structured and informal transit services, which are a prevalent, if not a dominant form of public transport in most LICs, and the absence of this data prevents their inclusion in those platforms and hinders the creation of an integrated system.

There has been work, both by academics and by for-profit companies, to generate GTFS data for informal transportation services. One academic example is the aforementioned Digital Matatus initiative in Nairobi(294). In the private sector, WhereIsMyTransport has generated GTFS data in several African cities, such as Cape Town (MIC) and Dar es Salaam (LIC)(804). However, the impact of this data generation, such as its integration into trip planning apps, and the impact on drivers and riders is not well documented.

5.4.2.1.d. Integrated Payment Systems

In terms of payment technology, in HIC and MIC cities, technology and data innovations have simplified and integrated fare payment across transport modes. For example, in Chicago, radio frequency identification (RFID) technology enables a common access card and payment account (branded as “Ventra”) to be used on Chicago Transit Authority buses and trains, commuter trains, and commuter buses(805). In certain markets, third-party apps like Transit enable users to purchase transit and/or bikeshare rides directly within the app(806). Finally, while not exclusive to the transportation sector, China’s trend toward cashless (and credit card-less) payments has been heavily supported by e-commerce companies offering mobile payment platforms(807). These platforms, such as Alipay and Wechat Pay, require a smartphone to interact with the Quick Response (QR) code technology. QR codes are emerging in taxis, buses, bikeshares, and carshares for easy, integrated payment across modes(807).

Cashless payment and multimodal fare integration have emerged in LIC and MIC cities as well, albeit along a different trajectory due to the limited access to financial services or bank accounts and slow uptake of credit cards. Whereas cashless fare payment in higher-income cities typically relies on a common credit card-based account, cashless fare payment in lower-income cities has been largely implemented through mobile phone- or network-based systems known as mobile money or “M-money”(626). Unlike mobile payment platforms like Alipay and Wechat in China, transactions with M-money do not require a smartphone or internet access. The use of M-money to pay for transportation has been documented across Asian, Latin American, and African cities, especially where informal transport accounts for a significant share of the network(736).

The sparse body of literature on M-money almost exclusively highlights the widely used M-Pesa programme in Kenya(626,736,808,809). M-Pesa enables users to purchase mobile phone airtime, transfer money, and pay for transportation, among other uses. As of 2010, the total value of money transferred using M-Pesa was equivalent to nearly 10% of Kenya’s GDP. Aker and Mbiti found that M-Pesa users are wealthier, more educated, urban and report having access to a credit card, despite the fact that the service is meant to “bank the unbanked”(736). BuuPass, an intercity bus ticketing platform in East Africa, accepts M-Pesa as a fare payment option, as well as other cashless alternatives, based on the unstructured supplementary service data (USSD) system(810). USSD enables users to dial a designated number (typically beginning with “*” and ending with “#”) to see a menu of vehicle registration numbers and corresponding lists of fares. Upon selecting a vehicle and fare, the amount is charged to the user’s mobile phone plan and an SMS confirmation is sent to the user’s phone as proof of payment(626).

Ultimately, cashless fare collection facilitated by mobile money and USSD has successfully overcome many of the cash-based barriers presented by informal transport. For example, the vulnerability and safety concerns raised by informal transport drivers carrying large amounts of cash while on duty are mitigated with a cashless fare system. These technologies could also provide the foundation for fare integration across modes—public and private—in the future(626). Finally, there may be potential for reverse innovation. This occurs when products developed for limited-resource markets end up being applicable and profitable as lower-cost goods in higher-income markets (e.g., the use of non-smart mobile phone-based cashless fare payment technologies by unbanked populations in HIC and MIC cities to access on-demand transport modes)(756).

As mentioned earlier, limited digital infrastructure, specifically a lack of mobile internet access, also limits the prevalence of integrated mobility systems in LICs. However, both local and international agencies, including development banks, have considered investments in integrated systems in LICs. Additional research could explore the potential for reverse innovation, wherein local LIC firms (Western-based companies like CityMapper or Masabi) develop alternative trip planning and payment services that can operate in low-

capacity contexts. Alternatively, innovative approaches to generating and maintaining GTFS data, particularly for informal transport, for trip planning services could also benefit from further study.

5.4.2.1.e. Automation

Recently, vehicle automation, self-driving vehicles, along with drone applications have been introduced to the transportation sector. These technologies have contributed to monitoring and evaluation capabilities across services and systems(811,812). Recently, automation, shared-use mobility and electrification (identified as "The Three Revolutions" by UC Davis and ITDP researchers) have been studied by institutions such as the World Resources Institute, ITDP, and the Brookings Institution(813–815). However, a key technological (and conceptual) distinction of MaaS from the Three (to date disparate) Revolutions is its integrative "platformisation", moving from individual modes, services, and applications to facilitating a system of systems that expand mobility and access but also integrates with wider city amenities.

While shared-use mobility, formal and informal, is growing in the form of bikeshare and rideshare services in LICs, it is likely that the adoption of autonomous vehicles will fall behind OECD countries due to the high costs of automated technology(568,816). Regardless of the location, it will probably take the confluence of automation with shared-use mobility *and* electrification (all of which can operate as part of a MaaS system) to realise the full potential of all three(814). (The HVT **Theme 3: Low Carbon Transport: Part 1** report addresses electrification in more detail.)

Automated vehicles are expected to offer mixed impact on cities, both high and low-income. In terms of benefits, they may improve road safety and lower emissions through more efficient driving(815). They may also lead to more holistic transport planning, integrated and automated payments, and new approaches to pricing. Integrated payments can encourage multimodal trips, and autonomous vehicles. In addition, their ability to produce large amounts of data could provide an opportunity for creating applications and platforms that synergise different transportation modes(813). The automated vehicle could also improve freight movement through smaller, safer vehicles and a consolidated distribution system that reduces vehicle travel(817).

Autonomous vehicles, once deployed, could bring a multitude of negative impacts. Autonomous vehicles could lead to more road congestion through induced demand(814). They could also cause large-scale job loss as automation forces drivers out of their vehicles(813,815). This would pose a significant risk to operators in LICs who provide informal transportation, such as matatus and other shuttles. Finally, there are concerns about autonomous vehicles leading to more sprawl and the optimisation of the vehicles could negatively impact the walking and cycling environment(818,819).

While automated vehicle deployment is not likely to arrive first in LICs, there is a clear need for research on the potential opportunities and risks (in terms of safety, cybersecurity, data collection and use, and social fabric) as the technology progresses, including an assessment of passenger and freight applications.

5.4.2.1.f. Moving Less: Trip Reduction and Replacement

HVT also encompasses reducing the length of trips or eliminating trips altogether (e.g., moving less). This can save time, reduce emissions and vehicle miles traveled, and even lower traveler stress(820). (We discuss the idea of moving less through better land-use planning in the **Avoid** section. Thi subsection focuses on technological innovations.) Telework, telecommerce, telemedicine, and tele-education, etc., have been made possible through technological advances, which can be combined with other transport infrastructure and services. A coordinated effort to incentivise trip reduction could be part of an HVT strategy, leveraging emerging apps and technologies, such as on-demand grocery delivery services.

The literature has well documented the impact of trip reduction incentives, services, and infrastructure on energy use, greenhouse gas emissions, and VKT(702,821). Telecommuting, in particular, has been shown to

impact travel behavior even on non-telecommuting days, with telecommuters choosing destinations closer to home and taking trips during off-peak times(822). However, in Europe and the United States (HICs) only 2 to 3% of work is done by telecommuting. In the long term, telecommuting appears to result in people moving farther from their place of work(823).

Impacts related to broader efforts to integrate moving less into HVT strategies, particularly in LICs, have proven difficult to find. Moving less has rarely been explored as a critical contribution to whole-systems transportation solutions or to MaaS. But as cities grow and congestion increases, research on concerted approaches to moving less will probably become more essential. This could include studies of telecommuting in sub-Saharan Africa and South Asia.

5.4.2.2. Innovative Business, Financial, and Regulatory Approaches

This section focuses predominantly on elements at the nexus of business models, financial models and integrative policy that seek to link business practices with HVT goals. However, the policy is playing catch up to the technology and service innovations underway. We may need new financial mechanisms to help fund emerging and integrated mobility projects and infrastructure, and to build the foundation for a local or a regional mobility economy. Integrative MaaS-like platforms could enable cost efficiency through system optimisation for businesses and governments, and cost savings for users. MaaS-like initiatives could also deliver economic benefits by creating employment opportunities in tourism; talent attraction and improved regional competitiveness related to reduced congestion; safer and more efficient transportation systems; and public spaces attractive to both citizens and visitors.

A 2013 report, 'Catalyzing the New Mobility in Cities', focused on the state of the New Mobility industry and enterprise space in cities, in particular in emerging economies, with attention to the underserved. Based on desk research, interviews and collaborative, on-the-ground projects, it broadly describes the new business and financing models, their contexts, drivers, opportunities, relationship to policy, challenges, and possible next steps(739). These findings foreshadowed the current growth of the MaaS-like space and applications on the ground, including in LICs. The following subsections describe in more detail the literature on new business models, funding and finance sources, and policy models that may support MaaS-like systems and HVT.

5.4.2.2.a. New Disruptive Enterprises and Business Models

Cities have traditionally provided testing grounds for new business models(824). In many cases, public funding constraints have motivated and encouraged private and multi-sector engagement not only in financing and managing transportation projects but also in driving MaaS-like projects and public–private ecosystems(743). The private sector, with the help of new technology, has transformed mobility-related business models and financing(825,826).

Within cities, MaaS often functions as a public–private partnership, in which the existing public transit network is enlarged by private shared mobility services, such as bikeshare, carshare, or TNCs like Uber, Didi, and Ola(824). New MaaS business models are being tested primarily in Scandinavia with Gothenburg and Helsinki at the fore. There, users greeted MaaS positively, but the business models faced challenges. One of these challenges is that it is difficult for a mobility broker to purchase public transit trips for less than an individual traveller can already purchase them. This creates an obstacle when the mobility broker is attempting to make a profit(728). Helsinki's Kutsuplus on-demand minibus service was innovative and popular but commercially unsuccessful(827).

A possible negative impact of the MaaS business model is the potential for induced trips resulting from unused trips in trip packages. The theory of loss aversion suggests that humans are more attuned to avoiding loss than they are to gaining something. For example, if a MaaS monthly trip package includes 10 car trips, 15

public transit trips, and 10 bikeshare trips, but a user does not take all the car trips in a given month, that user is incentivised to take the extra trips they've already paid for to avoid losing them. This could have a negative impact on congestion and emissions reductions goals of the MaaS/HVT system. A way to avoid this is to ensure that business models allow unused trips to roll over to the next month or pay period(727).

Meanwhile, TNCs such as Lyft, Uber, and others are expanding their original business models to offer the beginnings of MaaS-like ventures. Uber acquired the dockless, pedal-assist electric bikeshare operator, JUMP, in 2018, and now offers JUMP e-bikes for rent in the Uber app in HICs in North America and Europe(828). Uber has also invested in dockless electric bikeshare and scootershare operator, Lime, reportedly with the intention of offering Lime's electric scooters for rent through the Uber app. (Uber has introduced scooters in the Uber app under the Jump brand as of March 2019)(829). Similarly, Lyft acquired legacy docked bikeshare operator, Motivate, which runs the largest bikeshare programmes in the United States (cities include New York; Chicago; Washington, DC; and San Francisco)(830). While bikes are not yet available for rent in the Lyft app as of the end of 2018, Lyft has launched its own branded electric scooters in Denver, Santa Monica, and Washington, DC that are available in-app. In the MIC context, the Chinese TNC, Didi, is a partial owner of Ofo, a global dockless bikeshare company, and is in talks to acquire the company(831).

While TNC multimodal platforms offer users some benefits of MaaS, such as the ability to access different modes using a common account/payment, cities should be aware of these companies moving toward "walled garden" strategies. Walled gardens are closed technology platforms where users have limited access to the information or services available (e.g., Android mobile phone users can only download apps from Google's Play Store, and not from Apple's App Store)(832). This model gives companies complete control of the content available through their platform and can dissuade users from choosing services outside of their app. In the context of mobility, privately operated walled gardens have concerning implications for pulling riders away from public transit. Recognising this, the European Union is taking steps to limit the trend toward walled gardens. For example, to address competition concerns, BMW and Daimler are being required to provide open APIs as a condition of their carsharing service merger(477).

