WORLD BANK GROUP

Decarbonizing Urban Transport for Development

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Mobility and Transport Connectivity Series

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Acknowledgments

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The work benefited from background research conducted by Alejandro Tirachini (Universidad de Chile), Alexandre Jacquillat (MIT Sloan School of Management), Atiyya Shaw (University of Michigan), Camilo Andres Mora Quinones (Tecnologico de Monterrey), Cecilia Fabian Kadeha (Young Professional), Chinh Ho (University of Sydney), Jan Fransoo (Tilburg University), Gershwin Fortune (Consultant), Tamara Kerzhner (Consultant), and background data from Aitor Franco Arana, Alejandro Hoyos Guerrero, Alex Daniel Perez Cajilema, Ana Waksberg Guerrini, Armando Mollinedo Trujillo, Cesar Alejandro Ruiz Brito, Claudia Lopez Rodriguez, Ellin Ivarsson, Fatima Noor Aftab, Jaishree Jindel, Leonardo Canon Rubiano, Maria Jose Sala Pelufo, Mira Morad, Pablo Claudio, Sara Zafar Cheema, Shyam Srinivasan, Tais Fonseca De Medeiros, and Ximena Carolina Velandia Villamil.

The team thanks the following people for reviewing and commenting on the report: Jose Holguin-Veras (Director of the Center for Infrastructure, Transportation and Environment, Rensselaer Polytechnic Institute), Joanna Mclean Masic (Lead Urban Specialist), Carolina Monsalve (Lead Economist), Gerald Paul Ollivier (Lead Transport Specialist and Program Leader), and Franck Taillandier (Lead Transport Specialist).

This report was developed as part of the World Bank's Decarbonization of Transport activity led by Cecilia Briceno-Garmendia (Lead Economist) and Bianca Bianchi Alves with guidance from Nicolas Peltier (Director, Transport Global Practice) and Binyam Reja (Practice Manager, Transport Global Knowledge Unit). Jonathan Davidar (Senior Knowledge Management and Learning Officer) provided invaluable advice for strengthening the messaging of the report and oversaw its production. The report was edited and designed by RRD GO Creative.

Abbreviations

ASI	Avoid-Shift-Improve Policy Framework
ATC	Area Traffic Control
AVRP	Accelerated Vehicle Retirement Program
BRT	Bus Rapid Transit
CDP	Collection and Delivery Points
CO_2	Carbon Dioxide
EV	Electric Vehicle
FAR	Floor Area Ratio
FELU	Freight-Efficient Land Use
FCEV	Fuel-Cell EV
GNI	Gross National Income
HIC	High-Income Country
ICCT	International Council on Clean Transportation
ICE (V)	Internal Combustion Engine (Vehicle)
ICT	Information and Communication Technology
ILO	International Labor Organization
ITS	Intelligent Transportation System
LIC	Low-Income Country
LCV	Light Commercial Vehicle
LMIC	Low- and Middle-Income Country
LRT	Light-Rail Transit
LVC	Land Value Capture
MaaS	Mobility-as-a-Service
MDB	Multilateral Development Bank
MIC	Middle-Income Country
NGO	Nongovernmental Organization
NOx	Nitrogen Oxide
OEM	Original Equipment Manufacturer
OHD	Off-Hour Deliveries
O&M	Operations and Maintenance
PoA	Program of Activities
PPP	Public Private Partnership
PTI	Periodic Technical Inspection
RTTI	Real-Time Transit Information
TDM	Transportation Demand Management
TOD	Transit-Oriented Development
UCC	Urban Consolidation Centers
VKT	Vehicle Kilometers Traveled
WB (G)	World Bank (Group)

Definitions

Accessibility can be defined as the ability of an urban transport system to provide its users with access to opportunities in a defined length of travel time. Travel time is defined as door-to-door and is usually 60 minutes for large cities and 30 minutes for smaller ones (Ardila-Gomez, Bianchi Alves and Moody 2021).

ASI framework is a policy framework that seeks to decarbonize transport by avoiding unnecessary trips, shifting trips from high-polluting modes to lower-carbon modes and improve trips that were not shifted by enhancing vehicle and fuel efficiency.

BRT is a high-quality bus-based transit system that delivers fast, comfortable, and cost-effective services at metro-level capacities. It does this through the provision of dedicated lanes, with busways and iconic stations typically aligned to the center of the road, off-board fare collection, and fast and frequent operations (ITDP, 2023).

Built environment refers to a multidimensional concept that comprises urban design, land use, and the transportation system, as well as patterns of human activity within the physical environment.[1]

Co-benefits are defined as positive social, economic, and environmental impacts beyond emission reductions (Gouldson et al. 2018).

CDP is a network of facilities where carriers deliver orders, and e-customers collect the online purchases as an alternative to home delivery (Oliveira et al. 2019).

Compact cities have three key characteristics: (i) dense and proximate development patterns, (ii) urban areas linked by public transport systems, and (iii) accessibility to local services and jobs (OECD 2012).

Complete streets typically include sidewalks, dedicated cycling paths, public transport stops, numerous pedestrian crossings and median islands, pedestrian-friendly crossing signals, curb extensions, and narrow travel lanes (Ho and Isaacs 2018).

Decarbonization of urban transport entails reducing the greenhouse gas (GHG) emissions produced by the combustion of fossil fuels through urban transport (Cho 2022).

Decoupling here refers to the decoupling transport emissions from economic growth (which means, emission growth is not keeping pace with economic growth). This includes both the relative decoupling where emissions are growing slower than the GDP and absolute decoupling where carbon emissions are decreasing, and GDP is increasing (Foster, Dim, Vollmer and Zhang 2021).

E-commerce: is the act of electronically buying or selling products using an online marketplace platform service provider (IFC 2021). service provider (IFC 2021). service provider (IFC 2021).

Financing: refers to the capacity to access equity or loans to finance the large projects, such as the construction of a metro line, which have high upfront capital expenditure (Benitez and Bisbey 2023).

Funding: refers to the transport system's capacity to raise funds from its users - ranging from public transport passengers to car drivers - or use of public sector revenues (Benitez and Bisbey 2023).

[1] "Urban design" refers to the design of the city and the physical elements within it, including their arrangement and appearance, and the function and appeal of public spaces. "Land use" refers to the distribution of activities across space, including the location and density of different activities, where activities are grouped into relatively coarse categories such as residential, commercial, office, industrial, and other activities. The "transportation system" includes the physical infrastructure of roads, sidewalks, bike paths, railroad tracks, bridges, and so on, as well as the level of service provided as determined by traffic levels, bus frequencies, and the like (Handy, Boarnet, Ewing and Killingsworth 2002).

Land value capture is a financing tool that allows local governments to charge fees and taxes to developers and property owners and raise revenue that can then be reinvested into community and city services (Hart 2020).

Last mile is the final haul of a shipment to its end receiver, be it a shop; business; facility; or residence, in case of home deliveries (Dablanc, Giuliano, Holliday and O'Brien 2013).

LMIC are defined using the World Bank Atlas method. Low-income countries are those with a GNI per capita of $1,085 or less in 2021; lower middle-income countries are those with a GNI per capita of $1,086 to $4,255; and upper middle-income countries are those with a GNI per capita of $4,256 to $13,205 (World Bank 2023).

Mobility is the capacity of a system to move people per unit of time (Ardila-Gomez, Bianchi Alves, and Moody 2021). The more people per unit of time an urban transport system can move, the higher the mobility it offers to users.

Mixed land use is defined as a combination of many types of buildings that have different uses in the layout itself. For example, there may be a mix of residential buildings located near the office buildings, shops, cinemas, schools, coffee shops, parks, and transport stations (Nabil and Eldayem 2015).

Multimodal transportation includes public transportation, rail and waterways, bicycle, and pedestrian.

Opportunities are usually jobs, but can also be hospitals, schools, theaters, and parks (Ardila-Gomez, Bianchi Alves and Moody 2021).

Paradigm shift is an important change that happens when the usual way of thinking about or doing something is replaced by a new and different way (TNDH, 2023).

Transport policy refers to a set of constructs and propositions that are established to achieve specific objectives relating to social, economic, and environmental conditions, and the functioning and performance of the transport system. The goal of a transport policy is to make effective decisions concerning the allocation of transport resources, including the management and regulation of existing transportation activities, while transport planning concerns their effective implementation. Policies include infrastructure policies (roads, bike lanes, rail, ports, airports), pricing (levies on fuels, subsidies on public transport or environment-friendly road vehicles, road pricing), land-use policies (industrial, residential, commercial, mixed, social, and environmental special interests' zones), specific public transport policies (service hours, timetables), and marketing, information, and communication policies. Policies have many different types of effects on travel times, travel time reliability, accessibility levels, safety, the environment, and costs for the public sector, as well as for citizens and companies. This makes evaluating transport policies an important but also challenging task (Rodrigue, Notteboom and Slack 2013).

Road dieting is a technique in transportation planning whereby the number of travel lanes and/or effective width of the road is reduced to achieve systemic improvements.

Shipper is the party sending a consignment (Mejia 2021).

Sprawl is a pattern of development characterized by uniform low density, lack of a distinctive core, poor accessibility, dependence on automobiles, and uncontrolled and non-contiguous land expansion (Hiroaki, Cervero and Iuchi 2013).

Tele-activities refer to activities that can be performed remotely (Mouratidis and Peters 2022).

Transport demand refers to the amount and type of travel people would choose under specific conditions, taking into account factors such as the quality of transport options available and their prices (Victoria Transport Policy Institute 2015).

Transport poverty. Lucas 2016 defines an individual as transport-poor, 'if, in order to satisfy their daily basic activity needs, at least one of the following conditions apply:

- lack of a transport option that is suited to the individual's physical condition and capabilities
- the existing transport options do not reach destinations where the individual can fulfil his/her daily activity needs in order to maintain a reasonable quality of life
- the necessary weekly amount spent on transport leaves the household with a residual income below the official poverty line
- the individual needs to spend an excessive amount of time travelling, leading to time poverty or social isolation
- the prevailing travel conditions are dangerous, unsafe, or unhealthy for the individual

TOD is compact, mixed-use development organized around a transit station. TOD embraces the idea that locating amenities, employment, retail shops, and housing around transit hubs promotes transit usage and non-motorized travel (Hiroaki, Cervero and Iuchi 2013).

TDM is policy and incentive measures to reduce the demand for travel, particularly by automobile, and induces use of non-motorized transport or public transit. Typical measures include removal or reduction of fuel subsidies, congestion pricing, parking regulations and fee increases, higher car registration costs and associated taxes, and introduction of car-free zones or days. TDM reduces or redistributes travel demand by time, mode, or corridor (Hiroaki, Cervero and Iuchi 2013).

Urban here refers to city and/or metropolitan area. It includes urban agglomerations that cut across jurisdictional boundaries and bring together one or more cities along with their surrounding areas (Ijjasz-Vasquez, Karp and Sotomayor 2017).

Urban freight transport includes all movements of goods and materials into, out of, through, or within the urban area.

Urban passenger transport includes different modes of land transport such as motor bus (including minivans), tramway, streetcar, trolley bus, underground and elevated railways, three-wheelers, motorcycles, biking, and walking as well as emerging technologies such as e-bikes and e-scooters, and ride-hailing. The transport can be on scheduled routes, following a fixed time schedule, entailing the picking up and setting down of passengers at usually fixed stops, or flexible routes and flexible schedules (and any combination) (European Commission 2019).

Overview

Overview

As the world's population and economic activities concentrate in cities, pressure on urban transport systems is mounting. In low- and middle-income countries (LMICs), there is an immediate need for more sustainable, efficient, safe, and inclusive urban transport to improve quality of life. Expanded access to goods, services, and opportunities is a key enabler of economic growth, making urban freight and passenger transport an integral part of a complex urban fabric. As cities develop, demand for both urban freight and passenger transport is expected to increase, increasing stress on urban transport infrastructure and services. Climate change adds an additional stress to urban systems, requiring cities to rethink how they meet transport demand in a more climate-friendly way.

The decarbonization of urban transport requires cities to get the fundamentals of urban transport right—shaping the development of land, transport infrastructure, and transport services to prioritize the most space- and energy-efficient uses of valuable urban land. Most decarbonization measures for urban passenger and freight bring benefits for both climate and development, reducing negative externalities such as air pollution and congestion, while promoting economic activity. Measures that promote energy-efficient and inclusive accessibility to jobs, education, and other opportunities, also reduce spatial inequalities and bring wider economic benefits such as productivity gains, returns to scale and agglomeration, and stronger job markets (Ianchovichina 2023).

There is no single approach for all cities in LMICs to decarbonize their urban transport systems. The measures, policies, and tools that cities leverage in charting their own decarbonization trajectories depend on local contexts and needs. While there are many decarbonization measures that unlock synergies when packaged together, other measures necessary for decarbonization may be at odds with development objectives. Cities will need to carefully weigh trade-offs given their own context. To help guide national- and city-level policymakers determine the best low-carbon pathway for their urban transport systems, this report introduces different decarbonization measures organized into the AVOID-SHIFT-IMPROVE (ASI) framework and discusses how these measures interact with complex urban transport environments, their potential costs, benefits, synergies, and trade-offs. It also discusses the institutions, funding and financing, and stakeholder engagement needed to ENABLE these decarbonization measures.

The report makes these recommendations for LMIC cities:

1. **Pursue the decarbonization of urban passenger and freight transport together.** This will create a more integrated, efficient, accessible, and climate-friendly urban transport system. Both passenger and freight transport are essential services for the vibrancy and health of cities and must co-exist in limited and valuable urban space. Decarbonization measures that better allocate transport infrastructure—including roadways, parking spaces, and curbs—or improved vehicles must consider all their uses in the movement of people and goods. City governments have a critical role in integrating passenger and freight planning and engaging a range of stakeholders in building consensus aimed at decoupling economic growth from transport emissions.

2. **Rethink land use regulations to better incentivize efficient, inclusive, and low-carbon passenger and freight transport.** By leveraging land use regulations and integrated planning to align transport and urban development, cities can promote the use of low-carbon modes Poorly designed land use regulations and lack of integration with transport planning distort market forces by capping the supply of built space, driving up land prices, excluding lower income groups, resulting in urban sprawl that reinforces inefficient freight movements (Holguin-Veras et al. 2021) and passenger travel by private car (Ardila-Gomez, Bianchi Alves and Moody 2021). Conversely, transport infrastructure also contributes to urban sprawl (Brueckner 2000).