While LICs have not yet wholly engaged in the recent MaaS trend, their long-standing use of both public and private transport options, both formal and informal, may position them well for MaaS-like public-private integration. There is also a knowledge gap where it applies to establishing and sustaining innovative enterprises in LICs as well as potential barriers and risks. Finally, due to the recent nature of many innovations described above, their impact in terms of financial sustainability and HVT remains unclear.

5.4.2.2.b. Sustainable Funding and Financing: Gaps and New Sources

There is a demonstrated need for financial innovations to fund and sustain the integration of transportation modes and services, particularly in LICs. However, the appropriate mechanisms to deliver that change are still being identified and explored in the literature. (There is a more general review of funding in the **Enabling Structures: Funding and Finance** section.) Public financing is seriously limited in many cases and the potential for private companies to generate profits from what we once considered public goods opens the door to new sources of capital. Some countries have developed roadmaps for sustainable finance, which signifies a commitment to changing the status quo and could spur broader planning efforts, like those around integrated mobility(833).

Specific to MaaS, national innovation agency programmes are beginning to offer ongoing funding matches to legacy industries and disruptive startups to encourage their involvement in establishing, convening and advancing national public–private MaaS ecosystems. Participating countries, co-led by national innovation and transportation agencies, include Finland (Tekes), Sweden (Vinnova, Drive Sweden), Scotland (Scottish Enterprise), the UK (UK Transport Systems Catapult), and Austria (Austriatech). Many of these nationally catalysed groups are collaborating across Europe with a vision to develop a 'single market' for MaaS(712).

Future mobility financing scenarios may include blockchain and cryptocurrencies.[18] According to Herweijer et al., "blockchain provides a strong potential to unlock and monetise value that is currently embedded (but unrealised) in environmental systems, and where there is a clear gap within the market"(759). In terms of mobility, potential opportunities identified with blockchain include optimising logistics, decentralising delivery networks, facilitating vehicle sharing, optimising parking, and consolidating multiple mobility solutions by making them accessible through one application with a single global unit of currency. In LIC's, a distributed blockchain could offer more secure land transactions and more secure transactions in places where local transactional and geopolitical conditions may not be optimal. However, legal and regulatory challenges, security risks, and technology barriers may represent challenges to implementing blockchain in the service of HVT. Given how new blockchain is to the mobility space, we need additional research to understand these challenges and any unanticipated opportunities(834).

Cryptocurrencies could incentivise community engagement and socially responsible behavior (for example, crediting a digital wallet with starter tokens to onboard and/or donate mobility access to new or underserved users). The platform could also enable users to maintain control over their passenger data. Potential value to the transport operator includes the cost-effectiveness, flexibility, and security that a global distribution system might offer. It is still too early to know what impact these emerging technology and currency platforms and approaches will have on the success of HVT. This signals a need for research in this evolving area.

Many venture capital sources have financed recent technology-enabled, privately-operated mobility services. However, we could not find sources examining the impact of this trend on the long-term sustainability of that model. Tourism is also a potential source of investment and financing for integrated transportation initiatives in some LICs. Southeast Asian transport experts we consulted described how Chinese tourism is playing an important role in the growth of bikeshare in the region (specifically Bangkok). In some countries, dockless bikeshare was not well known when it launched, but once Chinese tourists came to the area, the bikes were used a lot. This simultaneously brought money into the system and encouraged local use of the bikes(835).

In many LICs, despite significant financing of large public transportation projects by national government agencies and international institutions such as the World Bank, experts say that there has been little financing of technology, data infrastructure or mobility integration (including traditional physical infrastructure). This type of financing, if available, could leverage on-the-ground market and industry development, entrepreneurship, and support the development of integrated transport solutions and related markets(753).

New financial innovations offer the potential to better integrate the transport system and meet HVT goals. However, with many of these innovations arriving recently, few examples exist of their implementation. We need much more research to understand their impact, especially in the LIC context.

5.4.2.2.c. New Policy Approaches

The pace of innovation in technology-enabled shared mobility services, such as rideshare and bikeshare, is often faster than many governments' ability to regulate it(661). This has forced cities to reassess existing regulatory avenues and consider new, flexible and proactive strategies to optimise privately operated services and minimise negative outcomes. These new approaches to mobility policy in LICs may help foster innovation and integration in both the public and private sectors while ensuring a focus on HVT goals. In the

[18] The potential of blockchain for mobility is being explored by the World Economic Forum, The Mobility Open Blockchain Initiative (MOBI), Ernst and Young's Tesseract platform, AI software company VMC, Swheels2Go blockchain-supported shared e-scooters, and Mobotique's autonomous travel pods, among other ventures. Additional noteworthy efforts go beyond the mobility space and have implications for the application of blockchain to the transport sector. Such efforts include George Brown College's blockchain development certificate programme, the first in Canada; the government of Dubai's conversion to blockchain as its monetary operating system; and Japan's transition to a 40% cashless economy (supported by blockchain) by 2025.

context of MaaS, policy development is a key driver, removing unnecessary delineations between modes, operators and users, and creating a fair, stable operating environment for businesses(836).

Past and present models for public–private partnerships often include long contracts that do not allow or incentivise much innovation by the operator or the city. Attempts to fit new, innovative services into these existing regulatory and formal partnership models may limit the efficiency and better service quality enabled by technology. Instead, we need more flexible and adaptable regulations and partnership models. This may gradually shift the role of government from a transport operator to an integrated transport manager, matching investor and public–private ecosystem catalysts and convenors. For example, in response to the rapid deployment of dockless bikeshare and e-scootershare services across Asia, Europe, and North America in 2017, cities developed adaptable, annual permits for private companies that showed a genuine ability to meet cities' standards and needs to provide a mobility service. Dynamic adaptive policymaking emerged in the early 2000s. This allows policymakers to create and implement provisional policies adaptable for the future. Dynamic adaptive policymaking is being applied as part of transportation infrastructure planning for climate change in San Francisco, and for MaaS in Nijmegen, Netherlands(273,837).

By setting parameters rather than detailed and prescribed rules, this approach can increase efficiency and generate innovative, multipurpose, locally and regionally customised solutions through dialogue and collaboration among a wide set of engaged players(825). Zielinski refers to this outcome—an innovation-specific approach—as "public-private innovation". This model, among other benefits, could bring together a broader set of public, private, non-profit, academic and, in some cases, citizen actors at an earlier stage than is customary for a formal public–private partnerships. This can enable implementation grounded in a better understanding of system needs, challenges, costs, opportunities and metrics for success(223). Greater participation by a range of players across sectors is key to inclusive, outcome-oriented policy frameworks(713,838).

Facilitating an outcome-oriented approach requires governments to direct and manage stringent long-term planning efforts related to HVT, particularly climate change resilience and adaptation. This includes four iterative pillars: systems planning, engineering and design, operations and maintenance, and contingency programming. Using tools such as geo-referenced hazard maps to identify and limit vulnerabilities as the system is being built—as opposed to after the fact—will help to reduce risk. Resources to finance a disaster risk management strategy also need to be considered(839).

There are gaps in research related to policies and policy models that have emerged when top-down leadership is not responsive or where capacity and political will is lacking. Aside from Finland's Act on Transport Services (see **Integrative Technologies**), few national or regional policy models exist that facilitate integrative mobility, especially in LIC's. It is necessary to note that contextualising measures in existing conditions and capacities in different locations will be critical to the long-term success of these new policy approaches. That said, if we make good practices and approaches more searchable and available, they can be adapted and applied to local conditions, saving time and money. As such, the documentation, evaluation, dissemination, and piloting of national and subnational policies that could be adapted and replicated would be useful.

5.4.2.3. Leadership Ecosystems

A leadership ecosystem is a collaborative network of actors participating in the planning, design, implementation, operation, management, and evaluation of the transportation system across sectors. By bringing together the knowledge of each actor to the transportation network, a leadership ecosystem could lead to greater efficiency, access, environmental, equity, and safety outcomes. As the mobility space diversifies, it is increasingly clear that stronger and more diverse leadership ecosystems are critical to the

development of resilient transport systems and their respective local and regional economies(713). This approach may also help to engage the next generation of researchers and practitioners, particularly in LICs.

In addition, leadership ecosystems may lead to a more resilient urban transport system. Researchers find that including communities in decision-making and cross-sectoral communications led to greater urban resilience(155). Similarly, Ernstson et al. emphasise the importance of building "knowledge networks". These are networks of scientists, public officials, and community organisations identifying threats to resilience in case studies of New Orleans, Phoenix, and Cape Town(840). Based on observations from within the active MaaS space, robust leadership ecosystems that lead to increased interaction and collaboration across the relevant actors and sectors could lead to:

- Broader understanding of potential measures and approaches;
- Increased understanding of the various roles, cultures, and values of actors and sectors across the ecosystem, increasing capacities for deployment;
- Greater breadth of collaboration opportunities across sectors and in some cases geographies;
- Increased pace of progress and acceleration of the demonstration-learning-deployment cycle facilitated by collaborative technology and face-to-face contact enabling faster and richer feedback across the ecosystem;
- Some challenges related to transparency and information flow in an increasingly competitive commercial setting;
- Some challenges in ensuring that information, specific approaches, and capacity building are credible(713).

Historically, different actors in the transportation system have operated largely independent of each other(836). Similarly, there has been little action across sectors within the industry or across departments or agencies within government, academia, and civil society. Engagement of diverse constituencies such as women, people with disabilities, children, the LGBT community, the poor and underserved has been even rarer(713,744). We may relate the lack of collaboration to several factors:

- Perceived or real lack of resources, authority, and/or staff capacity to engage in the work considered to be outside existing actors' prescribed parameters;
- Lack of a prescribed role responsible for integration across HVT elements, including the skills to fill that role;
- Lack of cross-collaboration culture and history;
- Lack of understanding of the value of and need for cross-collaboration;
- Perceived threat to existing power structures (formal and informal)(713).

As noted earlier, we associate public-private innovation with some of the most recent and vibrant ecosystem development work, primarily in Europe at the national and regional levels. Examples include the global MaaS Alliance and the Intelligent Transportation Society (ITS) World Congress. Similarly, the US-based Smart City Challenge has brought together a range of technology, economic, government and NGO stakeholders focused on smart cities with integrated, technology-enabled mobility at the forefront(841). The World Economic Forum also recently launched a mobility ecosystem-focused initiative—SIMSystem—which aims to use emerging technologies to identify friction points within existing mobility systems and move toward more efficient, integrated systems(842).

In Africa, smart city initiatives that link private sector innovation, particularly in the information and communication technologies sector, to public sector planning have been launched in Ethiopia (LIC), Rwanda (MIC), Nigeria (MIC), and Ghana (MIC)(843). Similarly, in 2015, the Smart Cities Mission was launched in India

(MIC) to foster HVT in cities through a collaboration with city officials, industry, and academia(844). As of April 2019, 87 projects in India have been awarded funding over four rounds of applications(844).

More recently, large consultancies (e.g., ARUP, Ernst & Young, McKinsey, and more) are incorporating multi-sector, multi-stakeholder approaches to their work with cities. Private mobility operators have broadened their scope to span multiple overlapping modes and services. In the MIC context, Didi, China's ridesourcing giant, offers a variety of mobility services through its platform including taxis, bikeshare, and shuttle buses, as well as financial services, artificial intelligence, and automated technology. Similarly, India's app-based ridesource leader, Ola, recently began offering bike-taxis, which it plans to use for food delivery in Indian cities. NGOs supporting the development of HVT systems in LICs, including ICLEI, Clean Air Asia, the World Resources Institute's Ross Center for Sustainable Cities, and ITDP, have expanded their scope to embrace new technologies and business models from the private sector and the evolving public-private ecosystems. Other NGOs, such as the Shared-Use Mobility Center and NuMo, have been established to focus on new technology and businesses. Beyond individual organisation, cross-sectoral industry clusters may help innovate, commercialise and even export local ideas and products(719).

Some of the earliest developments toward MaaS-like ecosystems focused on LICs. The SMART initiative at the University of Michigan established partnerships in LICs and emerging economies to advance IT-enabled, multimodal transportation systems focused on the user(724,739). Through these partnership efforts, a four-step SMART method evolved as a capacity building approach to strategically map and implement integrated door-to-door systems to move people, move goods, and move less. The steps include 1) convening the actors across all relevant sectors; (2) mapping the existing mobility and, in particular, connectivity and technology assets on which to build; (3) seeding long-term and inclusive public–private innovation partnerships; and (4) demonstrating and deploying integrated, technology-enabled mobility. Since 2007, over 25 cities (including in Brazil, China, India, Korea, the Philippines, South Africa) have applied this method(724,732).