3. **Resolve funding issues to enable better use of public resources as transport is at the heart of municipal fiscal challenges.** In many cities in LMICs, providing transport infrastructure and services takes up a significant share of public budgets (OECD 2020). Despite scarce resources, these cities can afford to improve urban transport and decarbonize the sector if they efficiently and inclusively allocate existing resources. Removing implicit subsidies for private vehicles and shifting funding toward improvements for more space- and energy-efficient modes can have major returns on investment.[2] As cities are looking for innovative ways to expand revenues, new road, fuel, and vehicle pricing measures can help decarbonize urban transport while providing a valuable funding source for re-investing in greener services and infrastructure (Venter, Mahendra and Hidalgo 2019). Finding the right allocation of resources is as important as identifying innovative ways to grow revenue sources (Benitez and Bisbey 2021; Venter, Mahendra, and Hidalgo 2019). By improving funding streams and cost-recovery of transport infrastructure and services, cities can bring positive implications for city budgets and allow for increased access to finance, including private finance.

4. **Scale-up the engagement of the private sector in urban transport to unlock more resources to fully finance decarbonization.** In LMICs, the majority of urban passenger and freight services are already provided by the private sector. Yet, there are many ways that governments can work with the private sector to develop more efficient, innovative, and sustainable funding mechanisms for urban transport infrastructure projects. These range from creating convening forums and adjusting regulations to increasing financing and de-risking in strategic areas through subsidies and guarantee instruments. For example, city governments can promote green last-mile deliveries through partnerships between carriers and receivers and regulations for alternative-hour deliveries and consolidation centers that allow for higher-load vehicles coming at lower frequencies. They can also promote demand pooling of alternative fuel vehicle purchases and/or reduce payment default risks through guarantee instruments (as under India's Faster Adoption and Manufacturing of Electric Vehicles [FAME] program) (Convergence 2022). These instruments help increase access to financial markets in the sector and allow for a larger pool of resources for investment beyond public budgets.

5. **Develop an effective and responsible governance system with adequate institutions, human resources, and funding to catalyze urban development and decarbonization measures.** This is critical to carry out urban transport functions, show commitment to climate change, and demonstrate public good. A first step is to empower an institution with a wide purview to manage transport and interrelated issues at the required scale (for example, metropolitan areas, multi-city regions). This will require coordination among different government agencies and the need to engage in difficult conversations with a wide group of stakeholders. While this institution may be formed from a combination/transformation of existing agencies (e.g., the recently established Sierra Leone Public Transport Authority, SLPTA) or set up as a new one (e.g., Conseil Exécutif des Transports Urbains de Dakar, CETUD), it will need to have qualified human resources and be empowered to make decisions on funding allocation and policies according to urban transport and decarbonization priorities.

6. **Recognize the critical role of policy in guiding the use of technology and data to improve efficiency and inclusiveness.** While not in itself a solution, technology can be a powerful ally to city governments trying to improve efficiency and inclusiveness (Bianchi Alves et al. 2022). With easy access to an ever-expanding library of global data to help aid decision making, governments are encouraged to use every available tool to enable the sharing of information and analysis, when possible, through open data standards. Further, cities need to ensure that they collect disaggregated data about different groups, including women and their distinct travel behavior, engaging with such groups to understand the barriers

[2] For example, an independent evaluation of a vehicle scrappage effort called the Yellow Sticker in Beijing found a benefit-to-cost ratio of nearly 2.5 (World Bank 2021).

and challenges they face. Technology needs to be adopted with the guiding policies and institutions in place to ensure that it is widely available and meets the needs of many different groups of freight and passenger transport users and operators. For example, the city of São Paulo, Brazil set up a dedicated and resourced Urban Mobility Lab to better collect, process, and disseminate data for urban transport decision-making and as a testbed for innovative pilot programs (Biderman and Coimbra Swiatek 2020).

7. **Capitalize on synergies among multiple decarbonization measures by adopting packages of complementary interventions.** Adopting a balanced package of interventions can ensure that all development and climate objectives are being met, unlock multiplicative effects for decarbonization, and help hedge against the risk of any one measure underperforming or stalling (Zhang and Hanaoka 2022). For instance, dense, compact, and mixed-use urban development concentrates passenger trips along key corridors and can increase the financial viability of public transport services. Conversely, good public transport networks support the densification of urban areas without worsening local congestion (Zhang and Hanaoka 2022). Combining measures can also make economic sense when money generated from one policy or measure can be used to fund another measure. For example, money generated from pricing mechanisms such as vehicle import taxes, can be reinvested in public transport to expand service, and encourage modal shift (Agarwal 2014).

8. **Weigh costs and benefits carefully in each context as some decarbonization measures may be at odds with development objectives or undermine other actions.** While combining ASI measures, it is important to acknowledge trade-offs and reconcile different objectives for decarbonization and other development benefits. For example, some cities in China have incentivized the adoption of EVs by providing preferential road or parking pricing. Chongqing and Wuhan do not charge EVs for tolls for highways, bridges, and tunnels, and Liuzhou city offers free parking at all street parking spaces and many public garages for EVs—with 8,000 spaces reserved for EVs at the end of 2019 (Hall et al. 2020). These policies can help incentivize the adoption of cleaner vehicle technologies, mitigating GHG and air pollutant emissions. The exemptions, however, can undermine the effectiveness of road and parking pricing policies in achieving the objectives for managing travel demand, particularly by private cars, thereby reducing the potential revenue that they could generate for reinvestment in the urban transport system or other services. Some cities may choose to delay adoption of EVs and invest resources in other measures until sufficient resources or infrastructure is available (Briceno-Garmendia, Qiao and Foster 2023).

Cities in LMICs cannot afford inaction when it comes to improving and decarbonizing urban transport. Now is the time to address fundamental gaps in accessibility and inclusion in a low-carbon way. The more governments delay interventions in urban transport, the higher the cost in terms of money lost, traffic crashes, air pollution, productivity and employment losses, and environmental degradation (Venter, Mahendra and Hidalgo 2019).[3]

LMICs are currently undergoing important transitions in economic development and urbanization. To take advantage of these transitions with constrained resources, city governments should focus immediate action where they will have the farthest-reaching benefits for economic activity and climate in the long-term. Policymakers and private sector practitioners can take advantage of growing momentum for climate action to build support for and accelerate deployment of urban transport investments and reforms aligned with their long-term vision for social and economic development. With greater urgency, cities can put in place the difficult but foundational changes to the built environment and travel behaviors that will bring a paradigm shift for people-centered urban mobility. This report collates the language and evidence needed for policymakers to leverage decarbonization objectives for greater ambition in their urban transport planning.

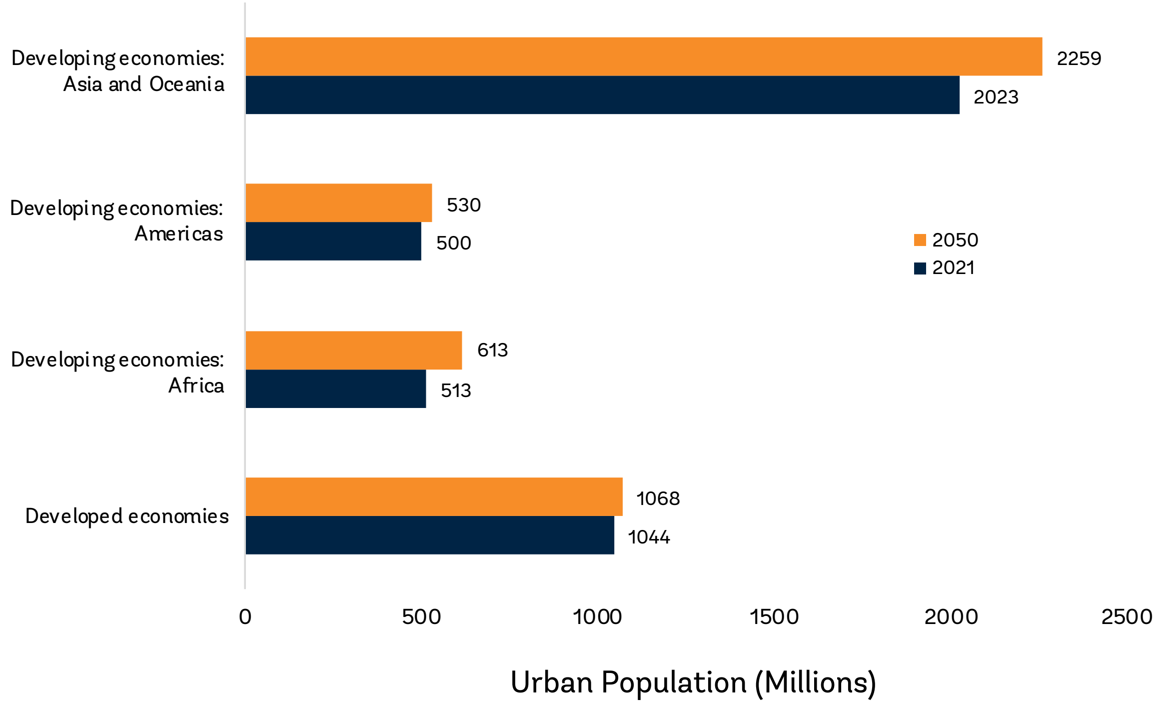
[3] Currently, the cost of transport externalities is high, especially in rapidly developing urban areas. For example, the costs of motorized transport's congestion, air pollution, motor vehicle crashes, noise, and climate change in Beijing are between 7.5 percent and 15.0 percent of its GDP (Gouldson et al. 2018).

Chapter 1
Setting the Context

Introduction

The world's population and economic activity are being increasingly concentrated in cities. By 2050, the urban population is expected to grow by over 40 percent, and almost 70 percent of the world's population is expected to live in urban areas (UN Department of Economic and Social Affairs 2018). This will be most pronounced in LMICs, with 90 percent of the urban population growth expected in Asia and Africa (Thondoo, Marquet, Márquez, and Nieuwenhuijsen 2020) (see Figure 1.1).[4] Sub-Saharan African countries are projected to have the highest rate of urban growth and by 2050, will be home to an estimated 613 million people (UNCTAD 2022). Meanwhile, cities in LMICs in Asia and Oceania are estimated to house over 2.25 billion by 2050. With their concentration of people, cities are also significant engines of global economic activity. For example, a study by Floater et al. (2014) found that 468 metropolitan areas with over 0.5 million people are expected to account for over 60 percent of the global GDP growth between 2012 and 2030 under business as usual.

Figure 1.1. **Urban Population for HICs and LMICs in Different World Regions, 2021 and 2050**



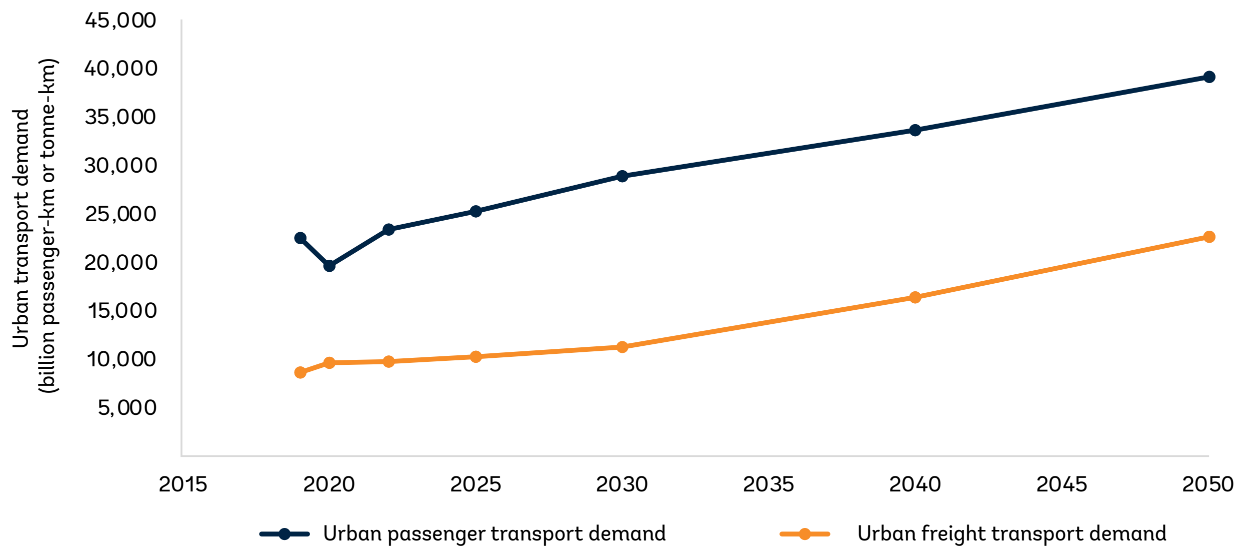
Source: Original figure produced for this publication with data from UNCTAD (2022).

Population and economic growth in cities will increase the demand for urban passenger and freight transport (ICCT 2020). As more people live in cities and their economic opportunities expand, there will be a greater demand for travel for work, education, social services, and recreation. In urban areas, passenger transport demand is expected to grow by nearly 75 percent from 2019 to 2050 under current climate ambitions (see Figure 1.2) (ITF 2023). Since most of the urban population growth is expected in LMICs in Asia and Sub-Saharan Africa, the greatest growth in urban passenger transport demand too is expected in these countries (see Figure 1.3, left panel). Simultaneously, more people living in cities means more customers for expanding businesses, leading to greater demand for goods in a concentrated physical space. Urban freight transport demand is forecast to grow at a rate greater than passenger transport demand, increasing by

[4] Countries in Eastern European and Central Asian Countries (ECA) are an exception as their cities are facing a population decline and population growth is being concentrated in a fewer number of cities (Restrepo Cadavid et al. 2017).