In the absence of significant peer-reviewed literature, the results and impacts of leadership ecosystems on cultivating MaaS-like integration are unclear. Thus, there is a need for greater assessment of the challenges and opportunities related to enabling leadership ecosystem development and successful approaches for accelerating capacity to develop robust and integrated sustainable HVT, especially in LICs. Further research is also needed to explore the geographical and cultural factors that contribute to or limit HVT ecosystem development. While some basic national-scale approaches and politics affect how initiatives progress, there is often significant variation from city to city or region to region. We also need more research in this regard.

5.4.3. State of Knowledge Conclusions

Improving urban high-volume transport requires a user-focused, whole-system approach to moving people, moving freight, and moving less. We present a summary of key findings from this section in **Table 19** below. Drawing on Mobility-as-a-Service-like approaches as a framework, technology, innovation and coordinated, multi-sector leadership could enhance and enable integrated HVT.

Key Findings Summary
Integrative Technologies, Data, and Platforms

- Technology, big data, and platforms could be the next wave of transportation infrastructure requiring planning and investment; - The digital divide hinders deployment in LICs and MICs, especially at the user level; - Protocols for sharing data across multiple platforms is key; open data is critical for integration between public and private modes and cohesive service delivery; may need to be mandated by national government; - Technology has enabled new services that generate extensive data: carshare, bikeshare, ridesourcing. - Ridesourcing, automation, and carshare may lead to more congestion and sprawl; - Bikeshare lowers to barriers to cycling, including in LICs, but poor street design, lack of payment methods, and limited internet connectivity may limit ridership;. - Carsharing can reduce car ownership, reduce need for parking, but its impact in LICs are unclear; Carsharing is not prevalent in sub-Saharan Africa or India; - LICs have many shared mobility options that may benefit from new technology; - Mobile-money (M-money) and unstructured supplementary service data (UUSD) are being used in LICs and MICs and have potential applications in HICs as well.
Innovative Business, Financial, and Regulatory Approaches
- Perceived commercial value has driven innovation in the urban mobility sector; the long-term financial viability of these new services is unclear; financial investment in LICs and MICs has not been as robust; - Mobility companies are diversifying their transport offerings, which could lead to “walled gardens”, where users can only access services affiliated with particular companies; - New financial mechanisms like blockchain and cryptocurrencies offer promise, but remain largely untested in the transportation field, especially in LICs and MICs; - Dynamic outcome-oriented policy frameworks could regulate transport services effectively in a rapidly evolving field.
Leadership Ecosystems
- Leadership ecosystems composed of the public sector, private sector, NGOs, and universities can improve coordination and collaboration in a complex, rapidly evolving mobility sector; - Including communities in decision-making leads to greater urban resilience.

Table 19: Key findings from the Improve section

Though powerful enablers, technology and big data are not ends in themselves, the means to achieve HVT and the risks and opportunities of technological applications need serious consideration. Technology-enabled shared and new mobility services, such as ridesourcing, bikeshare, carshare and automated vehicles, could complement existing transport options, especially when they are integrated. However, many studies have shown ridesourcing (one study has shown bikesharing) to increase vehicle travel. A number of studies have shown carsharing to lead to fewer car trips and increased public transit use. We need more research on the impact of these new services, particularly at larger scales and in LICs. Efficiencies in trip planning, fare payment, automation, traffic management, goods movement, and even moving less are increasing through technological advancements. However, these applications are significantly less developed in LICs. Other innovations such as urban freight and vehicle automation are largely untested, and we need more research to understand the positive and negative impact. Technology-enabled trip reduction innovations, particularly telecommuting, are less recent. Research has shown that telecommuting and telemedicine have a positive impact on access and the environment, but this research is mostly focused on HICs.

Commercial value has driven innovation in urban mobility, especially with the constraints of public funding on transport infrastructure. Recently, disruptive business models have pushed integrated mobility forward, leveraging alternative funding sources (such as venture capital) and expanding user information. The structure of business models and service packages is important to meeting HVT goals, as unsustainable or monopolistic businesses will fail to improve HVT. In terms of financing, we found that lending sources for technology, data infrastructure, and mobility integration are lacking in LICs. New financial innovations such as cryptocurrencies and blockchain may enable new efficiencies and potential for integration, but they are largely untested and unresearched. At the same time, new policy approaches, like the public-private innovation model and dynamic adaptive policymaking, provide flexibility for governments to leverage private capital and appropriate oversight. As governments move away from the direct operation of services, well-designed measures can help to remove delineations between modes and operators, and help to integrate HVT systems. Governments should, however, continue to manage long-term planning related to integrated mobility, such as efforts around climate resilience.

Finally, given the complex dynamics of the rapidly evolving integrated mobility space, leadership ecosystems made up of representatives across the industry, government, NGOs, civil society and research may lead to more effective and resilient HVT systems. Public and private sector stakeholders (including and beyond traditional transportation and planning roles) are key for leaders to understand how new regulations, technologies, business models and systems might affect different users and conditions. Equally, if not more, important, current and new players bring essential and synergistic knowledge, experience, and resources to ensure effective implementation and ongoing success on the ground. Increasingly, cities and private mobility companies are strategically moving to incorporate ecosystem development into their plans and operations in order to better design and deploy integrated mobility solutions worthy of further research. Since many of these ideas are new and relatively untested, we need much more research to understand their impact.

5.4.4. Key Research Gaps and Opportunities

The **Improve** section represents an emerging area within urban HVT in LICs. Our research focused on whole trip, whole-system HVT related to technology, innovation, and integration. We conducted scholarly and grey literature searches and consultations. While a small but growing body of literature focused on HICs, including in the areas noted below, we could not identify many sources relevant to LICs. Of the 132 sources we reviewed for this chapter, 120 were directly related to the report. Of those, none examined LICs and only 7 (6%) examined South Asia and sub-Saharan Africa, respectively. The literature is heavily concentrated on North America and to a lesser extent Europe and East Asia. (**Table 20** shows the research relevant to the paper.) The numbers do not sum to 120, as some papers covered multiple regions or did not cover a specific country or region at all.

	STUDIES PER ECONOMIC REGION (WORLD BANK DEFINITIONS)			STUDIES PER GEOGRAPHIC REGION (WORLD BANK REGION DEFINITIONS)						
REPORT SUBSECTION	HIC	MIC	LIC	EAST ASIA & PACIC	EUROPE & CENTRAL ASIA	LATIN AMERICA & CARIBBEAN	MIDDLE EAST & NORTH AFRICA	NORTH AMERICA	SOUTH ASIA	SUB-SAHARAN AFRICA
Integrative Technologies, Data, and Platforms	40	16	0	8	12	2	0	30	5	7
Innovative Business, Financial, and Regulatory Approaches	10	3	0	2	6	0	0	7	1	0
Leadership Ecosystems	1	1	0	0	0	0	0	1	1	0

Table 20: Research relevant to this paper

We provide a geographic assessment of sources in this section (see **Figure 25** below). The sources we found were heavily concentrated in the United States and, to a lesser extent, the most populous countries of China and India. We found some research in Europe, most notably in Finland. In most of Africa, we found little or no research at all, with the exception of Kenya.

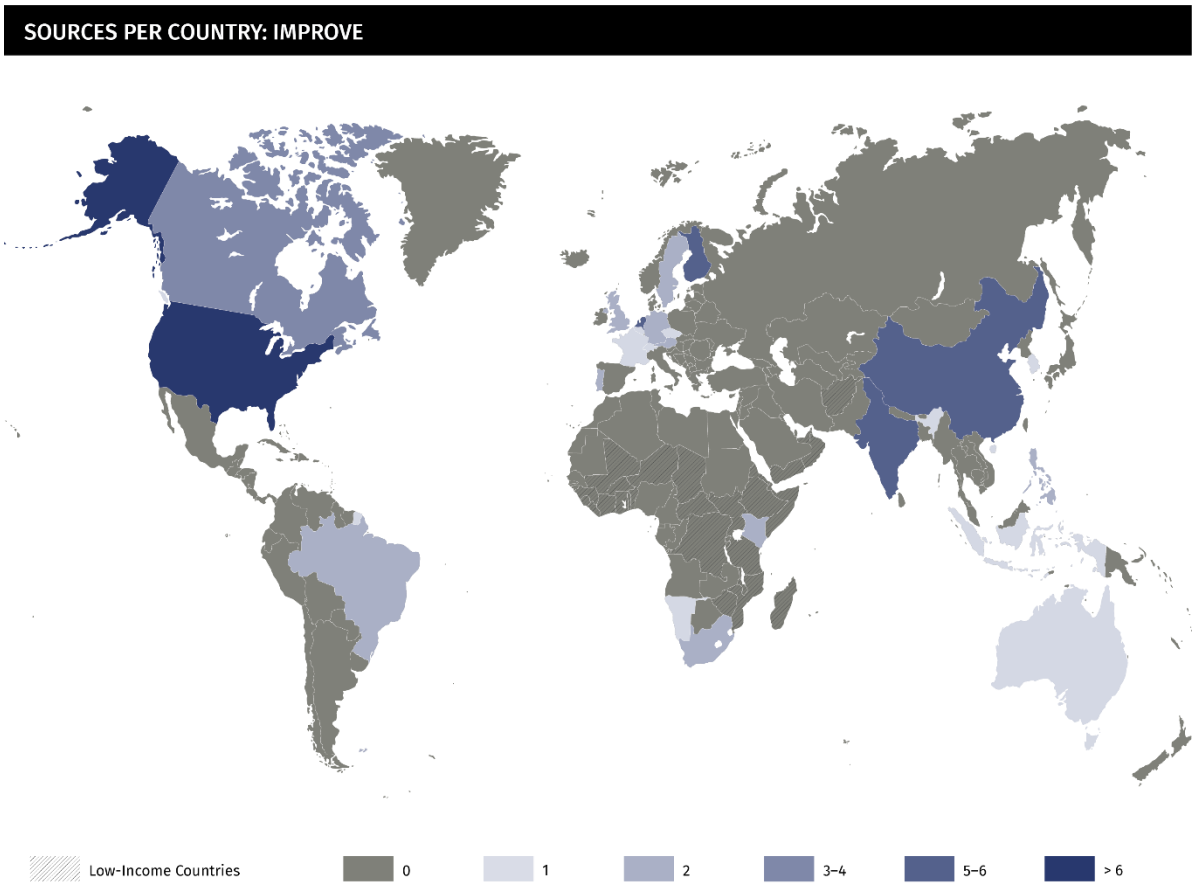

Figure 25: Distribution of Improve sources. Source: Created by the authors

It is possible that the factors affecting the understanding and adoption of MaaS-like approaches recently initiated by HICs may pose even greater barriers (real and perceived) or opportunities in LICs. These factors include complexity; leadership silos and ecosystems across government and industry sectors; technology challenges and opportunities; new business and financial models; and policy frameworks and incentives. Added to this, perceptions and evolution related to the digital divide may affect decisions and investments favouring integrated, technology-enabled MaaS-like HVT.

Related to the above, we posed the question whether MaaS-like HVT faces a knowledge gap, an implementation gap, or both. Based on the literature we could identify, along with selected consultations and internal expertise, the knowledge gap is closing in HICs, but an implementation gap remains (in terms of full deployment as distinguished from pilots and demonstrations). Uncertainty remains regarding the place of MaaS going forward, and whether it has changed or has the potential to change the way people travel(845). In LICs, there remains both a knowledge gap and an implementation gap in most of the areas below. The literature and consultations also suggest that the type and extent of these gaps vary by city and country. (We present a summary of the research gaps in **Table 21** below.)

Key Gaps Summary
Integrative Technologies, Data, and Platforms
- Given the digital divide, what are the best ways to use technology to bring about more efficiency for the user and make sure the benefits reach all people? - What are the impacts of new services, including ridesourcing, bikesharing, and carsharing, especially in LICs? Are there differences by user (age, gender, income, race, etc.) and location (i.e., higher-income cities versus lower-income cities)? - What are the skills needed by the public sector to use data and for what end? What are the barriers to using data in LICs and MICs? - Including informal transport options, what is the extent of shared mobility in LICs and MICs, how are they using technology now, and how can they incorporate more technology for more efficiency for both operations and the user? - What models are effective for operating bikeshare (station-based, dockless, and hybrid), especially in LICs? - How can telecommuting, telemedicine, etc. be used effectively in LICs and MICs?
Innovative Business, Financial, and Regulatory Approaches
- What are the right policy frameworks that facilitate integrative mobility? How can we apply dynamic adaptive policymaking in LICs and MICs? - What are sustainable financial models for mobility services in LICs and MICs? Can technology based mobility services be financially sustainable without venture capital? - How can informal mobility transition to a more formal shared mobility system? - How can LICs and MICs operationalise public-private innovation?
Enabling Leadership Ecosystems
- What are the challenges and opportunities to creating and enabling leadership ecosystems, especially in LICs and MICs?

Table 21: Key gaps in research for the Improve section

We describe the full set of research gaps related to the **Improve** section in greater detail below.

5.4.4.1. Integrative Technologies, Data, and Platforms

System-*Level Service Integration* in LICs

Additional research could accelerate the demonstration–learning–deployment cycle of MaaS-like ventures in LICs. System-level service integration generates complex questions around privacy, use, ownership, and monetisation of individuals' data. Combining public and private operators onto one platform raises concerns about data sharing, storage, and whether users can opt-out of sharing certain data with certain operators and still have access to the full system. These questions and others will require technical research.

Equity *I*mplications of *Service Integration*

Theoretically, integration reduces barriers to understanding and accessing an individual's transportation options, but what new barriers will we need to address? Are these barriers more or less burdensome to vulnerable populations, such as the elderly, low-income people, and children? How should we tailor integration approaches to operate successfully where the digital divide remains?

Impact of Technology on Urban Freight Systems

As technology enables new urban freight services, such as those combining passenger and freight trips, we need more research to assess the impact of existing services on HVT. Related research could address country- and city-specific freight system challenges and opportunities to apply new technologies and business models as solutions, which could serve as leapfrogging measures when adapted and applied to the LIC context.

Moving Less for High-Volume Access

As discussed above, moving less is an often overlooked component of the transport system. It is not about constraining mobility but about freeing users and businesses from unnecessary or inefficient trips. Specifically, the field would benefit from an examination of how internet access in HICs and related "smart city" developments have facilitated online banking, education, retail, medicine and remote employment, and the extent to which these conveniences have reduced unnecessary travel. It will also be helpful to understand which of these services can be realistically implemented in LICs (they could offer a leapfrogging opportunity where high-speed internet, mobile data, and other related services are less ubiquitous).

5.4.4.2. Innovative Business, Financial, and Regulatory Approaches

Community Willingness and Ability to Invest in Integrated Technology-Enabled HVT

As described in the previous sections, aside from local startup enterprises, there are significant gaps in the finance community's willingness or ability to invest in integrated technology-enabled HVT and sustainable development efforts. Reports like the United Nations' Finance for Sustainable Development shed light on this, but we need more research to understand how finance and business models can leverage the private sector towards more integrated and user-focused mobility systems. There is relatively little understanding about whether MaaS platforms are or will be sufficiently profitable to sustain private operators. Further questions arise when considering the incorporation of public services onto private platforms. Case study analysis would be useful for identifying opportunities, risks and existing good practices across a range of contexts and use cases.

Benefits of Blockchain and Cryptocurrencies

Peer-reviewed literature on cryptocurrencies, blockchain and their potential applications in mobility spheres could illuminate ways in which alternative currencies and systems could benefit HVT, how to mitigate potential risks, and how these could lead to leapfrogging in LICs. We need to pay attention to legal and regulatory challenges, security risks, and technology barriers.

Long-Term Sustainability of Venture Capital

Many technology-enabled, privately-operated mobility services are financed through venture capital, and there is uncertainty around the long-term sustainability of that model. What implications does this (often opaque) financing model have on existing public funding structures and other emerging hybrid financing approaches for transportation? If venture capital funding dries up and private mobility companies can no longer provide service, where does that leave the system?

Integrative Regulatory Models

Research in this area could help to identify regulatory models that have emerged in contexts in which top-down leadership cannot be responsive enough, or where capacity and political will is lacking. Aside from Finland's Act on Transport Services, we only identified a few other national or regional models that aim to facilitate integrative mobility, with a notable gap in LICs. As such, the documentation, evaluation, dissemination, and piloting of national and subnational policies that could be adapted and replicated would be useful.

5.4.4.3. Leadership Ecosystems

Research and Learning Supports Specific to 'Improve' (Technology, Innovation, and Integration)

Related to the fast-moving and innovative nature of the HVT Improve space, successful research endeavours may benefit from including more responsive engagements beyond strictly problem-focused desk research at a particular department or centre. This may include new platforms and approaches:

New Platforms:

- Development of a platform with searchable case studies, living examples, use cases, regulations, methodologies, business models, scaling, financing mechanisms, visioning processes, etc. to provide access to a broad range of examples that can be adapted/ customised, and applied elsewhere;
- Development of a range of online tools to enable simple and transparent assessment and data exchange for access to cumulative learning by all LICs;
- New networks across LICs and non-LICs, including dialogue, face-to-face visits, and other exchanges (south-south, south-north, public-private, and knowledge leadership);
- Courses and educational programmes for all potential movers of LIC HVT research and innovation;
- Online mentorships and speakers bureaus;
- Formation of local, multi-city or multi-country partnerships, from which to generate, gather and share data, insight, and inspiration from actual success and failure factors, thus accelerating the demonstration-learning-deployment cycle.

New Approaches:

- Identifying and pursuing research ideas stemming from leadership ecosystems;
- Development of LIC-customised state-of-the-art training and capacity building including technology, innovation, and integration relevant to urban HVT;
- Adopting a proactive approach to identifying opportunities as opposed to a reactive approach to address challenges;
- Involvement of users;

6. Conclusions and Recommendations

To develop this report, we reviewed over 900 sources and conducted over 28 interviews and 20 consultations with public officials, researchers, and leading experts to understand the state of knowledge for HVT. In this section, we first discuss headline results. Then we discuss the coverage of literature we identified and reviewed. We conclude with results from all four topic areas.

In this analysis, we discovered a wide range of knowledge of academic research across all four topic areas. We can break our results into the following categories: Needs for Urban HVT, Key Measures, Major Challenges and Knowledge Gaps, and Next Steps to Scale-Up Urban HVT. (See **Figure 26** below.) Needs for Urban HVT reiterates the five goals of HVT and the general activities we identified to meet those goals. These reflect the general concepts that helped frame the research but were also informed by the research. Key Measures describes the actions we identified that have been shown in the literature to improve access and support the other HVT goals. There is more evidence for these in HICs, so applications to MICs and LICs should be done cautiously with regard to the local context. Major Challenges and Knowledge Gaps describes

the primary areas we identified where HVT research and implementation capacity are lacking. From this, we identified key Next Steps to Scale-up Urban HVT. These are the priority areas for interventions to boost HVT. This includes new research areas, capacity building efforts, and stakeholders to target.

NEEDS FOR URBAN HVT	GOALS OF HVT	IDENTIFIED NEEDED ACTIVITIES	
	1. Improve access to needs/goods	1. Enable HVT measure implementation	
	2. Reduce environmental impact	2. Integrate land use and transport planning	
	3. Enhance safety	3. Improve walk, cycle, and public transport	
	4. Increase equity in transport	4. Reduce vehicle travel/improve efficiency	
	5. Use resources more efficiently	5. Integrate passenger and freight transport systems	
KEY MEASURES	Raise awareness with study tours, etc.	Eliminate parking requirements	
	Build capacity of local governments	Implement curb management and road pricing for passengers and goods	
	Develop integrated master plans	Establish proactive arterial/street grid in rapid growth areas	
	Develop walking and cycling infrastructure	Adopt responsive policy measures	
	Improve public transport quality	Encourage standardised data for HVT	
	Allocate dedicated space for HVT	Integrate fare payments and structures	
MAJOR CHALLENGES AND KNOWLEDGE GAPS	**KNOWLEDGE GAPS (GENERALLY)**	**CHALLENGES FOR URBAN HVT IMPLEMENTATION**	
	1. Translating measures to LICs	1. Lack of political will/understanding of HVT	
	2. Role of private and informal sector	2. Poor stakeholder and public engagement	
	3. Government/institution structures in LICs	3. Poor technical and managerial capacity	
	4. How to counter sprawl in LICs	4. Poor coordination within/across governments	
	5. Means of transport integration for passengers and freight	5. Lack of funding and authority with local government	
	6. Impact of new technology applications		
NEXT STEPS TO SCALE-UP URBAN HVT	**KNOWLEDGE NEEDED**	**CAPACITY BUILDING NEEDED**	**STAKEHOLDERS TO TARGET**
	1. Capacity needs assessments	1. Rapid practitioner (re)training programs	1. Local decision makers (politicians)
	2. Rapid response tools for rapid growth	2. Peer-to-peer outreach and study tours	2. Local transport practitioners
	3. Transforming informal sector in urban development and transport	3. Institutional guidance and assessment tool	3. National transport ministries
	4. Design of policies and institutions for low-capacity environments	4. Pilot projects with documented results	4. Development banks
	5. Using technology/MaaS to leapfrog car ownership	5. Locally adapted standards and guidance	5. Research institutions
	6. Identify and equitably meet the needs of vulnerable groups		

Figure 26: Key research findings and next steps

6.1. Overview of Sources

With regard to the HVT literature, based on our review, we generally found that across all topics, academic-level knowledge was focused on HICs and MICs, with little research on LICs. We found more information about measures and technologies that have been in use the longest and experienced the widest range of use, such as metro rail and bus operations. We also found more detailed assessments of measures in the places where those measures are most prevalent. For example, we found more rail studies in the Asian context (where rail is more prevalent) and more BRT studies in the Latin American context (where BRT is more commonplace). There are differences in how large and capital cities function, but we did not account for this directly in the research. Our experience is that bigger and more prominent cities are wealthier and better represented in the research, while smaller, secondary and tertiary cities are poorer and are less represented in the research. While we attempted to account for this in the capacity assessment interviews, we did not find significant differences, and we were not able to quantify differences in the literature review.

Many of the studies we found focused on case studies in one or a small number of locations. We also found many highly specific technical research papers, which examined specific sub-aspects of measures, such as the impact of fare collection technologies and bus lanes. Broader assessments of measures, including meta-analyses and literature reviews, were rare. The result of this landscape is a fragmented understanding of the effectiveness of various measures for supporting HVT.

Research in the **Improve** section came predominantly from HICs, but studies of topics in the **Avoid** and **Shift** sections also focused more on HICs. Only for the **Enabling Structures** section did a majority of papers cover MICs. HVT freight research was low across the board. In the key geographies of South Asia and sub-Saharan Africa, the amount of research was more or less comparable to research from other regions, especially other regions with many LICs and MICs. The most heavily researched topic area we identified is 'Shift: Modes and Services', which includes a large number of measures. Research from the Middle East and North Africa was particularly scarce. **Table 22** below shows the regional origin of the literature we reviewed in more detail.

		STUDIES PER ECONOMIC REGION (WORLD BANK DEFINITIONS)			STUDIES PER GEOGRAPHIC REGION (WORLD BANK REGION DEFINITIONS)						
REPORT SECTION	REPORT SUBSECTION	HIC	MIC	LIC	EAST ASIA & PACIC	EUROPE & CENTRAL ASIA	LATIN AMERICA & CARIBBEAN	MIDDLE EAST & NORTH AFRICA	NORTH AMERICA	SOUTH ASIA	SUB-SAHARAN AFRICA
ENABLING STRUCTURES	Building and Engaging Political and Community Will	13	28	2	9	11	15	0	12	11	11
	Governance and Institutions	31	46	2	26	18	21	1	16	19	17
	Education: Knowledge, Capacity, and Research	0	9	0	3	1	4	0	1	6	4
	Funding and Finance	13	21	1	16	5	12	0	8	14	8
AVOID	Regulation of Land Use and Built Form	58	36	2	20	9	12	1	41	13	10
	Metropolitan Compact Growth and Urban Retrofit Measures	14	19	11	10	9	11	3	9	9	13
	Land Use and Urban Design for Freight	13	2	1	3	7	0	0	6	1	2
SHIFT	Infrastructure	26	36	4	22	8	17	0	12	12	10
	Modes and Services	75	28	3	27	33	9	3	41	12	17
	Travel Demand Management	39	11	1	7	13	5	0	25	4	3
	Urban Freight Services and Regulations	1	6	2	1	1	1	0	0	0	5
IMPROVE	Integrative Technologies, Data, and Platforms	40	16	0	8	12	2	0	30	5	7
	Innovative Business, Financial, and Regulatory Approaches	10	3	0	2	6	0	0	7	1	0
	Leadership Ecosystems	1	1	0	0	0	0	0	1	1	0

Table 22: Literature by region and topic

6.2. Key Results

The following section provides an overview of key results stemming from the research, aggregating results from the individual sections.