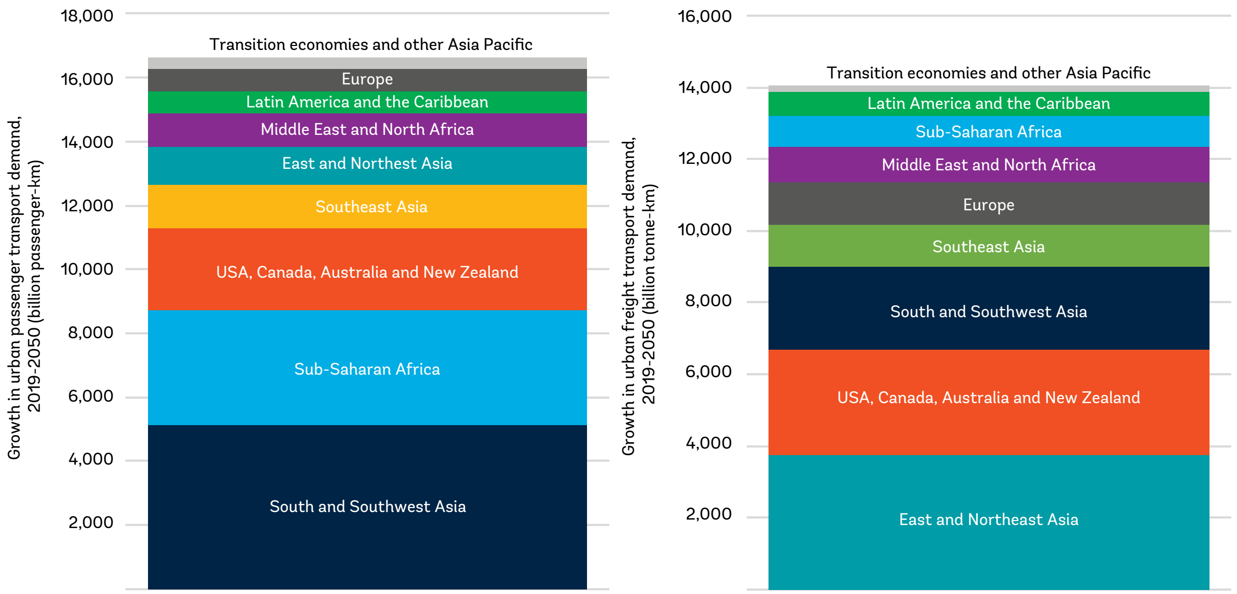
164 percent between 2019 and 2050 (see Figure 1.2). The greatest contributors to this growth are expected to be in Asia and in high-income countries (HICs) such as Canada and the US (see Figure 1.3, right panel).

Figure 1.2. Projection of Urban Passenger and Freight Transport Demand under the ITF "Current Ambition" Scenario, 2019-2050



Source: Original figure produced for this publication with data from ITF (2023) via OECD stat.

Figure 1.3. Growth in Demand for Urban Passenger (Left) and Freight (Right) Transport under the ITF "Current Ambition" Scenario by Global Region, 2019-2050



Source: Original figure produced for this publication with data from ITF 2023 accessed via OECD stat.
Notes: Transition countries include countries that were a part of the former Soviet Union and non-EU South-Eastern European countries.

Without ambitious climate action, as the demand for urban transport grows, so will its GHG emissions from cities that are already hotbeds of emissions. Cities today account for over 70 percent of the global carbon dioxide (CO_2) emissions and urban transport is a primary contributor. With continued urbanization, the contribution of urban transport to global CO_2 emissions is likely to grow. Private cars and delivery vehicles that run on fossil fuels are responsible for a significant share of urban travel and the majority of the emissions from urban transport (ICCT 2020). For example, in 2015, it was estimated that private cars accounted for more than half of all global urban passenger-kilometers (ITF 2021b). The ITF estimates that in 2021, private cars generated 75 percent of all urban passenger transport emissions (ITF 2021c). Therefore, achieving global climate goals will require concerted efforts to decarbonize LMIC cities and their urban transport systems.

Emission mitigation efforts in the urban transport sector need to go beyond curbing GHG emissions; it must also be aimed at reducing emissions from local air pollutants. Cities in LMICs usually top the charts for most polluted cities in the world, at a huge economic and social cost. In 2019, air pollution led to 6.7 million premature deaths globally, of which 89 percent occurred in LMICs, as they also lack the supporting health systems to deal with heavy exposure (World Health Organization 2022). In cities, the transport sector is the largest global contributor to the emission of fine particulate matter, which are strongly linked to the increasing incidence of respiratory and cardiopulmonary diseases and many forms of cancer (Anenberg, Miller, Henze and Minjares 2019). A recent metanalysis found that road traffic's contribution to air particulate matter varies from 5 percent to 61 percent in cities worldwide, at an average of 27 percent (Heydari, Tainio, Woodcock, and de Nazelle 2020). The underlying reason for this variation is a wide socioeconomic divide, with traffic's contribution to air pollution in cities located in Europe, North America, or Oceania being 36 percent lower than in cities in the rest of the world, despite their higher motorization levels (Heydari et al. 2020).

In the coming decades, cities in LMICs must balance two objectives: meeting and enabling growing transport needs while curbing emissions from travel. Many LMICs have not been able decouple economic growth from transportation emissions (Foster, Dim, Vollmer and Zhang 2021). Cities in LMICs differ from HICs socially, economically, and politically, potentially making decarbonization more challenging. At the same time, the lower levels of motorization in LMIC cities offer a unique starting point to achieve decarbonization. Despite differences across LMIC cities, their reliance on private vehicles is lower than in HIC cities. For example, vehicle ownership in African capitals is around 14.4 percent in Dakar, Senegal (2013), 12.9 percent in Douala, Cameroon (2011), 13.6 percent in Ouagadougou, Burkina Faso (2014), 13.9 percent in Niamey, Niger (2012), 22.3 percent in Maputo, Mozambique (2015), and 23.2 percent in Bamako, Mali (2015) (Olvera, Plat, and Pochet 2020). Without access to a car, many people resort to walking or public transport (when they can afford it). Many African cities, such as Addis Ababa, Dar es Salaam, Lagos, and Nairobi have more than 40 percent of their population traveling on foot (Adriazola-Steil et al. 2021). The concern is that residents and travelers often do not use these modes by choice, but rather out of necessity. These modes generally have inadequate infrastructure (such as sidewalks and bike lanes), poor operations (for example, infrequent service), low levels of service, and high levels of congestion and air pollution. Under such conditions, economic growth will push travelers to switch to a private vehicle rather than continue to rely on more space- and carbon-efficient transport modes to meet growing travel demand needs.

Cities in LMICs have an opportunity to direct sustainable growth and leapfrog to efficient, low-carbon, and inclusive urban transport. In the wake of growing urbanization and the urgency of the climate crisis, cities can either follow the path of relative inertia and reactive adaptation (status quo), or leapfrog towards a path that meets growing transport needs while mitigating emissions and negative environmental externalities. Projections show that status quo transportation policies will undershoot climate goals, with potentially disastrous long-term consequences, while ambitious but feasible policies can mitigate sector-specific emissions. As much of the urban development, services, and infrastructure in these cities needs to be developed and/or significantly upgraded, there are opportunities for leapfrogging to more socially and environmentally sustainable transport systems.

Decarbonization measures can, in most cases, also bring development benefits. Improving accessibility and environmental sustainability are not mutually exclusive objectives, and many of their pathways are shared, as shown by a review of over 700 papers focusing on low-carbon measures (Gouldson et al. 2020). Low-carbon measures can help achieve a range of development priorities such as job creation, improving public health, social inclusion, and improved accessibility. This gives cities an incentive to accelerate action on climate change and leverage low-carbon measures that can achieve mutual benefits in development priorities (Gouldson et al. 2020).

A closer look at the state of urban transport in LMICs, as well as governance practices, establishes that to decouple urban growth from urban transport-related emissions and accrue development benefits, a complete paradigm change is required in the way cities plan, design, operate, and prioritize investments for urban transport.

1.2. Cities and Urban Transport Systems in LMICs

While cities in LMICs take many forms and have distinctive local contexts, they also share a few characteristics that present unique challenges to and opportunities for the decarbonization of their urban transport systems. This section outlines some of these critical characteristics as context for understanding the implications of different decarbonization measures discussed in the following chapters.

Cities in LMICs are dense but sprawling. While cities in LMICs are generally dense—a desirable characteristic to achieve economies of scale—they are often crowded and living conditions are poor. Inadequate supply and the low quality of housing and transport systems hinder the provision of minimal floor space, good accessibility to firms, employment, and social interactions. Despite existing densities, LMICs' spatial expansion is mostly horizontal, which lowers the livability through several factors including higher pollution (Lall et al. 2021). Kinshasa and Karachi are prominent examples. While of similar population density per built up area than Hong Kong, their pancake urban form results in a much higher population density per floor space and much lower livability (Lall et al. 2021). Sprawl makes providing urban transport infrastructure and service more expensive, increases travel distances, reduces accessibility, and creates car-oriented travel patterns that bring significant externalities. Conversely, the provision of transport infrastructure favoring private vehicle travel encourages additional sprawl.

Poorly designed land use regulations and a complex political economy around land management hinder efforts towards building a more sustainable urban form. Typically, planning regulations that are based on standards from HICs—such as high minimum standards for land plots and buildings, parking minimums, and high infrastructure requirements—are unrealistic in LMICs. These planning regulations then restrict the supply of land and housing, drive up land prices, and result in the exclusion of lower-income individuals, and greater sprawl as development moves towards lower-value peripheral areas (Ardila-Gomez, Bianchi Alves, and Moody 2021). Inadequate land use regulations in LMICs also aggravate the lack of integration between transport and land use planning, as a complex regulatory framework tends to distort market forces (Ardila-Gomez, Bianchi Alves, and Moody 2021). Land has a relatively high value with many competing functions and is often captured by higher income individuals. When combined with weak institutional capacity and limited land use instruments in some regions—such as cadasters in Africa—it becomes difficult for policymakers to plan for efficient urban form and attract the private sector to support development.

In LMICs, informal settlements are a part of the urban fabric. Informal settlements house a significant share of the urban populations due to the significant supply-demand gap in low-income housing units. For example, the General Household Survey (2017) in South Africa revealed that 2.2 million people live in informal settlements. At the same time, the South African Government had a housing delivery backlog of 2.1 million units in 2018 (Moyo, Zuidgeest and van Delden 2021). Similarly, in India, 17 percent of the urban population (approximately 65 million people) lived in extremely inadequate housing such as slums in 2011; it is estimated that 25 million low-income housing units would be needed by 2030 (Zia et al. 2021). Peru has an equally challenging gap; with 45 percent of the population not being able to afford the housing market, it requires 1.3 million units but lacks sufficient land with access to services that can be used for housing (World Bank 2016). Although common, informal settlements are usually characterized by poor living conditions, poverty, and inaccessibility (see Image 1.1).

Image 1.1. Informal Settlements in (a) Alexandra Township Outside of Johannesburg, South Africa and (b) Lima, Peru

Image sources: (a) Mike Tigas (2017) and (b) Mariano Mantel (2020).

In cities in LMICs, road infrastructure is often insufficient to provide adequate, high-quality transport for people and goods, reducing the quality of life. Many cities in LMICs have poor road infrastructure and still require substantial investments in upgrading their roads. For example, in 2013, Kinshasa had only 63 m of paved roads per 1,000 people; Dar es Salaam, 150 m; and Abidjan, 346 m—compared to an average of 1,000 m per 1,000 population in LMIC cities (Africa Development Bank 2014, pg. 51). This creates significant logistical challenges for the supply of goods and access to opportunities by any mode. Even in cities where paved roads exist, they lack other important infrastructure such as sidewalks, traffic signals or calming measures, adequate lighting, dedicated bike and bus lanes, and well-maintained bus stops, among others (Arroyo-Arroyo and Frame 2021). Poor maintenance practices compound infrastructure challenges. Almost USD 45 billion worth of road infrastructure (urban, interurban, and rural) was estimated to be lost in 85 LMICs in Asia, Africa, and Latin America between 1970 and 1990 due to inadequate maintenance when USD 12 billion could have averted it with preventative maintenance (Pojani and Stead 2015). Continued sprawl exacerbates the already existing infrastructure and service gaps. Infrastructure needs in LMICs will continue to grow, and the type of investment that cities use to address these needs has serious implications for the way cities will develop to meet both development and decarbonization goals.

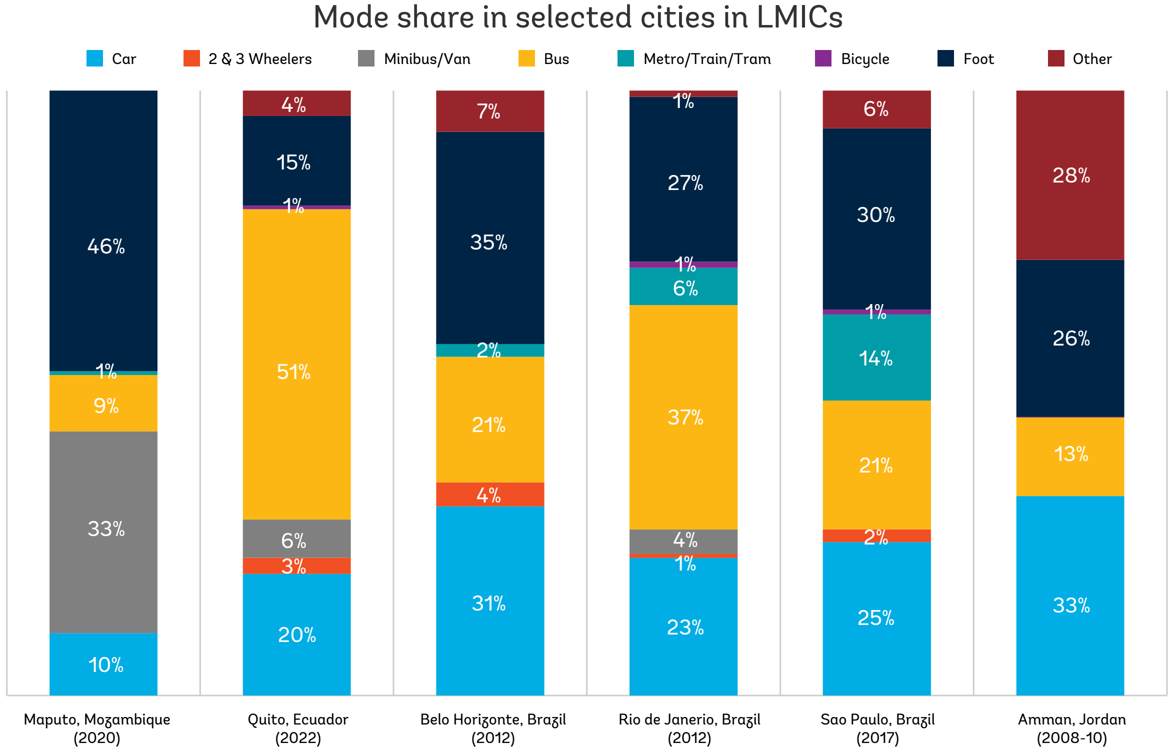
Despite significant fiscal constraints in LMICs, private vehicles such as cars and motorcycles traditionally receive many forms of direct or implicit subsidies. In many cities, most transport spending is dedicated to road construction, and private vehicles owners and users often pay for very little of the cost of road maintenance, especially when fuel prices are low. Furthermore, the revenue is collected from car users is not always channeled towards road maintenance at the city level. Private vehicles also receive preference in the allocation of road and curb space, often with free, underregulated, or unenforced on-street parking.[5] More than 95 percent of road spaces in LMICs are devoted to cars, including on-street parking (Welle, Abubaker and Ali 2022). This allocation disproportionally favors the lowest-occupancy, least space- and energy-efficient vehicles, resulting in negative externalities such as congestion, traffic accidents, air pollution, and GHG emissions. As private vehicles compete for valuable urban space with other lower-carbon modes, their preferential treatment leads to poor performance of buses and eat into the space that could be allocated to sidewalks, bicycle lanes, bus stops, bays for delivery trucks, or other uses.

The preferential allocation of resources and space to private passenger vehicles is regressive, particularly in LMICs. Car ownership remains far lower in many cities in LMICs than in cities in HICs[6] and is most often associated with the wealthiest households. In cities, private vehicles account for a relatively small share of trips compared to walking and public transport (see Figure 1.4). Therefore, for many LMICs, investments in alternatives to private vehicles can be both more environmentally sustainable and more socially inclusive.

[5] A study surveying parking on 30 roads of Hanoi found that 80 percent of the roads had illegal parking, mostly concentrated in new development areas where sidewalks were wider to accommodate cars (Thanh and Friedrich 2017).

[6] For example, data collected from World Bank teams for this report suggests car ownership levels (in terms of vehicles/1000 people) of: 28 in Maputo, 40 in Dakar, 107 in Amman, 191 in Quito, 312 in Rio de Janeiro, 482 in São Paulo, and 631 in Belo Horizonte. Furthermore, only 11 percent of people have driver licenses in Dakar compared to 50 in São Paulo.

Figure 1.4. Urban Passenger Transport Mode Share in Select LMIC Cities



Source: World Bank data collected for this report.

Note: bus % for Belo Horizonte and Sao Paulo includes minivans; bus % for Amman includes all public transport. Other % for Belo Horizonte includes "fretado", school transport service, taxi (including app-based services), and others; for Rio De Janeiro it includes trips by boat and other; for São Paulo it includes fretado, student services, taxi, and others; and for Amman it includes private buses and taxis.

Walking is a main mode of travel in many cities in LMICs (especially in Africa), but many cities lack the basic infrastructure to support it, rendering it unsafe and unattractive, used out of necessity rather than choice. Pedestrian city infrastructure is often severely underdeveloped (Basil and Nyachieo 2022). For example, in Dakar, Senegal, only 4 percent of urban roads have sidewalks. When sidewalks or pavements exist, they tend to be unconnected and the lack of enforcement means that they are used for activities other than walking (such as sidewalk parking, vendors). For example, in Douala, Cameroon, pavements are occupied by vendors from the informal economy, as public spaces maximize their chances of finding customers (Martinie et al. 2017). Even in cities with lower shares of door-to-door trips by walking, walking remains an essential means of accessing public transport services daily. Poor quality walking infrastructure disproportionately impacts the poor, the youth and elderly, women in care-giving roles, and those with limited mobility (Adkins et al. 2017).

While some cities in LMICs are addressing transport infrastructure and service gaps by improving their public transport, these projects are focused on mega-infrastructure and suffer from integration and financial sustainability issues. Corridor-specific investments in public transport infrastructure often lack consideration for physical integration (such as intermodal station design, connectivity of walking infrastructure for access) and service integration (such as coordinated operating schedules, fare policy and collection systems), deterring their use (ITDP 2019). Large public transport infrastructure projects like urban rail, light rail transit (LRT), or bus rapid transit (BRT) often lack stable funding sources to sustain operations, and subsidies to public transport account for a significant share of limited municipal budgets. For example, in Ulaanbaatar, Mongolia, as many as 30 percent of bus trips were made free of charge in 2016 under the city government's subsidy program. With a low, flat fare charged to other users, provision of bus subsidies represented 15 percent of the city budget, leaving no room for spending on the expansion of urban transport services or bus fleet upgrades (Olyslagers, Chen and Bat-Orig 2018). In Buenos Aires, public transport is highly affordable at the expense of low-cost recovery: 20 round trips cost only 3.3 percent of the minimum wage. In 2019, the cost recovery rate from fares was 26 percent, but this dropped to 9 percent in 2020 and 2021 during the COVID-19 pandemic. In 2021, public transport subsidies in the Buenos Aires Metropolitan Area amounted to USD 3.1 billion, or 0.72 percent of the GDP, and as a significant proportion of these subsidies are used to offset operating costs, the system faces underinvestment in infrastructure (World Bank 2022b).

Subsidy policies in LMIC cities are not well targeted, worsening the funding gap for the provision of transport. Increasing fares without affecting the most vulnerable or those who depend on public transportation must be a key goal of many cities looking to reduce operating subsidies for public transport. Although the subsidies can be significant, they can be recovered in the form of increased productivity and may have an important equity impact. However, the funding mechanisms and subsidy policies for public transport are often not well targeted, resulting in reduced investments and therefore, quality of service. This creates a vicious cycle of lower ridership, cost-recovery, and investment. Financial sustainability challenges create an unfavorable environment for organized financial markets, making it difficult for public transport projects to secure the necessary financing for growth and development.

Informal (or paratransit) services, prevalent in LMICs, meet demand where more 'formal' urban passenger and freight transport services are inadequate; without support, these are associated with many challenges. Informal services exist in both passenger and freight transport and are provided by an array of vehicle types, from two- and three-wheelers to (midi) buses. These services often operate with limited regulatory oversight, which results in aggressive competition for passengers, speeding, vehicle overcrowding, 'fill-and-go' system behavior, and poor or no service during off-peak periods and on low-demand routes (Jennings and Behrens 2017). Competition, low fares, and a lack of access to private financing often mean vehicle owners cannot afford maintenance, ignore vehicle depreciation, and rely on the import of second-hand vehicles. This leads to low-quality vehicle fleets (Kumar, Zimmerman and Arroyo-Arroyo 2021) that negatively impact user comfort, operational efficiency, and emissions. Private sector participation in the provision of informal passenger and freight transport services is already high in many LMICs, but the lack of access to private capital financing remains a key barrier to improving vehicle fleets and modernizing services. In many LMICs, two- and three-wheelers provide an advantage over other informal services but are especially notorious for road unsafety. An e-survey of road users in Africa revealed that 30 percent of motorcyclists used their phones while riding, 50 percent do not use helmets, and 40 percent report exceeding speed limits (Addo-Ashong 2021). In Kampala, crashes and fatalities were so common that Mulago National Referral Hospital dedicated a 'boda' crash department, with larger incidents regularly reported in the papers (Evans, O'Brien and Ng 2018).

Given congestion and other delays in the logistics chain, inadequate infrastructure for freight movement, loading and unloading, and poor regulations on delivery times and modes, freight connectivity is a special challenge in LMIC cities. Freight last-mile connectivity costs account for about 40 percent of the total logistic costs globally (Suguna, Shah, Raj, and Suresh 2022), much of which is generated in cities. With LMIC cities' masterplans lacking a focus on freight considerations, trucks are normally subject to intense regulation, increasing the cost of last-mile delivery. Further, the poor road infrastructure, lack of parking facilities, and congestion intensify that problem, particularly in highly dense areas such as slums and peripheral poor neighborhoods. The result is that the price of goods in more vulnerable areas becomes higher than in more central, wealthier areas. While e-commerce might increase access to more affordable items, the lack of accessibility will continue to increase the overall prices.

In LMICs, poor integration of urban freight and inefficient logistics create significant externalities and tensions with urban passengers. Inefficiencies in urban freight can contribute to disproportionate GHG emissions (while they take up 20 percent of space, commercial vehicles can contribute to as much as 40 percent of GHG), air pollution, noise emissions, and safety issues. In India and Bangladesh, trucks make up 6 percent of on-road vehicles but are involved in 26 percent and 24 percent of road accidents in the two countries, respectively (GIZ 2021). Moreover, urban freight competes with urban passengers for road and parking space and contributes to infrastructure wear and tear (see Box 1.1). The discussed externalities have rendered urban freight to be often viewed by policymakers and planners as an issue to contend with rather than an essential component of urban development (GIZ 2021). Decoupling the demand for essential goods from increases in freight transport services and its externalities is critical.

Emerging technologies and digital platforms provide new opportunities for improving the operations of urban passenger and freight transport services, but only if their adoption is contextualized to the realities and needs of cities in LMICs (Bianchi Alves et al. 2021). Access to technology-enabled mobility services is currently limited to a portion of the population, raising equity concerns (Schechtner and Hanson 2017), and it is still unclear whether ride-sharing services in LMICs provide net decarbonization benefits or whether the congestion and emissions they induce outweigh their accessibility benefits (Chalermpong et al 2022). There is also a question on the viability of their business model in the long run, and how judicious it is to rely on such services as a large part of the transportation mix. In urban freight, growth in e-commerce and just-in-time inventory management and deliveries have increased the frequency of deliveries of small orders, raising the demand for transport services and their accompanying externalities.

Box 1.1. Passenger and Freight Transport in Urban Areas—Essential Services Sharing Valuable Space for the Vibrancy and Health of Cities

Urban freight is essential to economic activity and should be an integral part of the urban fabric. Both the provision of necessary services (such as health and education) and facilitation of discretionary activities (cultural, recreational) depend on the movement and delivery of goods. The type and extent of urban freight influences the livability and well-being of residents, attractiveness to visitors and economic competitiveness of cities. Moreover, effective responses during extraordinary conditions also rely on the efficient distribution of necessary materials and goods, with COVID-19 being an extreme example. Finally, urban freight is an important source of employment, generating an estimated 5 to 10 percent of the total employment in metropolitan areas (GIZ 2021).

Urban freight transport must co-exist with urban passenger transport in limited and valuable urban space (see Image 1.2). This can create tensions such as:

- **Competition for road space**. Passengers and goods often share road infrastructure, with commercial vehicles taking up roughly 20–40 percent of motorized road space. This can create competition in an already crowded environment and results in externalities such as congestion and decreased safety for motorized and non-motorized modes. For example, the maneuvering of larger trucks can be a risk to pedestrians and other transport network users.
- **Competition for parking space**. In LMICs, commercial vehicles often need to compete for parking space with urban passengers. Illegal parking and the use of curbs for non-transport services (such as selling merchandise) can exacerbate related issues.
- **Shared road infrastructure damage**. Heavy-duty trucks can cause greater wear and tear due to their weight. Detrimental practices that are more prevalent in LMICs such as overloading or the use of vehicles that are not roadworthy can add to the issue.

Source: World Bank's elaboration based on GIZ 2021.

Image 1.2. **Vibrant Street Market in Cairo, Egypt where People and Goods Must Move Together**

Image source: Adam Cohn (2023).

Biking can be an attractive mode for short trips, but the lack of biking infrastructure is a strong deterrent to their uptake. Despite recent efforts in many cities in Latin America—most prominently, Bogota, Buenos Aires, Santiago, and Mexico City (Sibilski and Targa 2019)—bike infrastructure is usually lacking in cities in LMICs. While bicycles are often seen as an affordable transport option, in some cities like Addis Ababa, the cost of bike ownership can be a barrier due to the lack of bike manufacturers and high-import duties on bikes (Global Designing Cities Initiative 2020).

Urban transport systems in LMICs fail to cater to all residents. A World Bank analysis showed that 50 percent of women surveyed in Cairo, Egypt, and 53 percent of women in Beirut, Lebanon cite commuting as a barrier to jobs; in Jordan, three in five non-working women state that the lack of affordable, comfortable, safe, time-efficient, and reliable transport prevents them from looking for work (Alam and Bagnoli, 2023). Work in Jordan also shows that more than 60 percent of women report facing harassment when using public transport (Kurshitashvili et al. 2022). In Delhi, women are forced to choose lower quality colleges and use behavioral strategies to reduce risk while traveling (Gopal and Shin 2019). Similar situations are seen in Buenos Aires, Rio de Janeiro, Lima (Dominguez Gonzalez et al. 2020), Mexico City and Bogotá (Munro and Moloney 2018), and Nairobi (UN Women 2021). In Mexico, 70.9 percent of the respondents agreed that public transport did not have the minimum standards to be used by people with disabilities (Dodero, Georg, and Hamrick 2019).

For many LMICs, used vehicle imports make up most of the urban passenger and freight vehicle stock and constitute a significant part of their economy. Imported vehicles can be cleaner and more energy efficient than the existing vehicle stock and play a role in promoting fleet turnover to meet environmental, climate, and road safety goals (Gorham et al. 2022; UNEP 2020). However, under current trade conditions, many imported vehicles have outdated safety and emission technologies (Gorham et al. 2022; World Bank 2021). Poor maintenance practices, wear-and-tear, removal of safety and emissions technologies, unregulated structural modifications, and unchecked operation once in use in LMICs worsen these conditions (World Bank 2021). In the absence of an effective 'motorization management' regime to control the sale, in-use quality, and end-of-life of passenger and freight vehicles, older and poorly maintained vehicles pose both climate and development challenges. In addition, a lack of fuel quality regulation and controls in many LMICs further limit the use of advanced emission control technology.

Institutional gaps and fragmented governance underpin many of the efficiencies in urban transport systems in LMICs. One of the biggest hurdles to enhancing urban transport and decarbonization in LMICs is the governance structure (or lack thereof). Often, governments in LMICs are reactive and focused on responding to ongoing crises rather than proactively developing strategies based on a vision, mission, and long-term planning. The governance structure is also limiting when it has unclear or inefficient division of roles and responsibilities between local and national governments. Within the local government, institutions are fragmented with separate land use planning and urban development departments at various levels despite the intrinsic connection between the two. There is also limited coordination in policymaking between key sectors within interrelated dimensions and objectives (such as energy and transport). Moreover, scarce resources, coupled with inefficient spending that prioritizes car over people, puts the most vulnerable groups at a disadvantage.

The challenges described herein are significant and complex, and their resolution will require political will, institutional capacity, stakeholder engagement, and significant investments. Governments have an opportunity to acknowledge these challenges and work toward tackling them to place their cities (and the world) on a path that promotes development with long-term social and environmental benefits, such as reductions in GHG emissions and air pollution and improvements to well-being, health, and safety.

1.3. The AVOID-SHIFT-IMPROVE Framework

Cities in developing countries have a small window of opportunity to influence the climate impact of their increasing urban transport activities. As LMICs continue to urbanize and develop, demand for urban passenger and freight transport will grow. This growth in travel demand is fundamental to development as people expand their ability to access opportunities (such as jobs, schooling, shopping, leisure), goods, and services. Meeting this growing need for urban transport in LMICs in a low-carbon way is a critical agenda for both development and climate.