6.2.1. Enabling Structures

The **Enabling Structures** research identified a number of key factors supporting the implementation of HVT measures. The literature and interviews suggest that a lack of understanding of HVT and political will to implement HVT may be the biggest impediment to enacting HVT measures. Improved communications about the benefits of HVT and engagement with a broader group of stakeholders can help build political will and more resilient projects, in some circumstances. Finally, in our interviews, we found that there is a bias toward large projects, which are associated with more risk and less community engagement.

We found that more integrated governance structures are important to supporting measure implementation. While strong institutions are more effective at implementing policy, they are more resistant to change;

informal structures have greater flexibility. In LICs and MICs, the process of formalisation of transport services may increase government capacity and lead to safer and more efficient transport systems, but this may also lead to increased costs. The private sector can complement government in service provision if structured well, but further study is needed. The literature suggests that the national level can provide guidance, coordination, and resources for HVT implementation, but that the municipal and metropolitan levels may be best suited to implementing HVT measures if capacity exists.

The education and capacity of decision makers in government is also hypothesised in grey literature to play a key role in measure implementation. Multiple guides have been produced specifically to boost local implementation capacity. This topic has not been well addressed in academic research. There is a particular need to better understand the role of leadership in better integrating agencies within governments.

In terms of funding, multiple researchers advocate for beneficiaries of measures to pay the cost of their implementation. In practice, many capital funding sources appear to be unrelated to policy beneficiaries. The literature suggests that the funding of service operations is more directly tied to beneficiaries through user fees but many places also subsidise services for low-income populations to improve equity. Many grey literature sources emphasise the need for continuous financial flow to support the raising of capital funds through debt as well as to support ongoing subsidies to operations.

As shown in the research, the process of successful HVT measure implementation involves a multitude of factors to addresses key problems. These factors include understanding the problems to be addressed; understanding which measures are effective in which contexts and how to adapt measures to local contexts; building the capacity and political will to implement them; securing funding; and measuring continued progress over time. In LIC and MIC contexts, and often in the HIC context, some of these factors may be missing. To help with this, other partners may bridge gaps in terms of evidence, capacity building measures and finance. Below is a brief list of potential partners and their roles:

- United Nations organisations: These include the United Nations Human Settlements Programme (UN-Habitat) and the United Nations Environment Programme (UNEP), which foster collaboration between national governments, NGOs, and multilateral and bilateral development banks (MDBs). They help to spread HVT measures and good practices. They also help to track progress through the measurement of SDGs related to urban HVT;
- International partnerships: Coalitions of international MDBs, NGOs, and private sector organisations, such as Sustainable Mobility for All (SUM4All) and the Partnership on Sustainable Low Carbon Transport (SLoCaT), build consensus among the various actors in the HVT space. This helps coordinate action and enables the coalition to speak with a collective and more powerful voice for HVT measures to influence government decisions;
- Multilateral and bilateral development banks (MDBs): Interview subjects in Africa noted a lack of data as a constraint to HVT implementation. MDBs can support HVT by encouraging the collection of rigorous and uniform data on HVT and the opening of data as part of their projects This could set the stage for regular collection of data, creating a baseline for measuring progress of HVT goals. The World Bank's Open Data Institute is a good first step. MDBs can also support the investment in transport data. To further this, MDBs could fund evaluations of project implementation to help document lessons to share with others internally and externally. In our review, we also found evidence of persistent car-centric planning by government staff. MDBs can encourage more HVT training and capacity building as part of their projects. This can be particularly useful to retrain technical staff in HVT, as opposed to the car-centric planning used in many places. However, more resources for car-centric planning could hinder HVT goals. MDBs may consider sector-wide interventions where capacity building is part of the investment package. The research shows that

many big HVT infrastructure projects are not well operated or maintained, leading to failed investments. Capacity building is integral to the successful implementation of HVT. MDBs are a catalytic voice for financing and funding HVT. While MDB funding represents a small percentage of overall transport funding, they can influence national governments and link to and enforce international normative frameworks, like the Paris Agreement and the SDGs;

- National governments: National governments are the main sources of financing and funding for HVT infrastructure. They can also establish institutional structures for metropolitan coordination and set national standards for HVT measures. Many have capacity building programmes that can support implementation if they are developed. Finally, nationally determined contributions (NDCs) are a lever for advancing HVT in countries. Often, national governments neglect urban transport or only fund large infrastructure projects, some of which (such as urban highways) run counter to HVT goals. Continuous education and raising awareness about the changes in the field of HVT can help ensure that national governments effectively support HVT;
- Subnational governments: State and local governments are the main implementers of HVT projects and policies and will be the focus of capacity building efforts and targets of information and technical awareness raising. They may also play a role in establishing institutions to coordinate HVT measures across metropolitan areas;
- International and local NGOs: This includes international non-governmental organisations like ITDP, WRI, and networks such as the C40, as well as local organisations engaged in furthering HVT goals, such as Transporte Ativo in Brazil. These organisations can help with setting normative frameworks to build community consensus and technical awareness about what makes HVT work. They can act as the bridge between research and action, ensuring research is reaching the right audiences of practitioners. They can act as facilitators of capacity building activities;
- Development agencies: This includes national development agencies such as GIZ, AFD and DFID. These agencies can help establish normative frameworks and fund research to better understand challenges to achieving HVT. They can build technical awareness through developing and promoting publications and guidance. These agencies can fund and facilitate capacity building to increase government ability to implement HVT measures.
- Research Institutions and networks: Universities and research consortiums and centres (e.g., the Volvo Research and Educational Foundations' Centres of Excellence for research) will be strong partners to make sure evidence is being collected and tested about how to increase HVT in cities around the world. They help ensure that measures lead to desired results in different locations.

A unified message from the actors mentioned above could increase the impact of these organisations' individual activities. The DFID Phase 2 research programme has the opportunity to help align different actors towards a shared sense of gaps and needs for research and practitioners. At the very least, this next stage of the HVT programme should reach out to these partners to ensure that the research agenda and findings, as well as capacity building means, are being coordinated with these other actors.

6.2.2. Avoid

In the Land Use and Urban Development section ('**Avoid**'), the literature suggests that a clear metropolitan-wide vision, effective coordination between land-use and transportation planning actors, and effective governance structures to implement the vision and plans are key to developing land use that supports HVT. Within this framework, there are a variety of examples of success shown in the literature. The results were less clear on the role of national and subnational governments. There were many tools discussed in the literature, including land value capture and town planning schemes, that show promise as tools to implement and finance land-use plans, although the details of measure implementation vary widely. Finally, the

literature suggests that more inclusive methods of planning may be more effective at upgrading informal settlements to better achieve HVT.

The path to achieving sustainable HVT systems is not clear for cities in LICs and MICs, where the capacity to facilitate such metropolitan-scale coordination and vision are often lacking. Several authors suggest simpler regulations to reduce the capacity burden on government. Some efforts have also been made to prepare land for urban expansion, such as creating gridded street networks that support HVT, for both formal and informal development. Major gaps, however, include the tools governments in LICs might use to regulate land use, generate affordable housing, and better integrate informal settlements into cities.

A number of guides provide recommendations on the specifics of how street and arterial networks should be planned. There is strong evidence that relatively high densities and a mixture of land uses are effective in supporting HVT. The literature suggests multiple strategies for changing land uses based on different levels of government intervention. In terms of maintaining socioeconomic diversity, multiple tools have shown success, particularly in LICs, including increasing density, limiting the size of housing units, and selling additional development rights to fund affordable housing. Other tools, such as inclusionary housing incentives and tax increment financing, have been shown to work well in HICs.

Urban design factors, such as active frontages and functional street lighting, have been shown in the literature to strongly support walking in HICs. Design standards are used in many HIC cities and some MIC cities to facilitate environments that support walking. In addition, a greater supply of off-street parking is shown to lead to additional driving. The research also suggests that increasing the price of that parking may be an effective way to reduce parking demand and shift driving trips to other modes. Urban freight, however, has been studied less extensively, particularly in LICs. In that context, the research suggests that planning for freight is rare and often done at the regional or national level. Finally, the impact of new mobility services on land use is not clear in the literature. It may reduce car ownership and lead to more compact cities, or it may lead to longer and more frequent vehicle trips and consequently to greater sprawl. More research is needed on urban freight, parking and New Mobility as they relate to land use.

6.2.3. Shift

The information about transport infrastructure, modes, services and supporting regulations ('**Shift**') was the most technically robust of the four topics reviewed, but it focused on specific cases, rather than on a broader understanding. The literature suggests a positive link between increasing income and the use of private motor vehicles, while increases in density and the provision of HVT measures and infrastructure are related to declining private motor vehicle use. The literature suggests that increased street density and connectivity, particularly around transit stations, may lead to declines in private motor vehicle use. A number of studies have shown that dedicating space to specific HVT modes—walking, cycling, bus, rail, and HOVs—is associated with increased efficiency, accessibility, equity, road safety, and decreased environmental impact. Finally, the literature links most road expansion to congestion and sprawl, but governments continue to expand road capacity to ease congestion. The street network, however, may benefit from increased connectivity as many cities in LICs and MICs have an insufficient network. This disconnect requires further study.

The provision of walking and cycling facilities is related to improved safety and health but is often neglected in LICs and MICs, despite a greater prevalence due to lower incomes. Public transport usage varies widely around the world. Rail and buses provide most service in HICs and paratransit vehicles provide most service in LICs. The literature suggests that increases in public transit supply can help reduce traffic congestion. High public transport use is associated with lower greenhouse gas emissions and lower energy consumption. Urban rail and BRT, in particular, are associated with higher land values and greater use of public transport in nearby areas. Research indicates that BRT is the more cost-effective solution and may be expanded more quickly, but that rail has the advantage in operational speeds. BRT systems, particularly in LICs, have also

experienced implementation challenges, including overcrowding, poor maintenance and low frequencies and are often regarded as 'second best'. Fare revenues often do not cover operating expenses. Many LIC and MIC governments, including in sub-Saharan Africa and South Asia, are reluctant to provide operating subsidies, which leads to deteriorating service quality. Paratransit, or informal public transport, comprises the majority of public transport services in LICs, but it is associated with a lack of affordability and flexibility, poor road safety, poor quality of service, and an inequitable distribution of service.

For public transit, walking and cycling, having a well-connected network is critical to improving HVT mode share. After that, the quality of service or infrastructure is the net driver for HTV mode share. For public transport, many users in LICs and MICs are sensitive to the affordability of services. In terms of service quality, users are sensitive to reliability, frequency, comfort, and safety—both in terms of personal security, especially for women, and road safety. In LICs and MICs, road safety is a main concern as those counties bear the burden of road crashes. Speed is the biggest factor in fatalities and injuries; the most vulnerable road users, pedestrians and cyclists, suffer the most. Motorcycle usage is rising in LICs and MICs exacerbating poor road safety. Not much is known about how best to regulate motorcycles.

Travel demand management (TDM) measures, which aim to reduce demand for private motor vehicle travel, have spread from HICs around the world. With regard to parking, the literature suggests that the demand for on-street parking often exceeds the supply, leading to negative externalities, such as increased vehicle kilometers travelled. The literature suggests that pricing and access restrictions can be important tools to manage parking and to avoid negative impacts. Additional research is needed to better understand how parking and curb space can be managed for TNCs, automated vehicles and urban freight, particularly in LICs. Road charging or 'congestion pricing', in particular, has been shown to reduce congestion and emissions while raising revenue for governments, but researchers have found that the policy context and the planned use of revenue are important to political success. However, studies of traffic bans, commonly implemented in Latin America, have shown these measures to be ineffective at reducing congestion beyond the short term and to lead to the additional purchase of cars.

The urban freight sector represents a large and growing portion of urban transport trips. Many academic studies have examined route efficiency, supply chain management, consolidation centres, non-motorised last-mile modes, and information and communication technology to improve the efficiency and sustainability of urban freight. The research in urban freight is dominated by HICs, while assessments in LICs have documented challenges such as extortion, poor road conditions, and insecurity. Many of the research gaps are from a lack of research in LICs, including the provision and distribution of infrastructure and services, the process and structures for upgrading services, TDM, walking and cycling, and intermediate modes for freight delivery. Other key research gaps include measures for new mobility services and freight, broader geographical coverage for different modes, and better data and technology for monitoring progress.

6.2.4. Improve

In the Technology, Innovation, and Integration section ('**Improve**'), we found a relatively small amount of academic research, possibly due to the rapid pace of change in the topic area. There was, however, not a lack of interest in the field. Many academics are closely following such changes, but owing to the time frame required to produce academic-quality research, the research may be outdated by the time it is published. This suggests that a different approach to research may be necessary to facilitate the understanding of this shifting topic. Academics have already adopted strategies to develop more rapid and qualitative assessments of trends and understanding based on expert consensus. There may be a greater need for such strategies as technology continues change rapidly.