Cities need a paradigm shift in the policies they implement and in their approach to governance to enable the decarbonization of transport. The required paradigm shift involves a significant change from a vehicle-centric approach to a people-centric approach, with implications for how public space is used, how city governments invest in new infrastructure, and how this infrastructure is operated. As the movement of people and goods in urban areas is complex—involving the supply of transportation services by many different modes and demand for transportation services for different purposes by many different users—only a comprehensive package of measures will help achieve these objectives.

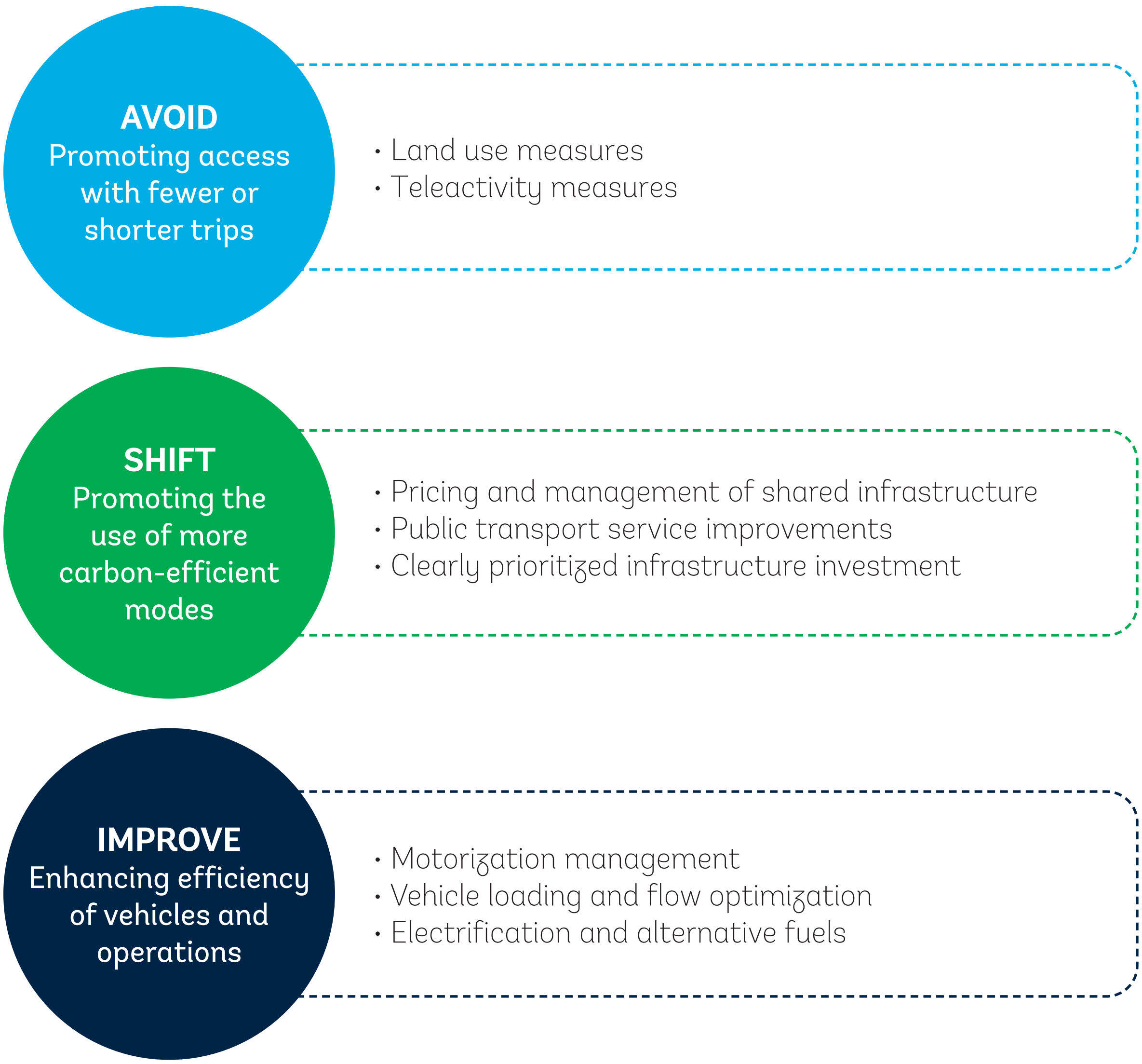
ASI is a simple framework for guiding and prioritizing actions to address climate change mitigation in the transport sector. The ASI framework categorizes actions at three levels (Figure 1.5):

1. AVOID - address the overall demand for transport activity by promoting access with fewer or shorter trips.[7]
2. SHIFT - address how trips are distributed or split among modes by promoting a SHIFT of passenger or freight trips from more carbon-intensive modes to less carbon-intensive modes.
3. IMPROVE - address the efficiency and quality of vehicles, operations, and fuels.

[7] While some literature will define AVOID measures as those that reduce *motorized* trips, in this report we consider AVOID measures only as those that change the underlying demand patterns for passenger or goods movement (regardless of mode) to make a clear distinction with SHIFT measures that may encourage non-motorized or more efficient motorized transport.

The ASI framework for transport decarbonization stresses the importance of adopting a system-wide perspective and actions at every level will be required to achieve the decoupling of urban transport growth and GHG emissions. When resources are scarce, policymakers in LMICs should prioritize actions at that have the greatest and longest lasting development benefits accompanying their climate mitigation. Actions at the AVOID tend to be less resource consuming and have important cascading effects that enable actions at the SHIFT and IMPROVE levels. For instance, changes in land regulation may reduce distances traveled and increase the attractiveness of walking and biking, promoting SHIFT. They may also result in technical feasibility of electric mobility technologies, promoting IMPROVE. Development benefits that may accompany decarbonization measures include improved accessibility, job creation, greater economic productivity, reduced local air and noise pollution, improved public health and safety, and greater social inclusion (Gouldson et al. 2020; Oliveira et al. 2013). To help inform these decisions, the following sections of this chapter outline the urban transport policy actions available at each level of the ASI framework and discuss their climate and development impacts.

Figure 1.5. **AVOID-SHIFT-IMPROVE Framework for Decarbonizing Urban Transport**



Source: Original figure produced for this publication.

1.4. Decarbonization of Urban Transport: How to Determine which Measures to Adopt

The decision on the decarbonization measures to be adopted must be made after performing a basic analysis of alternatives, weighing generalized costs, benefits, and tradeoffs. Any given measure categorized under the ASI framework naturally comes with an implementation cost, consisting of administrative, capital, and operating and maintenance costs, as well as time and political will. The costs of implementing any measure must be weighed against the potential benefits gained, in terms of GHG emissions reductions and other economic, social, or environmental benefits. This analysis relies on data that many LMICs do not regularly collect and the development of new analytic skills in key institutions responsible for urban transport governance.

The outcome of any analysis of alternatives will depend on each city's complex urban context, but the process of determining the most effective measure is generalizable across contexts. The heterogeneity of urban form and development patterns and availability of urban passenger and freight transport infrastructure and services makes it challenging to provide generalizable recommendations. However, the process to determine the most effective measures is generalizable. Therefore, each main chapter of this report concludes with a flow chart, highlighting the key questions that cities can answer as they guide their urban transport systems to better outcomes for development and climate.

This report represents only the first of many steps for national- and city-level policymakers working in the urban, transport, and environmental sectors in LMICs to determine for themselves the best low-carbon pathway for their cities. The report introduces the different measures that can help decarbonize urban transport systems and discusses how they interact with complex urban transport environments. It discusses, albeit qualitatively, the potential costs, benefits, and tradeoffs of different measures under the ASI framework. This report also serves as a call for collective action to better document and measure the impacts of ASI measures and to share this knowledge widely across cities around the world. Although considering climate change impacts and infrastructure resilience is critical, this report focuses on climate mitigation rather than climate adaptation. This report targets policy makers in urban transport in local and national governments; multilateral and bilateral financing institutions; private sector operators; civil society; not-for-profit organizations; investors; and other stakeholders interested in public policies for the decarbonization of urban transport.

Image 1.3. **On the Road in Kumasi, Ghana**

Image source: Carsten ten Brink (2018).

Chapter 2
AVOID Measures:
Promoting Access with Fewer or Shorter Trips

Actions at the first level of the ASI framework, AVOID, address the overall demand for transport activity by promoting access with fewer or shorter trips (Figure 2.1). The most efficient way to achieve greater access with fewer kilometers-traveled is to bring opportunities, activities, services, and goods closer to the people accessing them via land-use measures that control sprawl and encourage dense, compact, and mixed-use urban form. In some cases, digital access can replace physical access that requires travel through tele-activity measures.

Figure 2.1. **Urban Transport Decarbonization Measures at the AVOID Level**

Land use measures	Revise zoning and other requirements for land development to discourage sprawl and encourage dense, compact, and mixed-use development
	Address affordable housing backlogs and lack of connectivity and integration of informal settlements
	Consider encouraging the use of urban land for localized freight consolidation and distribution centers, embracing “proximity logistics”
Teleactivity measures	Expand access to digital connectivity of firms and households to address inequalities
	Monitor trends in telework and teleshopping and proactively put in place land use policies and demand management measures to mitigate potential long-term consequences

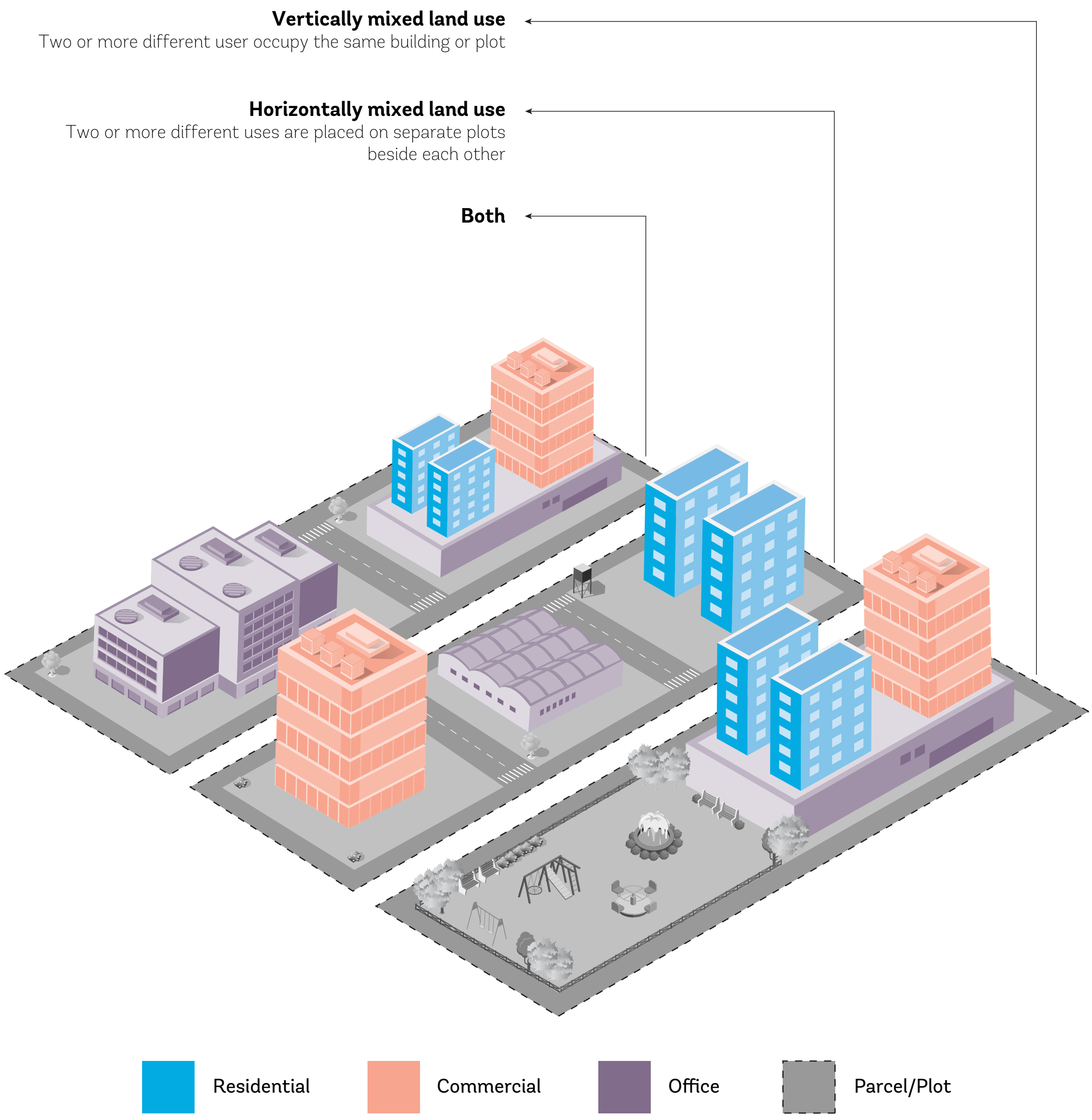
Source: Original figure produced for this publication.

2.1. Land Use Measures

Land use measures guide urban growth and assign space to different uses or activities. Land use measures enable local governments to influence the location of economic activities, urban infrastructure, and households, which, in turn, impact transport choices, accessibility, and human interaction (Ardila-Gomez, Alves and Moody 2021; Duque et al. 2017; Nabil and Eldayem 2015).

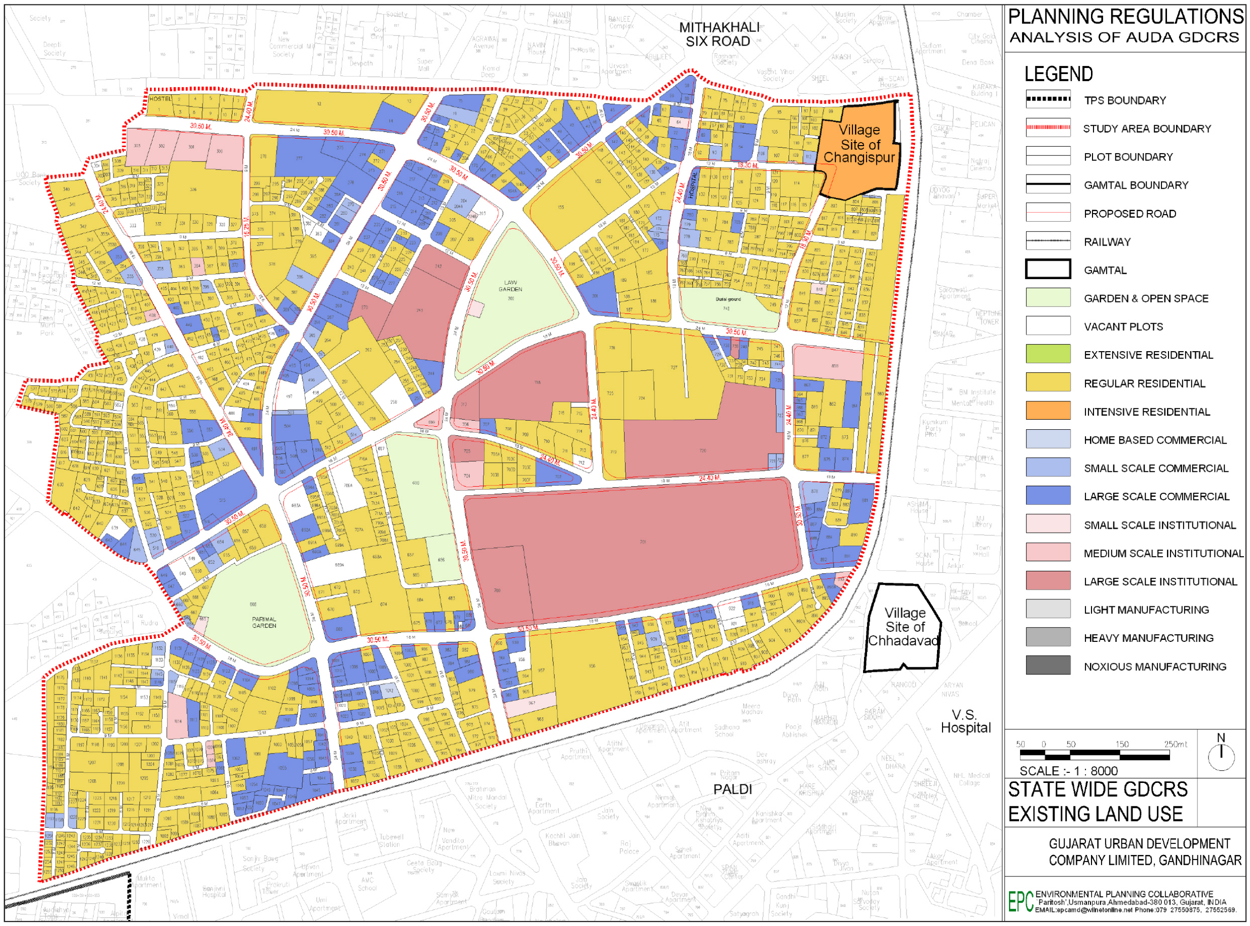
Mixed land-use can be horizontal, vertical, or both (Figure 2.2). Vertically mixed land use occurs when two or more uses occupy the same building or plot. For example, the Global Trade Center Tower in Nairobi is a 7.5-acre plot comprising six towers. The office tower includes three stories of retail space (from the ground floor to the third floor), above which are office spaces. The other towers include a hotel and residential space (Nkirote 2023). Horizontally mixed land use occurs when two or more different uses are placed on separate plots beside each other. For example, areas of Ahmedabad, India, have a mix of plots each dedicated to green space, commercial, institutional, and residential uses (Figure 2.3).

Figure 2.2. Types of Mixed-use Urban Development



Source: Original figure produced for this publication.

Figure 2.3. Map of Current Land Use by Plot of Changizpur Village in Ahmedabad, Gujarat, India, Showing Areas with Horizontally Mixed-Use



Source: Reproduced from Nohn 2011 (Map 3, pg. 22).

Land use measures can be powerful levers for encouraging agglomeration and innovation in urban economies, improving citizen welfare, and decarbonizing urban freight and passenger transport systems. Dense, compact, and mixed-use urban development aids the development of a vibrant economy (Lall et al. 2021), reduces the cost of providing transport, and facilitates access to opportunities with fewer kilometers traveled (Cervero 2013; Bertaud 2004). Dense, compact, and mixed-use cities typically generate shorter trips than sprawling cities as the length of a trip depends on how residential, commercial, educational, work, and recreation centers are located within a city (Agarwal 2014). This has a positive effect on the total emissions from the city and the emissions from transport. For example, a study of 104 cities in China showed that a more centralized and compact urban form was associated with lower emissions (Wang, Madden and Liu 2017). Compact, walkable, and mixed-use communities also have development benefits well beyond GHG emissions mitigation. For example, they are found to improve public health and reduce public health spending by lowering obesity, high blood pressure, heart disease, and diabetes rates (Benfield 2017).

While land use measures primarily reduce emissions by AVOIDing kilometers-traveled, they also have positive spill-over effects for SHIFT measures, which further amplify their emissions reduction potential. By encouraging shorter travel distances, dense, compact, mixed-use development makes walking and biking more attractive. And when combined with investments in high-capacity transport infrastructure and service, dense, compact, and mixed-use transit-oriented development (TOD) can result in the greater use of public transport and lower use of private vehicles, saving people time and money while reducing GHG emissions (Salat and Ollivier 2017). Research in Latin American cities finds that TOD led to higher use of BRT and, in Santiago, greater urban densities and closer proximity to metro rail stations is linked to lower per capita levels of vehicle-kilometers traveled (VKT) (Rodriguez and Vergel-Tovar 2018; Cervero 2013). Conversely, lower-density, single-use, peripheral development leads to more travel and greater reliance on private vehicles, which increases urban transport emissions. In Shanghai, research on 900 households showed that relocating from the urban core to housing units on the periphery increased their VKT by 50 percent (Cervero 2013).

As part of land use measures, cities need to be intentional about the integration of informal settlements and ensure that affordable housing is well-connected to transport infrastructure and services. Cities in LMICs have often taken one of two approaches to improving informal settlements:

i in-situ upgrading of the settlements so that people who live in these areas have better quality housing and services as well as access to transport and opportunities

ii new low-income residential areas and employment-generating land uses (re)located along transport corridors to improve access to transport and economic opportunities

A simulation exercise for Capetown, South Africa found that 'in-situ' upgrading is a viable option when informal settlements are in areas with easy access to economic centers (Moyo, Zuidgeest and van Delden 2021). When it comes to re-location of low-income residential areas, access to social and economic networks is critical (see Box 2.1) (Barnhardt, Field and Pande 2017; Belchior, Gonzaga and Ulyssea 2022). Furthermore, cities need to be aware of the potential 'gentrification' impact of new development and carefully balance regulations to keep housing prices affordable (Teller 2021; Moyo, Zuidgeest and van Delden 2021).

Image 2.1. **A Congested Crossing in La Paz, Bolivia.**

Image source: Katie Wheeler (2018).

Box 2.1. The Relationship Between Affordable Housing Location and Transport Connectivity in India

A housing lottery in an Indian city provided winning slum dwellers the opportunity to move into improved housing on the city's periphery. Fourteen years later, the program saw significant exit, with 34 percent of lottery winners never moving to the subsidized housing provided and a further 32 percent leaving the program after entering. Lottery participants reported improved housing, but no change in tenure security, family income, or human capital. They also reported increased isolation from family and caste networks and reduced informal insurance. These results suggest negligible long-term economic value of this expensive public program and underline the importance of considering social networks in housing programs for the poor.

Source: Barnhardt, Field and Pande 2017.

Land use measures are equally important for urban goods movement. Proximity logistics or '*the development of logistics facilities in high-demand areas, which are essentially urban, dense, and mixed-use*' (Rai et al. 2022) can reduce GHG emissions from urban freight transport by limiting logistics sprawl. Low-impact and high-performance supply chains, especially in high-demand areas, gain from logistics facilities being closer to where goods are used and consumed. Proximity logistics allows logistics providers to increase and improve (not replace) networks of logistics facilities in the direction of urban cores to mitigate some of the undesirable externalities associated with logistics sprawl (Rai et al. 2022). The relationship between urban sprawl/proximity and emissions is complex. Still, examples from around the world show the potential for proximity logistics to reduce distances and curb emissions (such as the micro-hub in Paris) as well as link the logistics sprawl to negative externalities. One study found that logistics sprawl contributes to a 2.5 g increase in CO_2 emissions per purchase for online shopping compared to a 1 g increase for store shopping in Europe (Rai et al. 2022).

Cities have an important role to play in integrating logistics into land use planning and development to promote proximity logistics. It is critical to foster freight efficient land use (FELU) as part of land use plans (Holguin-Veras et al. 2022). While the decision on locating distribution centers and other logistics facilities typically rests with private companies, regulations and incentives can influence their decision and encourage the efficient use of valuable land in urban areas. Cities can explicitly integrate logistics into their land use plans, earmarking land for new development, mandating that new developments include space for logistics operations where viable, or the use of abandoned or underutilized sites for energy-efficient logistics (Holguin-Veras et al. 2022). In the long-term, promoting FELU also includes using zoning laws to preserve existing logistics land use and logistics-focused 'land banking'—the reserving of land near existing facilities to avoid logistics sprawl (Holguin-Veras et al. 2022). The City of Paris has leveraged integrated land use and logistics planning and zoning requirements to reshape logistics development from the outskirts of the city to the urban core (see Box 2.2). In Shenzhen, the Urban Development and Land Use Plan for 2016–2020 suggests an urban logistics network for last-mile delivery hubs and the redevelopment of former industrial sites into e-commerce logistics facilities (Rai et al. 2022).

Box 2.2. Logistics and Land Use Planning in the City of Paris, France

Without government intervention, logistics facilities tend to locate outside of urban areas to avoid high land prices and pushback by local communities, leading to environmental and systemic inefficiencies when making deliveries to cities.

The logistics land-use plan enacted by the City of Paris demonstrates how identifying locations for urban logistics facilities and supporting their development can improve the efficiency of urban logistics. Paris' regional plans—supported by zoning ordinance plans—identify land parcels in strategic locations reserved for logistics facilities. The city reserves parcels based on a two-tiered framework consisting of:

- larger multimodal sites on the edges of the urban areas
- smaller distribution centers throughout the urban core

The purpose of the bigger, multimodal (and sometimes mixed-use) developments is to receive larger shipments by rail, waterway, or large trucks and then send out smaller, environment-friendly vehicles for delivery to the more dispersed urban distribution centers or directly for delivery. The smaller distribution centers in the urban core are often converted parking structures and encourage cargo consolidation and the use of clean transport modes. For example, the Beaugrenelle underground facility, which opened in 2013, is reported to have reduced the environmental impact of its freight activities by decreasing VKT by 52 percent, which, in turn, significantly reduced noise pollution and emissions.

Ensuring that land is available (and affordable) for freight activities throughout the urban area helps mobilize private sector investment in urban logistics facilities development. Paris does not just reserve land for freight activities, it also supports private sector developers by cleaning up earmarked sites or developing infrastructure to ensure that the sites are well-connected prior to development. Only after the public sector makes these initial investments does the City of Paris organize bids for tenders to transform abandoned or underused urban sites into urban logistics hubs. Paris has also experimented with 'location perimeters' on private land, where developers can get a building permit only if they integrate a logistics facility for new buildings or reconstitute it when one is present.

Source: Adapted from Holguin-Veras et al. 2022.

Integrating land use and transport planning to reverse ongoing processes that promote urban sprawl requires a review of practices and regulations. This can be done either by implementing transport projects where densities exist or by directing urban growth to where transit corridors are implemented. The latter will require intense collaboration among urban/land and transport departments, even when they belong to different jurisdictions (Agarwal 2014). In some cases, a thorough re-evaluation of existing land use policies (such as floor area ratios [FARs], minimum lot size, setbacks and parking requirements, single-use requirement, maximum plot coverage ratio, number of housing blocks per unit) is necessary to encourage densification and competition in private sector development and decrease the cost of land (Cervero 2013). Inappropriate land use regulations or investments in transport infrastructure improperly aligned with land use policies can lead to urban sprawl, characterized by long, radial travel patterns, which are too expensive for public transport supply and too far for walking and biking. These issues, in turn, make transport unaffordable (requiring a high share of people's income) and ultimately prevents access to jobs and other basic needs (Ardila-Gomez, Bianchi Alves and Moody 2021). In other cases, where regulations do not exist, policymakers may incentivize densities in transit areas while reducing density in areas with no such provision. Policymakers should be aware that building height is not always synonymous with densification.

Finally, cities need to navigate a complex political economy to implement land use measures. In many cities in LMICs, a complex political economy makes it hard to change land use. This includes:

- the nature of the land market and its management, in terms of land allocation (for example, those who do not have formal cadasters)
- lack of good land use management, partly due to limited institutional knowledge and capacity (monitoring and managing the implementation of regulations)
- resources and high value of land with many competing claims (Dunkerley 1983)
- the limited attractiveness of the sector to the private sector due to issues with land security (Lall, Henderson and Venables 2017)

Cities also need to have an open discussion with all stakeholders to ensure acceptance and promote sustainable logistics. For instance, the City of Paris conducted online workshops on urban logistics, land use, and real estate to craft its future strategy based on consultations with stakeholders from logistics, manufacturing, and energy companies (Rai et al. 2022).

2.2. Teleactivity Measures

Teleactivities—or activities that can be performed remotely—affect the transport patterns of people and goods in complex ways, with significant implications for GHG emissions. On a trip-by-trip basis, teleactivities can substitute, complement, modify, or even neutrally interact with travel (Andreev, Salomon and Pliskin 2010) in the following ways:

1. *Substitute* trips: a location-based trip is replaced by a virtual one.
2. *Complement* trips: engaging virtually can lead to additional trips that would have not occurred otherwise.
3. *Modify* trips: there is no replacement or additional trips but there are changes in timing, modes, and so on.
4. *Be neutral:* the use of teleactivities does not impact another personal activity.

On a trip-by-trip basis, the more teleactivities substitute trips, the more they contribute to AVOIDing kilometers traveled and associated GHG emissions from transport. Conversely, where they complement trips, teleactivities expand access to goods and services but with greater kilometers traveled and associated GHG emissions.