Recent research on information and modal integration reflects a growing shift from thinking about transport in terms of modes that compete with each other for users, towards thinking about transport as a series of

modes that can be combined to serve a variety of different trips, a concept known as 'Mobility-as-a-Service'. MaaS has benefitted from New Mobility options—TNCs, bikeshare, and carsharing—which have grow substantially in the past decade. Research has shown that while these new technologies show promise in reducing pollution and congestion, TNCs have led to an increase in vehicle traffic in some places. In addition, many of the private business models that support these modes may include conflicts of interest that impede their success. There is some evidence, however, that carsharing has promoted a shift away from private motor vehicle ownership and use.

From a technology perspective, the literature suggests that the 'digital divide' appears to be eroding, with a growing presence of mobile and smartphones around the world. Now, the divide seems to reflect a lack of access to data and internet service. Investment in technology and big data support the next wave of transportation improvements. Having the right technology network as a foundation could be an enabler of HVT. Vehicle automation could produce a variety of effects, which could include both improved road safety and reduced emissions, as well as increased road congestion and significant job loss in the transport sector. Researchers hypothesise that automated vehicles will become prevalent in HICs earlier than in LICs owing to the high cost of the technology. New technology is also enabling new means of data collection to better understand, regulate, integrate and improve existing services. This new technology and data also pose risks, particularly regarding privacy.

New technology has fostered the rise of new business models, seen in TNCs and other New Mobility companies, that have grown rapidly in recent years. Business models specific to MaaS, however, have experienced obstacles to profit and growth, despite popularity among users. To catalyse new businesses and leadership environments, several HICs have created national programmes that fund innovative businesses in the transport sector working towards a MaaS vision.

Key research gaps include studies on more flexible, outcome-oriented policy frameworks, such as dynamic adaptive policymaking, as well as the development of sustainable financing and business models. In addition, more research is needed on the role of leadership ecosystems in supporting more integrated and innovative transport systems. The freight sector, in particular, has received less attention and would benefit from additional research. Finally, the research needs are particularly strong in LICs to better understand the potential for leapfrogging (i.e., achieving rapid progress via new technology and integration).

Overall, we found a considerable amount of research on the implementation and assessment of HVT measures around the world. HVT measures are the most extensively implemented and studied in HICs, but some measures, such as BRT, have been implemented more in MICs. Measures that have the longest history of implementation, such as metros, are the most widely implemented and studied. However, some measures, like congestion pricing, have not gained widespread adoption, despite documented successes over decades. Some newer HVT measures, such as bikeshare, have spread rapidly around the world, and are attracting commensurate research. Generally, the measures that promote HVT are frequently found in the mainstream of academia, civil society, development banks, United Nations organisations, most HIC governments, and many MIC governments. Yet acceptance of implementation of HVT measures has lagged. LICs have seen little HVT implementation or research, despite rapid urbanisation and economic growth, with the exception of some urban growth assessments. In South Asia and sub-Saharan Africa, many decision makers and technical practitioners are unfamiliar with HVT measures and appear to be strongly influenced by the auto-centric approach to transport and urban development developed in the United States. The most pressing next step is to increase understanding and acceptance of HVT among technical practitioners and decision makers to increase implementation of HVT measures around the world and to document these measures and implementation processes rigorously.

6.3. Next Steps

After reviewing 900 sources and 48 interviews, ITDP identified twelve actions that governments, development institutions, NGOs, and practitioners could start doing to galvanise HVT. (See **Figure 27** below.)

Figure 27: Actions to galvanise HVT

ITDP's review also revealed over 40 gaps that could be addressed in a future research programme on urban HVT, as well as some key needs for capacity building in the regions of sub-Saharan Africa and South Asia.

Around half of the gaps identified specifically address a lack of knowledge about LICs and MICs, with many of them directly related to informality. Given what appears to be a unique lack of focus on these areas, we recommend that a future research programme focuses on issues in LICs and MICs through the lens of informality, as it seems to be a defining characteristic of transportation in these cities. We need to understand how weaker institutions and informality impact the transportation system and how we can strengthen those institutions and transform the informal sector. Another issue that seemed to dominant in all sections is how to translate HVT measures and policies to LIC and MIC contexts. Finally, for LICs and MICs, we need to understand the challenge of rapid growth within the context of informality and weaker institution.

Technology, data and the rise of new mobility needs more research, as does freight more broadly. These issues could mean more research on the role of the private and public sectors, given the pace of change. Additionally, climate change will necessitate more research on adaptation and resilience. Finally, we need a better sense of different users' needs and behaviors (e.g., women, the young and old, the disabled, the lower income, different ethnicities and races.) People travel differently and it is important to know how and why.

We found the biggest questions for urban HVT implementation in the enabling section. Political will and leadership are key enablers, but we need to better understand how to cultivate that will. We also need to understand how to build functional and nimble institutions that can address the governance concerns in metropolitan regions. Capacity building is a potent agent of change, yet it is not clear what mechanisms are the most effective, how to measure impact, and what capacities need to be built. Finally, the perennial problem of a lack of funding and financing needs more work to help figure out solutions. (**Figure 28** outlines the major challenges and knowledge gaps we identified.)

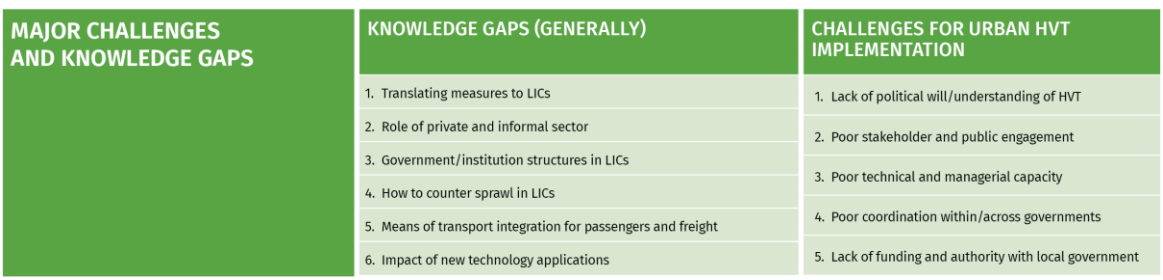

Figure 28: Key knowledge gaps and implementation challenges

We present a more detailed list of these issues below. Each section in the State of Knowledge chapter also concludes with a more detailed expounding of these topics.

1. **Research in Low- and Middle-Income Countries**

1.1. Informality

1.1.1. Land-Use Management

- Setting Density, Infrastructure, and Accessibility Goals for Rapid Urban Expansion
- Integrating Informal Settlements and Urban Villages
- Rapid Growth Planning Tools for LICs
- Road Network Standards for LICs and Informal Settlements
- Mixed Land Uses in LICs and Informal Settlements
- Affordable Housing Incentives in Informal Settlements

1.1.2. Infrastructure, Services, and Policies

- Transit Services in Informal Areas
- Walking and Cycling in Rural–Urban Transitions
- Upgrading and Integrating Informal Transit Systems
- Enabling Structures for Modernising and Integrating Public Transport Systems

1.2. Enabling Structures

- Private Sector and Informal Sector Involvement in HVT
- Policy Implementation Process in LICs
- Relationships and Negotiations with Private Operators in LICs and MICs
- Institutional Structures in LICs and MICs
- Raising Revenue in LICs
- Public–Private Partnerships in LICs

1.3. Infrastructure, Services, and Policies

- Infrastructure for HVT in Developing Countries
- TDM User Behaviour Impact in MICs and LICs
- Accessibility and Income in LICs and MICs
- HVT in LICs (moving people, moving goods and moving less)

1.4. Urban Freight

- Urban Freight in Africa
- Sustainable Urban (LIC HVT) Freight Systems

2. **General Research**

2.1. Enabling Structures

- Equity, Politics, and the Role of Citizen Involvement
- Role of Capacity and Capacity Building as a Potent Agent of Change
- Role of Citizen Experience as an Enabler of HVT Policy
- Implementation or Knowledge Gaps
- Metropolitan Integration
- Role of Leadership
- Integrative Policy Models
- Research and Learning Supports Specific to Technology, Innovation, and Integration
- Competing Narratives and the Effectiveness of Policies
- Data and Technology for Intervention Monitoring and Mapping

2.2. New Mobility and Technology

- MaaS-like Service Integration (moving people, moving goods and moving less)
- Business and Financing Models
- New Mobility, Land Use, and Urban Form
- Incorporating On-Demand Services into HVT
- Flexible Policy Approaches to On-Demand Services

2.3. Freight

- Urban Freight Land-Use Policies
- Non-Motorised Freight
- Curb Management for Freight Deliveries

2.4. Infrastructure, Services, and Policies

- Parking Policy
- Non-Dominant Infrastructure
- Residential Self-Selection

- Moving Less for High-Volume Access

To take this knowledge into practice, we recommend developing some tools for rapid assessment of institutions and capacity, as well as tools to help with policy design, informal sector transformation, and inclusion. Given the pace of change, researchers, trainers and policymakers need to be flexible in their approaches. It also means providing measures and capacity building must address local conditions. Overall, the science on HVT is clear and the trends show that it is on its way to being mainstream. With this research and capacity building, we can scale HVT for an equitable and inclusive future that mitigates the effects of climate change. (See **Figure 29.**)

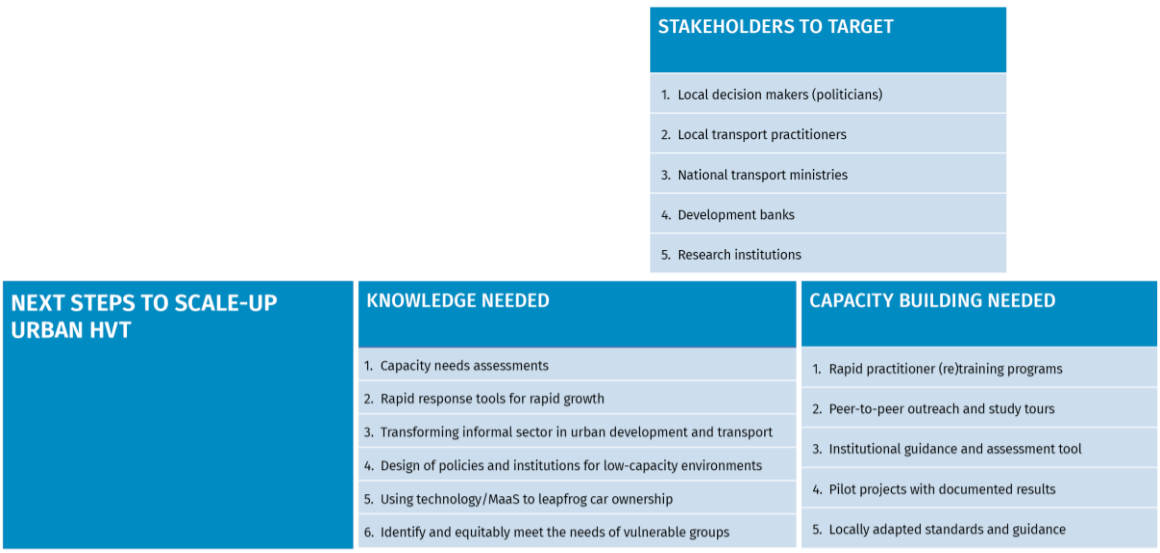

Figure 29: Next steps to scale-up urban HVT

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Appendix A: Interview Protocol

1. Overall Study Purpose, Design, and Procedures

1.1. Study Purpose and Rationale

The UK's Department for International Development has engaged ITDP to research the implementation of high-volume transportation (HVT)—urban transportation that improves access to destinations in an equitable, safe and environmentally friendly way. This study examines the implementation strategies of public and private sector stakeholders for HVT systems in countries in South Asia and Africa. Researchers will gather qualitative data from interviews with planners in national, state, metropolitan and municipal governments, public transportation operators, private and civil sector representatives in India, Ethiopia, Kenya, Zambia, Nigeria, and Ghana. The interviews seek to identify successful strategies for, as well as barriers to, implementation of HVT systems, including the infrastructure, services, policies, actors, and institutions that comprise them. The interviews include discussions of policy transfer from high-income countries as well as South-South cooperation. The study intends to inform a research and capacity-building programme that can contribute to improving the efficacy of policy transfer for the successful implementation of HVT systems.

1.2. Study Design

This study employs qualitative methodology (interviews) to gather information on the transfer of policies and implementation of projects for HVT systems in South Asia and sub-Saharan Africa from the perspective of planners in the public and private sectors. The researchers plan to interview 28-35 government and private sector employees from a variety of national, state and local jurisdictions, jointly selected by ITDP and DFID/IMC. The geographic selection was based on the following goals and constraints:

- Produce results in a narrow timeframe by focusing on areas with strong existing relationships with ITDP, the PMU team, and DFID;
- Reflect a range of conditions by selecting locations representative of conditions across each region and within each country;
- Reflect a range of levels of government by selecting at least two levels of governance in each region;
- Reflect strategic importance by selecting DFID-defined low-income countries that are experiencing rapid urban growth and have significant levels of informality;
- Avoid overlap with other research themes by working with the other research teams.

No children, minors or at-risk populations will be interviewed.

1.3. Research Questions

Note: these are not the specific interview questions but rather questions that guide the entire research process.

Central Question:
What are the key aspects of successful strategies for, and barriers to, the implementation, operation and maintenance of HVT (a.k.a. sustainable transport) in the selected countries, states and cities?

Subquestion:
Under what conditions could policy transfer contribute to implementing, operating and maintaining HVT systems effectively in the selected countries, states, and cities?

1.4. Scientific Abstract

The broad objective of this study is to inform a research and capacity-building programme that contributes to the successful implementation of HVT systems in cities in South Asia and Africa. The subject population is public and private sector decision makers in these regions. The subject population is a non-representative (convenience) sample of decision makers in these cities. Researchers will analyse qualitative data from interviews with these decision makers to discover facilitating factors for, and barriers to, the implementation of HVT systems in the cities in the sample. This analysis will seek to uncover common themes and key differences, as well as emerging topics for sustainable urban transportation.

The countries, states, and cities in the sample have been selected because they are representative of the diversity of their respective regions (South Asia and sub-Saharan Africa).

In South Asia, researchers will gather data in one country, India. Because India is large and diverse, the researchers have chosen three states that reflect different conditions in that country: one in the South (Tamil Nadu), one in the West (Maharashtra), and one in the North (Jharkhand).

Researchers will gather data in four countries in three different regions of sub-Saharan Africa: Eastern Africa (Ethiopia and Kenya), Southern Africa (Zambia), and Western Africa (Ghana). This selection is based on the following criteria:

- Produce results in narrow timeframe by focusing on areas with strong existing relationships with ITDP, the PMU team, and DFID (convenience sample);
- Reflect a range of conditions by selecting locations representative of conditions across each region and within each country;
- Reflect a range of levels of government by selecting at least two levels of governance in each region;
- Reflect strategic importance by selecting DFID-defined low-income countries that are experiencing rapid urban growth and have significant levels of informality;
- Avoid overlap with other research themes by working with the other research teams.

The cities in the sample are primary or secondary cities in their respective states (in India) and countries (in sub-Saharan Africa). Primary cities are the most populous cities in their states or countries, and secondary cities belong to a second tier of cities in a country or state in terms of population. Compared with other parts of their respective countries and states, primary cities have populations with higher levels of education and income, and are centres of culture, commerce, and administration.

The participants in the study will be selected via convenience and snowball methods. The first group of participants will be recruited based on pre-existing relationships with the researchers and their knowledge of implementation and policy transfer of HVT policies (convenience sample). Researchers will then ask these participants to recommend other interview subjects (snowball sample).

Interviews will be recorded and transcribed by field researchers. These will be stored in a central database. The researchers will use “lean coding” (1) to organise the content of the interviews into themes.

This research aims to uncover key factors that could facilitate the successful implementation and possibly the transfer of sustainable urban transportation policies in South Asia and sub-Saharan Africa. To the best of our knowledge this is the first study that examines this topic. As such, this study may be of great use to researchers and practitioners who seek to improve the social equity and environmental sustainability of urban transportation systems in these two regions.

1.5. Study Procedures

This study uses qualitative research methods. Researchers will conduct guided, but open-ended, in-depth interviews to collect data from policymakers, public transportation service providers and private sector leaders.

1.5.1. Study Setting

The study will be carried out in national, state, metropolitan and municipal governments; public transportation operators; and private sector organisations in India, Ethiopia, Kenya, Zambia, Nigeria, and Ghana. These places have significant populations living in informal settlements, and informal public transportation systems are also present in all the locations.

1.5.2. Study Participants

The researchers estimate that 28-35 subjects will participate in this study, with each interview lasting approximately 60 minutes. The target groups of this study are policymakers from government, managers of public transportation operating companies, and leaders of the private sector, local NGOs, and international organisations involved with urban transportation systems. We will place a strong preference for senior leaders who have the most knowledge of capacity and structural conditions and constraints.

Of these, 4-6 participants will probably come from national governments (4), 4-6 from state governments (3), 8-12 from municipal governments (7), 3-6 from transportation operating companies, and 6-9 participants from private-sector organisations and/or NGOs (both local and international). We expect that the most individuals in this study will be men, given that many policymakers, transportation operators, and business leaders are male. There will be no children interviewed or involved in this research. Participants will be selected to reflect the public and private sectors.

1.5.3. Data Collection

The lead researchers and field researchers are employed by or affiliated with ITDP, an international NGO that has been working in these two regions since the 1990s. ITDP has pre-existing relationships with key players and potential interview subjects in these cities.

Staff in ITDP field offices in South Asia and sub-Saharan Africa will identify potential interview subjects for this study based on their knowledge of, and relationships with, urban transportation planners and operators in the selected cities, states, and national governments. Further, when needed the field staff will ask these contacts to identify other potential interview subjects. The interview subjects will be a nonrandom sample of policymakers and private-sector actors, and will be recruited using the convenience and snowball methods.

Researchers will carry out in-depth interviews face-to-face with subjects. Government employees and public transportation operators will be interviewed in their private offices, homes, or public spaces, such as a café and outdoor eating area. This approach is culturally sensitive to the social norms of each group of participants. When face-to-face interviews are not possible, researchers will conduct interviews via telephone or web-based tools (e.g., Skype).

The objectives of the in-depth interviews are to gain a deeper understanding of the conditions that could allow for the implementation and ongoing successful functioning of HVT systems. The researchers' intention is to inform a capacity-building and research programme that can effectively support the creation of such urban transportation systems. The information obtained will be transcribed from hand-written notes and recordings for analysis, if the interview subject formally and freely agrees to be recorded. A direct form of content analysis will not be used, but categories will be created and analysed to identify sub-themes and themes, and to identify the areas of urban transportation with the potential for high-impact capacity-building and research. Any audio recordings will be stored on ITDP's internal network.

1.6. Recruitment

Researchers will recruit study participants through telephone and/or email notifications.

Field researchers will initially use their professional networks to recruit interview subjects. For subjects recruited via snowball methods, researchers will explain that the potential subject's contact information was obtained through a colleague or acquaintance who knows the subject.

1.7. Informed Consent Process

Researchers will obtain verbal consent from all participants. This consent will include the possibility that participants can remove themselves from the study at any time, and that the decision to participate or not to participate will not jeopardise their professional standings.

During the verbal consent process, the investigator will verbally express who he/she is, the reasons for the study, the fact that they are not obligated to answer questions that would make them uncomfortable, and that they have a right to stop the interview at any time. The researchers will also ask permission to record the conversation via written notes and on an electronic recording device.

Field researchers may adapt the verbal consent script included in this protocol (section 2.5) to best fit local cultural norms and makes study participants feel as comfortable as possible in the interview.

All interview subject will be identified generically to provide anonymity. At the close of the interview, the field researchers will ask the interview how they'd like to be identified. For example, "municipal transportation planner, Accra."

1.8. Potential Risks

There are only minimal risks associated with participation in this research. Interviewees who feel uncomfortable will be told that they may stop participating at any time. During interviews, no questions will be asked of participants to reveal specific insider information about their companies or organisations, which could pose a risk to their professional or social standings if such responses were disclosed. Instead, questions will be framed broadly to gain insight without exposing specific people or important information.

We will ask to study participants to illustrate their answers with concrete examples as much as possible without putting themselves at risk professionally. We will tell them that we will share our notes and possible attributions with them later to make sure they are comfortable with the information we are including in the study and the way we are attributing it.

Further, the investigator will ask interview subjects explicitly if they prefer not to identify their names in the study. In this case, the researchers will not identify subjects except generically in reports and/or research papers, for example, as “municipal government officials, Accra.” If the participants would prefer even more anonymity, or if we deem this would be desirable because of the sensitivity of the information, we may attribute the data in a more anonymous way (e.g., “transportation official, African municipality” or “Transportation Planner 1, Accra”).

Field researchers will preserve the confidentiality of study participants by keeping their names only on documents viewed by ITDP staff. Data from the interviews will be shared with those outside of ITDP only after study participants’ names have been made anonymous as described above.

1.9. Data and Safety Monitoring

Data backups of notes from library research and transcriptions of interviews will be stored locally, on the ITDP field office’s network, and backed up in an online directory (“cloud”) that is only accessible by ITDP staff and associates directly related to the DFID HVT project. As stated above, this data will only be uploaded to the cloud after they have been made anonymous.

The research manager for this project, Jacob Mason, will perform the data and safety monitoring for this protocol.

If adverse events or unanticipated problems occur, Jacob Mason will consult with the team leads of this project, and contact the DFID and project management group, IMC, if necessary.

1.10. Potential Benefits

This research project has the potential to identify ways in which HVT systems can be effectively implemented and maintained in South Asia and Africa. It will inform capacity-building and research programmes in the selected countries that will be carried out by DFID directly following the conclusion of this study. The study will directly inform these capacity-building and research efforts, helping ensure these will be effective in supporting HVT systems in the places of study.

2. Instructions to Field Researchers

2.1. Overview and Procedure

We will be conducting 28-35 interviews with policymakers from government, managers of public transportation operating companies, and leaders of private-sector organisations.

We have identified potential interview subjects (also referred to as “participants” or “study participants”) and organisations to recruit participants. However, there is some flexibility here and ITDP staff is welcome to suggest additional interview subjects to direct supervisors for this project and to ITDP’s internal research manager, Jacob Mason.

We wish to interview one to two people from each organisation. A good way to do this may be by having two participants sit for the same interview; although the details of interview scheduling will be developed by each interviewer.

2.2. Participant Recruitment

We will recruit study participants in two ways: 1) from professionals ITDP has worked with before that have knowledge of implementing and operating HVT, and 2) other professionals that the first group of participants may recommend we speak to.

Use the method of contact that you feel will be most effective, for example, email or telephone. You may wish to combine methods, for example, by calling first and following up with an email.

Below is a draft email you can modify to contact potential interview subjects (also referred to as “participants” or “study participants”). Again, please modify this draft text to best suit local cultural norms and make the potential interview subjects feel as comfortable as possible.

For potential participants you know well, you may want to add something like: “I hope this email finds you well”.

For potential participants you do not know, please add something like: “Jane Smith at the Municipal Transportation Secretariat recommend that I contact you because of your in-depth knowledge on public transportation”.

2.2.1. Draft Email

Dear ____,

As we have discussed previously, The UK’s Department for International Development has engaged ITDP to research the implementation of high-volume transportation (HVT)—urban transportation that improves access to destinations in an equitable, safe and environmentally friendly way. The study intends to inform a research and capacity-building programme that can contribute to supporting the successful implementation of HVT systems.

If possible, I would greatly appreciate the opportunity to speak to you in order to gather information for this study; specifically, I wish to get your perspective on the assets for, as well as barriers to, the implementation of equitable, safe and environmentally friendly urban transportation systems in [Country/State/City]. I would like to conduct a brief interview with you and ask you questions about this topic. Your total time commitment to the project would be 55-65 minutes.

This interview can take place at the place that is most convenient for you. If possible, we would like to conduct this interview in-person, at a quiet place of your convenience, but we could also speak over the telephone.

If you have any questions or would like to participate in the research, I can be reached at [telephone number] or [email].

Thank you very much for your time and consideration.

Sincerely,

[Researcher
Contact Information]

2.2.3 Other Recruiting Practices

There may be other actions that are considered good practices when recruiting potential study participants in the sample countries and cities. For example, in order to request an interview with a local transportation

official, it may be a good idea to write a letter to that official's supervisor (an ITDP staff member in Africa advised that this is a common practice). Please follow local norms as appropriate in the recruiting process (and in the entire data-gathering process - while still minimizing risk and following ethical research considerations outlined in this protocol).

2.3. Interview Description

The interviews will be open-ended, meaning that the questions and answers are not as specific as in a survey which only has a limited amount of possible responses.