The net impact of teleactivities on travel activity and emissions cannot be assessed on a trip-by-trip basis; instead, they must account for complex and interconnected patterns of land use, urban travel, and mode choice. While many studies have shown that on a trip-by-trip basis, teleactivities can lead to substantial reductions in travel and associated emissions, studies that consider the net impact (for example, Erdmann and Hilty 2010) have shown more modest reductions in GHG emissions or even increases in kilometers traveled and associated emissions (for example, Kong, Moody and Zhao 2020; Mokhtarian 2009). This is because urban transport almost always involves a complex patterning of trips for different purposes on different time scales (day, week, month, or year) and by different modes.[8]

The most promising teleactivity for reducing travel is telework (or teleschooling), which can replace commuting trips from home to office (or school) with remote access. Studies suggest that it can reduce up to 20 percent of annual vehicle distance traveled and 30 percent of trips. Since many individuals chain other types of trips (shopping and recreation) with work trips, teleworking leads to changes in trip-chaining

[8] For example, studies of travel behavior among people working from home during the COVID-19 pandemic have shown that while the numbers of trips decreased overall, a greater share of trips were taken by car, contributing to the return of traffic congestion long before public transport ridership (Vallejo-Borda et al. 2022).

behavior. While a complete understanding of the interactions among telework, mode choice, and trip-chaining behavior is lacking, particularly in LMICs, recent evidence suggests that US telecommuters are more inclined towards complex tours (Zhu and Guo 2022). In the longer term, the ability to work from home may create incentives for suburbanization, countering the impact of land use measures. Evidence shows that those who telecommute for a part of their employment tend to live further away from their jobs, tolerating fewer but longer days of commuting (Denham 2021).

Teleshopping is changing the way that people in cities access goods, and is increasing pressure on urban logistics and freight transport systems. While online shopping has been shown to reduce passenger transport and associated GHG emissions from shopping trips (Rosqvist and Hiselius 2016), it does so by replacing a passenger trip to a brick-and-mortar store with a freight trip (such as delivery). The combined outcome of complex shifts in shopping patterns and changes in per capita consumption (in terms of volume and price of goods purchased) can actually increase urban freight transport GHG emissions on net, although those impacts are likely to be localized (Mokhtarian 2004). The rise in consumer expectations for on-demand deliveries of goods purchased online is a particularly worrying trend, as it limits opportunities for shippers to consolidate loads, which, in turn, increases costs and emissions (Snoeck 2020). The World Economic Forum estimates that the growing demand for delivery could increase emissions and traffic congestion by more than 30 percent in the world's top 100 cities by the end of the decade (Boudreau 2021) (see Image 2.2). To alleviate these negative impacts, significant improvements in the locations of urban distribution centers, more efficient loading of delivery vehicles, staggered delivery hours, and other demand management strategies would be needed (discussed in the following chapters).

Image 2.2. **On-demand Food Delivery, Often Carried by Motorcycle, Adding Vehicle Kilometers to Beijing's Roads**

Image Source: Kentaro Iemoto (2016).

The scope for teleactivities is limited in all cities, but particularly in LMICs. In any city, not all activities can be performed remotely, teleactivities may not be feasible (inadequate ICT infrastructure), and remote connection may not always be a desirable substitute for human interaction (Mokhtarian 2009). Due to the prevalence of informal employment, a lower share of employment in service sectors, and a lack of access to electricity and internet service, LMICs have a smaller share of employment amenable to teleworking. Only 20 percent of the population in Maputo and 50 percent of the population in Dakar have internet access, for example. One study estimated that only 4 percent of employment in major African cities and around 8 percent in major Latin America cities can be conducted remotely, compared to 14 percent in OECD countries (Gottlieb, Grobovsek, Poschke and Saltiel 2021). Other estimates indicate that one in 36 jobs (less than 3 percent) can be performed from home in LICs compared to one in 5 jobs (20 percent) globally (Garrote Sanchez et al. 2020). When it comes to teleshopping, a lack of access to online banking systems, existing retail practices, and culture (whether online shopping can be trusted) are other reasons that could explain the lower levels in LMICs (Garrote Sanchez et al. 2020). Low levels of "bankarization" or credit card penetration in LMICs (around 7 percent on average for LICs and 36 percent for middle-income countries [MICs]) are also considered a challenge (Hook et al. 2020). The data collected for this report suggests that credit card penetration is as low as 4 percent for Maputo and 11 percent for Dakar, for example.

The COVID-19 pandemic and recent innovations in the technology industry in LMICs provide growing opportunities for teleactivites, which cities need to be ready to manage. Estimates from the International Labor Organization indicate that between 20 percent and 30 percent of wage earners in the labor markets of Latin America and the Caribbean teleworked during lockdowns compared to less than 3 percent before the pandemic (ILO 2021). Furthermore, the recent proliferation of digital payment mechanisms such as mobile money has expanded access to teleshopping, particularly during the pandemic (Hook et al. 2020).[9] The International Finance Corporation estimates that more than 230 million jobs in Sub-Saharan Africa will need digital skills by 2030, with the services industry expected to require the highest levels of digital skills (IFC 2019). The World Economic Forum suggests that to prepare for the growth in digital skills and the tech industry, cities need to address the gaps in the power infrastructure and internet connectivity, develop skills among the population, and improve digital access (Monthe 2022). To make the most of these massive transformations in behavior, cities need to align urban planning with decarbonization strategies in the transport, digital, energy, and financial sectors.

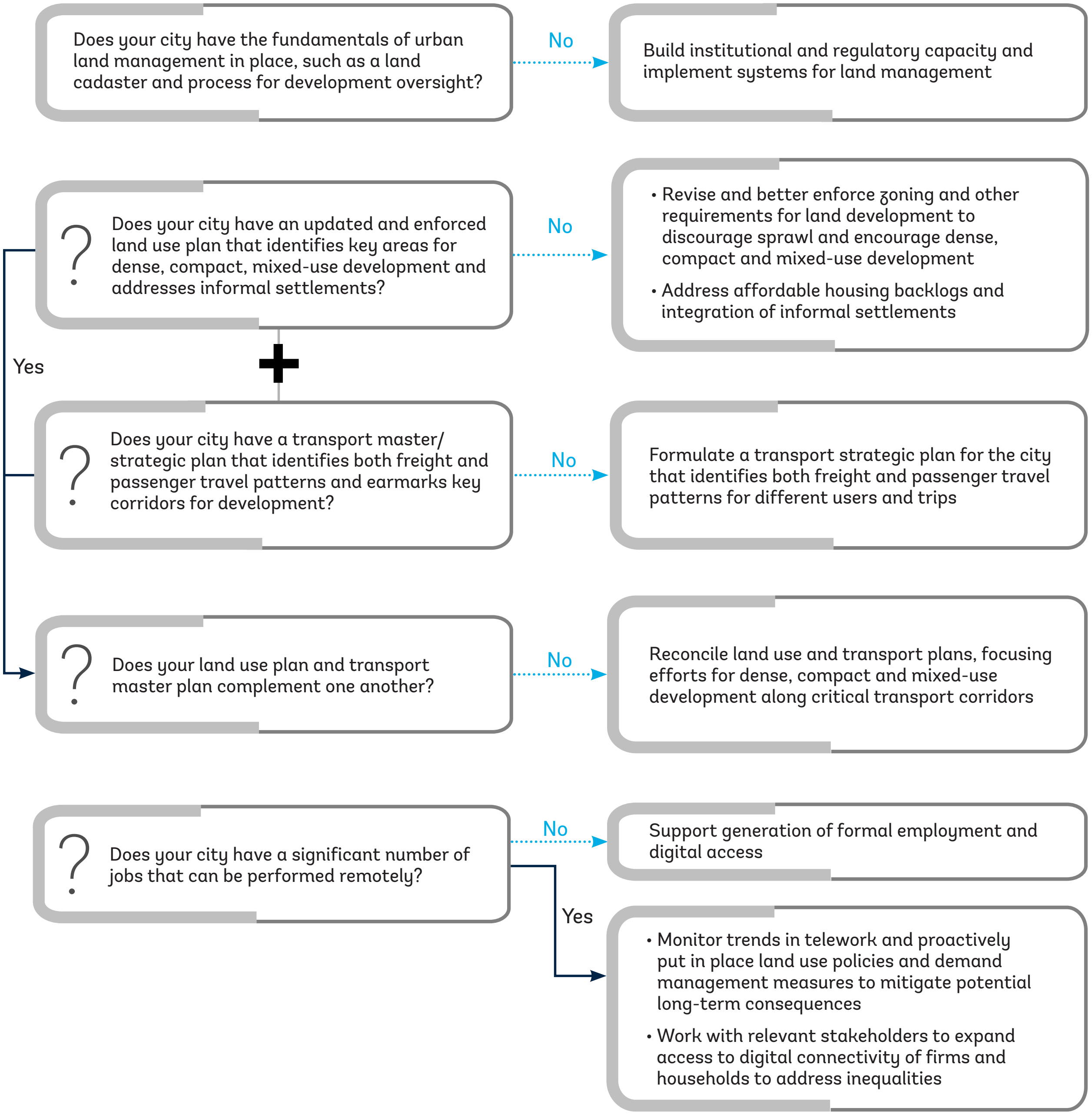
Recognizing the limitations of teleactivity adoption in LMICs does not negate its importance for cities as one of many potential decarbonization measures. Teleactivity measures can be one part of an urban transport decarbonization strategy. Cities have an important role to play in establishing policies and incentivizing firms to facilitate teleactivities while monitoring the long-term land use and travel behavioral consequences and distributional impacts of these actions. The dynamic environment in terms of both technology innovation and use cases is quickly changing their viability and impact within LMICs. Once the infrastructure and digital skills are available, cities can ensure that all households are well-connected to electricity and internet services and work with employers on teleworking policies to help increase the levels of telework. It is equally important to develop neighborhoods in ways that incentivize walking and cycling, reducing the need for cars for everyday activities. Similarly, land use policies and demand management measures (discussed in Chapter 3) are critical for mitigating the impact of rising urban freight activities due to e-commerce and teleshopping.

[9] The share of people making or receiving a digital payment has grown considerably from 2014 to 2021, from 12 percent to 35 percent for LIC and 36 percent to 57 percent for MIC (Hook et al. 2020).

2.3. Deciding on AVOID Measures

The patterns of land use, realities of land ownership, and the specific processes of land use planning and management differ across cities in LMICs. These differences make it challenging to provide generalizable recommendations in terms of the most effective measures for a given city. However, a few guiding questions can help cities determine where to take AVOID actions in terms of land use policy reform and based on their local context (see Figure 2.4).

Figure 2.4. **Guiding Questions for Determining AVOID Measures for Decarbonizing Urban Transport**

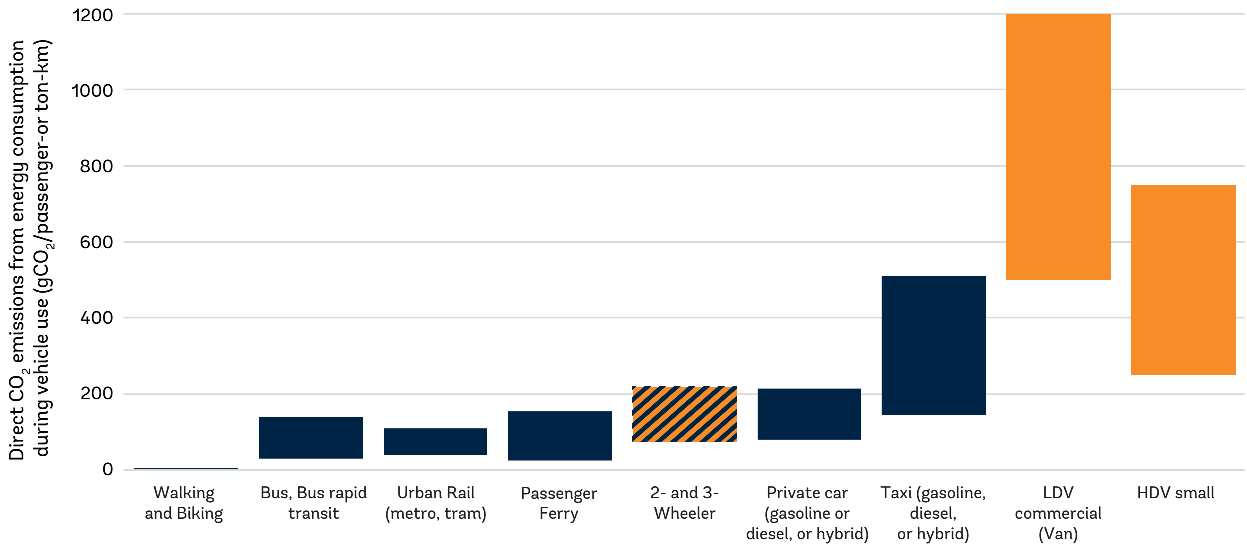


Source: Original figure produced for this publication.

Chapter 3
SHIFT Measures: Encouraging the Use of More Carbon-efficient Modes

Decarbonization measures at the SHIFT level of the ASI framework leverage the natural space- and energy-efficiency of some modes over others (see Figure 3.1). Walking and biking are space- and energy-efficient modes because the vehicles are right-sized for a trip by an individual person or shipment and they are either fully human-powered or require only a small amount of electricity to move (for example, with electric-assist bicycles and e-scooters). Modes such as public transport are space- and energy-efficient as well because they pool multiple trips into a single vehicle—and the higher the occupancy or loading factor, the greater the efficiency (see IMPROVE measures in Chapter 4). Therefore, switching an urban passenger or freight trip from a low-occupancy private vehicle to a right-sized or pooled mode, where appropriate, naturally improves efficiency. In many cities in LMICs where car ownership and use remain lower than in cities in HICs, SHIFT measures are more focused on retaining users of more space- and energy-efficient modes and making their quality of travel better so that even when they can afford cars in the future, they do not need them.

Figure 3.1. Typical Ranges of Direct CO_2 Emissions from Energy Consumption for Different Modes of Urban Freight and Passenger Transport



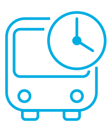
Source: Original figure produced for this publication based on IPCC 2015, Figure 8-6.

There are many different types of trips in an urban environment, meaning that no single mode will be able to meet all transport needs. Thus, the urban transport system must be a functioning multimodal system that leverages each mode where it is best suited. Pooled modes for passenger transport are most efficient along corridors or in areas with dense trip flows among similar origins and destinations, whereas walking and biking may make sense for shorter door-to-door trips or as access/egress from longer trips served by pooled modes. Most importantly, no passenger trip is solely an in-vehicle trip. Similarly, numerous factors feed into the choice of urban freight mode and vehicle size choices, such as shipment distance, size, and frequency; commodity type; shipper and receiver characteristics; logistics costs; and many more (NAS 2019; ITF 2022). In general, a strong and efficient transport network includes a balanced set of different modes of transport that match the capacity of each mode to the specific corridor/need.

Since where and how to travel are decisions made by individual travelers (for passenger transport) and shippers and receivers (for freight transport), SHIFT measures must target the fundamental factors that influence individual mode choice. While many factors influence mode choice, the main factors that cities can use to shape this choice include transportation supply/availability, service performance/quality, and attitudes and preferences (Mwale, Luke and Pisa 2022).[10]

SHIFT measures consist of demand management for shared infrastructure, service improvements, and clearly prioritized infrastructure investment (see Figure 3.2). Across the three measures, SHIFT efforts should seek to create an accessible and affordable integrated multimodal system built around public transport for passenger trips and serving the efficient loaded and right-sizing of urban freight trips.