Please think of the script as a guide for a conversation, rather than something that must be closely adhered to. For example, you may feel that the participant has already spoken about knowledge and capacity when he/she spoke about governance. If this is the case, you may not want to ask about knowledge and capacity again.

Please be as polite and appreciative as possible. We are interviewing busy professionals who are helping us greatly by giving us their valuable time.

We are not offering compensation for participation in this study beyond perhaps a coffee or a meal, according to local customs. In such an event, please keep all receipts for reimbursement.

Please try to keep the interview to around 60 minutes. If the participant speaks for longer than 60 minutes and appears not to mind speaking longer, do not cut the interview short, but rather end the interview when it seems the participant has said all he/she wants to say.

Please inform the participant that we will share our interview notes and possible attributions with them later to make sure they are comfortable with the information we are including in the study and the way we are attributing it.

Please Remember:

- Make the participant comfortable and let them know that we greatly appreciate their time;
- Reassure the participant that we will do our best to ensure that participating in the interview poses no risk for them professionally or in any other way;
- Ask them if they are comfortable being recorded;
- Remind them that that they should not put their professional standing at risk through this interview or reveal specific sensitive information;

- Remind them that we are attributing all interviews generically, and ask them how they wish to be attributed, to preserve anonymity (e.g., “senior transportation official in Accra”);
- Let them know that you are available to answer any questions they might have at any point;
- Make sure they know that we will follow up with them to ensure they are comfortable with the information they have given us as well as the attribution;

2.4. Note-Taking and Transcription

We find that the most time-efficient way to gather the interview information is to take complete notes by hand while the interview is taking place and recording the interview on an electronic device at the same time (most smartphones make excellent audio recordings).

After the interview is over, begin to transcribe your notes as soon as possible (e.g., immediately after you get back to the office). The interview will still be fresh in your mind and you will remember many details. Try to transcribe the interview in the voice of the participant, using the same language that he/she used.

Consult the audio recordings if there is something you are unsure of.

You can also check for the consistency of what you have written against the audio recordings.

If you feel it is necessary, you can also transcribe the audio recordings verbatim.

2.5. Verbal Consent Script

We will ask participants to state explicitly that they wish to participate in the study, and that they can end the interview and withdraw from the study at any time.

Below is a draft verbal consent script, which you can modify to suit your needs. We encourage you to modify this script so it best fits local cultural norms and makes study participants feel as comfortable as possible in the interview.

Draft Verbal Consent Script:

As you know, I am staff at the Institute for Transport and Development Policy's office in [CITY]. On behalf of the UK's Department for International Development, ITDP is conducting a study on the implementation of high-volume transportation, which we define as urban transportation systems that are environmentally sustainable and improve safety and socially equitable access to opportunities. Examples include high-quality public transportation, walking. and cycling.

I would like to ask you some questions about enablers and barriers to implementing these types of urban transportation systems in [COUNTRY/CITY/STATE]. If possible, I would like to make an audio recording of our conversation, so that I can get your words accurately. If you prefer, I can take only hand-written notes.

If at any time during our talk you feel uncomfortable answering a question please let me know, and you don't have to answer it. Or, if you want to answer a question but do not want it recorded, please let me know and I will stop taking notes and will turn off the machine. If at any time you want to withdraw from this study, please tell me and I will erase the recording of our conversation.

Now I would like to ask you if you agree to participate in this study and to talk to me about implementing sustainable and equitable transportation systems. Do you agree to participate? Would you allow me to make an audio recording of our conversation? I'm happy to take only handwritten notes if that's better.

2.6. Interview Questions

Below is a list of interview questions. Field researchers may modify the wording of these questions to ensure that the language is most suitable to gather rich, high-quality data on the questions' topics from study participants. At the same time, however, field researchers should take care to cover the range of topics outlined in the questions below in the interviews.
Please remember that these are open-ended interviews, and you can modify the questions as you see fit as the interview progresses. You must, however, ask the background questions and the last follow-up question (about how we should attribute the data gathered in the interview).

2.6.1. Background

1. Could you please tell me how long you have been working here?
2. What is your position and what are your responsibilities?

I will now get into the interview questions. As much as possible, please illustrate your answers with concrete examples, but without putting your professional standing at risk. For example, you might discuss how the technical ability of your staff impacted the implementation of a public transportation or cycling project.

2.6.2. Detailed Interview Questions

Institutional Frameworks

Institutional frameworks specifically look at how different institutions and their arrangements, including relationships between national, state, metropolitan, and municipal levels, and their authority and jurisdiction enable the implementation of sustainable transport measures.

1. In your experience, how have institutional frameworks contributed to or hindered sustainable transportation in [COUNTRY/STATE/CITY]?
2. What could be done to improve institutional frameworks for sustainable transportation in [COUNTRY/STATE/CITY]?

Political (and Community) Will

Political will includes leadership from government and the ability to gain public support for sustainable transport measures.

3. Can you think of examples in [COUNTRY/STATE/CITY] where political will, or lack thereof, helped or hindered sustainable transportation?
4. What could be done to improve political will (leadership and public support for) sustainable urban transportation in [COUNTRY/STATE/CITY]?

Knowledge, Capacity, and Research

Knowledge and capacity is the actual understanding and technical ability of institutions and organisations (or consultants) in charge of implementing sustainable transport measures. We have also observed that researchers and practitioners increasingly call for "evidence-based policy," meaning policies are assessed (or tested) rigorously before, during, and after their implementation to evaluate their effectiveness. This assumes that governments will have the ability to carry out their own research on the effectiveness of policies (or at least hire consultants for such research).

5. What examples have you learned about or taken part in from [COUNTRY/STATE/CITY] where knowledge and capacity from technical staff, or lack of it, has helped or hindered sustainable transportation measures?
6. If you think knowledge and capacity should improve in [COUNTRY/STATE/CITY], how do you suggest achieving this?
7. What examples of own-research capacity can you describe from [COUNTRY/STATE/CITY] for sustainable transportation or other sectors (e.g., public health)?
8. If own-research capacity needs improvement in [COUNTRY/STATE/CITY], how could this be achieved?

Involvement of the Private Sector

Some practitioners and researchers emphasise the involvement of the private sector to achieve successful sustainable transportation policies. Some argue that this should also include informal transportation. We are thinking of the private sector very broadly here, from public transport operators to bikeshare operators or app-based "transportation network providers".

9. How has [COUNTRY/STATE/CITY] been successful in involving the private sector? Please provide examples.

10. What would be good ways to improve the involvement of the private sector in [COUNTRY/STATE/CITY], if at all?

Involvement of Other Stakeholders

From international development agencies to grassroots community organisations, there are many potential stakeholders for sustainable urban transportation in addition to government and the private sector.

11. Which other stakeholders have been involved in sustainable transportation measures in [COUNTRY/STATE/CITY]? If not, do you think such organisations could contribute to sustainable urban transportation in [COUNTRY/STATE/CITY]?
12. How could the involvement of such organisations improve sustainable urban transportation policies in [COUNTRY/STATE/CITY]?

Funding

We understand that funding and finance (including loans) is an important issue for sustainable transportation, for project implementation, operation, and maintenance. Funding can come from municipal, state, national or international sources or even the private sector.

13. In your experience, how has the existence or lack of funding from such sources enabled or been an obstacle to making urban transportation systems more sustainable and socially equitable in [COUNTRY/STATE/CITY]?
14. How could funding structures or processes be improved to enable the implementation, operation, and maintenance of sustainable urban transportation systems in [COUNTRY/STATE/CITY]?

Policy Transfer

Some researchers and practitioners emphasise policy transfer (implementing policies from one place in another place) as a promising path to improving the environmental sustainability and social equity of urban transportation around the world.

15. In what ways would you think policy transfer can help improve the sustainability and equity of urban transportation in [COUNTRY/STATE/CITY]?
16. Which examples can you describe where policies from another place have been implemented here, and if so, what were the outcomes?
17. What could be done to improve the likelihood that policies transferred to [COUNTRY/STATE/CITY] are successful?
18. Which specific types of urban transportation policies from other places that would be especially well-suited to [COUNTRY/STATE/CITY] can you think of?

Thank you very much for this valuable information.

Other Questions

- Is there anyone else that you recommend that we speak to for this study?

- How would you like us to attribute the information you gave us? We can either use your name, or if you prefer, we can maintain your confidentiality by attributing it to a "[national/state/municipal government] official, [Country/State/City]".

[For example: "municipal government official, Accra".]

Follow-Up

- I'll be sending you the notes from our interview as well as how we would like to attribute the information you gave us. We will only include the interview in our reports and any other documents after you confirm that it is accurate and that you agree with the attribution we are proposing.

Thank you for your time. Please feel free to reach out to me with any questions.

Appendix B: List of Consultations

- Peter Adriaens (Center for Smart Infrastructure Finance, University of Michigan);
- Chris Ballinger (Mobi Open Blockchain Initiative);
- Bruce Belzowski (Automotive Futures Group);
- Jeb Brugmann (100 Resilient Cities);
- Ceit Butler (George Brown College Blockchain Program);
- Adam Cohen (UC Berkeley);
- Benjamin de la Pena (Seattle Department of Transportation);
- Claire Enslin (Where Is My Transport);
- Efon Epanty (Fairfax County, VA);
- Danielle Guillen (Ateneo de Manila University);
- Bern Grush (Harmonize Mobility);
- Ralph Hall (Virginia Tech);
- Jackie Klopp (Columbia University);
- Holly Krambeck (the World Bank);
- Alan McKinnon (Kuehne Logistics University);
- Apiwat Ratanawaraha (Chulalongkorn University);
- Lauren Reid (Sidewalk Labs);
- Lake Sagaris (Pontificia Universidad Católica de Chile);
- Mimi Scheller (New Mobilities Research and Policy Center, Drexel University);
- Kristin Schondorf Slanina (Thirdware Solution INC).

Appendix C: Full Research Proposal

- **1) Research in Low- and Middle-Income Countries**
    - **1.1) Informality**
        - **1.1.1) Land-Use Management**
            - Setting Density, Infrastructure, and Accessibility Goals for Rapid Urban Expansion
            - Integrating Informal Settlements and Urban Villages
            - Rapid Growth Measures for LICs
            - Road Network Standards for LICs and Informal Settlements
            - Mixed Land Uses in LICs and Informal Settlements
            - Affordable Housing Incentives in Informal Settlements
        - **1.1.2) Infrastructure, Services, and Regulations**
            - Transit Services in Informal Areas
            - Walking and Cycling in Rural–Urban Transitions
            - Upgrading and Integrating Informal Transit Systems
            - Enabling Structures for Modernising and Integrating Public Transport Systems
    - **1.2) Enabling Structures**
        - Private Sector and Informal Sector Involvement in HVT
        - Measure Implementation Process in LICs
        - Relationships and Negotiations with Private Operators in LICs and MICs
        - Institutional Structures in LICs and MICs
        - Raising Revenue in LICs
        - Public–Private Partnerships in LICs
    - **1.3) Infrastructure, Services, and Regulations**
        - Infrastructure in Low- and Middle-Income Countries
        - TDM User Behaviour Impact in MICs and LICs
        - Accessibility and Income in LICs and MICs
        - HVT in LICs (Moving People, Moving Goods and Moving Less)
    - **1.4) Urban Freight**
        - Urban Freight in Africa
        - Sustainable Urban (LIC HVT) Freight Systems
- **2) General Research**
    - **2.1) Enabling Structures**
        - Equity, Politics, and the Role of Citizen Involvement
        - Role of Capacity and Capacity Building as a Potent Agent of Change
        - Role of Citizen Experience as an Enabler of HVT Policy
        - Implementation or Knowledge Gaps
        - Metropolitan Integration
        - Role of Leadership

        - Integrative Policy Models
        - Research and Learning Supports Specific to ‘Improve’ (Technology, Innovation, and Integration)
        - Competing Narratives and the Effectiveness of HVT Measures
        - Data and Technology for Intervention Monitoring and Mapping
    - **2.2) New Mobility and Technology**
        - MaaS-like Service Integration (Moving People, Moving Goods and Moving Less)
        - Business and Financing Models
        - New Mobility, Land Use, and Urban Form
        - Incorporating On-Demand Services into HVT
        - Flexible Policy Approaches to On-Demand Services
    - **2.3) Freight**
        - Urban Freight Land-Use Measures
        - Non-Motorised Freight
        - Curb Management for Freight Deliveries
    - **2.4) Infrastructure, Services, and Regulations**
        - Parking Policy
        - Non-Dominant Infrastructure
        - Residential Self-Selection
        - Moving Less for High-Volume Access