Figure 3.2. Urban Transport Decarbonization Measures at the SHIFT Level

Pricing and management of shared infrastructure 	Allocate street space to the most space- and energy-efficient modes using multimodal and complete streets principles
	Manage and price parking and curb space
	Manage and price road infrastructure use to reflect all costs to society, considering appropriate application of low-emission zones or other vehicle access restrictions
	Advocate for better pricing of transport fuels at the national level
Public transport service improvements 	Improve service frequency, coverage, reliability, quality, and safety
	Integrate informal operators
	Leverage digital platforms and user/vehicle data to create more multimodal and demand responsive services in the spirit of "mobility-as-a-service"
	Balance affordability for users and for the city government
Clearly prioritized infrastructure investment 	Invest in high-capacity public transport along key corridors
	Invest in infrastructure for walking and biking at a network-level
	Consider the long-term funding of infrastructure maintenance and service provision

Source: Original figure produced for this publication.

By moving away from a transport ecosystem dominated by a single higher-emission mode to a lower-carbon and more inclusive mix of multiple modes, SHIFT measures can help cities put people first by serving everyone. Cars are not affordable for many people in LMICs and a transportation system that prioritizes cars often marginalizes low-income residents. Multimodality through shift measures can also better serve women, who more often must resort to 'trip chaining', which requires them to take more complex, multimodal trips to complete their activities (Gauthier 2022). By catering to women and other disadvantaged communities, cities have an opportunity to provide lower-carbon and more inclusive transport systems, even as they participate in larger numbers in the workforce, by turning them from captive users to low-carbon, inclusive, and multimodal travelers by choice. (Mwale, Luke and Pisa 2022). That said, the relationship between low-carbon modes and inclusivity is not systematic and cities should explicitly work towards integrating a gender lens into new and existing urban policies and plans (World Bank 2022c).

[10] Other factors influencing mode choice but outside of the influence of urban transport policymakers include individual characteristics/socio-demographics and other macro trends such as pandemics, inflation, or economic recessions (Sameni, Tilenoie and Dini 2021).

3.1. Pricing and Management of Shared Infrastructure

Roadways, curbs, and parking facilities all represent valuable city space that is shared among modes of urban freight and passenger transport. Policies that appropriately allocate this space and price its use by different modes can set clear priorities for the most space- and energy-efficient modes for improved efficiency and climate outcomes. Road space—including the travel lanes, medians, curbs, and sidewalks—is one of the city's main assets. Therefore, maximizing the use of this road space is one of the most cost-effective ways to increase road capacity and reduce emissions.

Multimodal and complete streets are a powerful tool to decarbonize urban transport and implies re-purposing the infrastructure to adequately and fairly allocate space for both passenger and freight road users. A "Complete Street" typically includes sidewalks, dedicated cycling paths, public transit stops, numerous and signalized pedestrian crossings and median islands, curb extensions, pick-up and drop-off areas for urban freight deliveries, and narrow travel lanes (Ho and Isaacs 2018). Complete streets are streets repurposed to increase throughput of people and goods by the most space- and energy-efficient modes available and reduce preferential treatment of low-occupancy motorized vehicles. In doing so, complete streets inherently encourage a shift to these modes, reducing emissions. Complete streets also improve the efficiency of urban transport infrastructure. The hourly capacity of a multimodal street can be 30,000 people per hour versus 12,000 for a car-oriented street (Global Designing Cities Initiative 2016). When implemented right, they also make roads more accessible for all travelers, improve safety, contribute to better public health, improve air quality, and unlock economic benefits for local businesses (Global Designing Cities Initiative 2016; Steer 2015) (see Box 3.1). While complete streets were originally conceptualized for passenger transport, more recent applications have included innovations for freight operations for even greater improvements to residents' wellbeing and economic activities (City College of New York and New York City Department of Transportation 2018; Tierney 2017). While cities in LMICs—from São Paulo, Brazil to Chennai and Pune, India—are already implementing complete streets, governments can do more to promote the concept by updating street design guidelines.

Box 3.1. Measuring the Climate and Development Benefits of Policies to Promote Walking and Biking in Tianjin, China

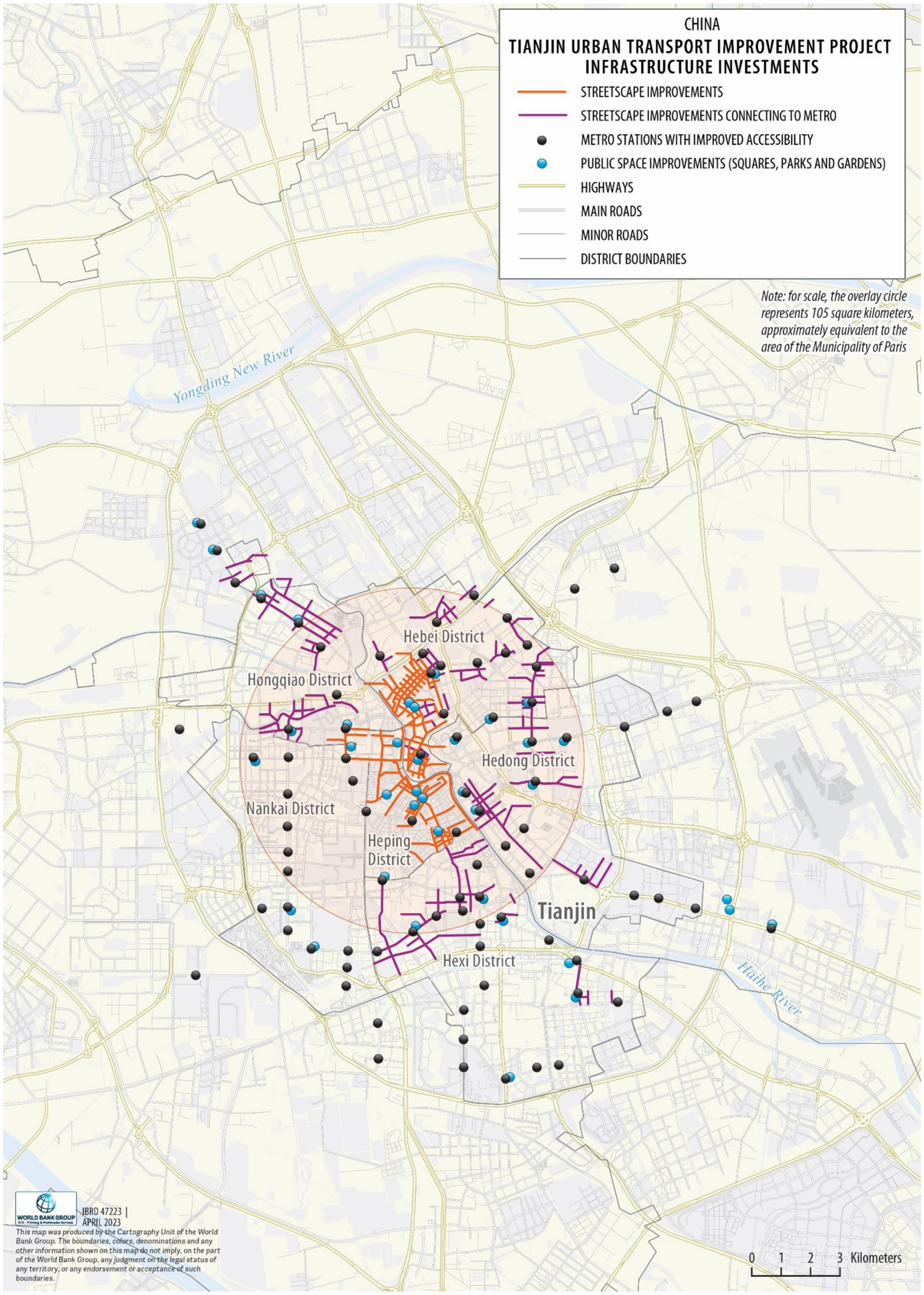
Tianjin, China—a megacity of an estimated 14.23 million people in 2023—has achieved rapid, city-wide and transformative change by promoting walking and biking as part of a sustainable transport strategy. The city's leadership has ambitious plans to transform the urban planning paradigm from car-based to people first. To achieve truly transformational change, the city undertook a streetscape improvement project with support from the World Bank and other development partners. This project considered street space allocation not at the corridor-level but at the network-level, covering an area larger than the size of the City of Paris (see Map B3.1). The project improved 132.19 km of streets, 96 metro stations, and 38 public parks, squares, and gardens.

Box 3.1. Measuring the Climate and Development (Contn.)

One of the critical success factors of the project was its rigorous data collection and impact monitoring and evaluation, which has been recognized as a world-class practice and helped to inform national policy in China—National Standards for Urban Pedestrian and Bicycle Transportation System Planning and Design (2021)—and academic literature. The project provides clear evidence for its environmental benefits as well as many other positive development outcomes for the city and its residents. The key benefits of the project included expanded mobility, safety, social inclusion and equity, economic activity, resilience, and decarbonization:

- **Mobility**. An estimated 261,144 additional daily trips are now happening by walking and biking, and there is an associated increase of 175,750 daily trips by metro.
- **Safety**. 284 streetlights were installed to improve public safety at night. The Project also made substantial contributions to road safety. A sample of the streets improved (20 roads, totaling 16.5km) were assessed in an independent post-construction road safety audit following the International Road Assessment Program Star Rating methodology. All (100 percent) of the streets were rated three-star or better for pedestrians and bicyclists (compared with 30 percent pre-project); 56.7 percent of the streets received the highest rating of five-star for pedestrians; and 77.7 percent of the streets were rated five-star for bicyclists. Finally, reported number of accidents on the streets improved by the project reduced from 1,201 in 2019 to 1,104 in 2022—a 9.2 percent reduction. This achievement is especially impressive considering biking traffic volumes increased substantially over this period, largely due to the popularity of bikeshare services and e-bikes.
- **Social inclusion and equity**. Those in poverty and in the bottom 40 percent of the income distribution benefited most from the project. Surveys in 2015 estimated that over 65 percent of households in the bottom 40 percent of the income distribution walked or biked for their trips, compared to about 30 to 35 percent for higher income groups. About 44 percent of the extreme poor (those with an annual income below USD 1,252 in 2015) lived in one of the six central districts where streetscape improvements were made. Beyond this, the project explicitly considered physical disabilities by widening sidewalks and including features like tactile markings and curb cuts with gentle grade. Finally, the project tracked the percentage of female non-motorized vehicle users and pedestrians who were satisfied with the walking and cycling environment in Heping, Hebei, and Nankai pilot areas (53 percent for women versus 55 percent for men and women combined), and also tracked the number of women providing feedback to the project.
- **Economic activity**. The streetscape improvements implemented by the project were found to make the areas more attractive for small businesses. Empirical analysis found significant increases in the number, density, quality, popularity, and average consumption of stores. Finally, the ex-post project Economic Internal Rate of Return (EIRR) was 53.5 percent.
- **Resilience**. To reduce the risk of flooding, 11,200 meters of drainage pipe was installed. A key success was the improvement of drainage on a core pedestrianized commercial shopping street that used to suffer from severe summer flooding. Furthermore, 3,541 trees were planted to provide shading throughout streets and parks.
- **Decarbonization**. The project reduced the number of trips made by private cars and increased the number of trips made by walking, biking, bus, and metro. In 2022, the annual estimated GHG emission reduction was 34,281 tons per year. This is a significant reduction, but is only one step in reducing all GHG emissions from Tianjin's transport sector, which amounted to nearly 14.5 million tons in 2017 (Li 2022).

Map B3.1. Scale of the Tianjin Urban Transport Improvement Project



Source: China: Tianjin Urban Transport Improvement Project https://projects.worldbank.org/en/projects-operations/project-detail/P148129.

Once road space is appropriately allocated, further policies may be needed to manage access to the infrastructure by different types of vehicles. Access restrictions, such as license plate schemes, are often focused on low-occupancy private vehicles. While a few cities (Singapore, Beijing, Shanghai, Guangzhou, and Shenzhen) have restrictions on vehicle ownership via lottery or auction systems, the restrictions on the use of vehicles (typically based on whether the last digit of the license plate is odd or even) are more common. Road access restrictions can be based on any combination of:

- vehicle technology (for example, only higher efficiency standard vehicles are allowed to operate)
- size (for example, only small trucks are allowed in business districts areas)
- time of travel (for example, peak hour travel is restricted on a certain day for odd/even license plate)
- geographical coverage (for example, downtown areas or historic centers)

These restrictions have been applied throughout LMIC cities such as Mexico City, Beijing, Bogota, Quito, and Santiago with mixed results in terms of impact on congestion and emissions. In the absence of high-quality alternatives to private vehicles, drivers often fail to comply with both ownership and use restrictions, undermining the effectiveness of the policies (Zheng, Moody, Wang and Zhao 2021; Guerra and Reyes 2022; Blackman 2020). Furthermore, these policies can place disproportionate burdens on lower-income drivers, who are more likely to drive older, restricted vehicles and do not have the financial means to purchase exemptions, legally or illegally (Guerra and Reyes 2022).

Low-emission zones (LEZs) are another popular form of access restrictions applied to a certain geographic area based on vehicle technology. These zones need to be in high-activity, high-pollution, or high-population-density areas to maximize impact and careful research and policy analysis need to be made to drive decisions to mitigate distributional impact and improve policy acceptability (C40 Cities Knowledge Hub 2019). Examples include limiting access of heavy goods vehicles (HGVs) in many cities across Latin America, diesel-powered vans in many cities in Germany, or combustion motorcycles in many cities in China and Latin America such as Mexico City. Beijing, China, for example, implemented an LEZ in 2017 where heavy-duty freight vehicles with emissions below National IV Standards are not allowed to enter the central city area for air quality and human health purposes. In 2018, it expanded its perimeter from Sixth Ring Road to the whole city (Mejia 2021). The premise is that the implementation of these zones can encourage logistics providers to switch to less emitting modes and consider multi-modal alternatives to deliver goods. However, the presence of offsetting factors makes it challenging to evaluate the environmental impact, and most evidence put forward the benefits of improvements to air quality and public health rather than GHG emission mitigation. Moreover, restrictions on weight and size are often not well-received by carriers as they result in changes in operations and higher costs. Freight experts have also criticized these measures noting that for cost purposes, carriers would not use large trucks if smaller trucks would do the job and when forced to do so, will end up increasing their VKT (Holguin-Veras et al. 2020). Manilla, Philippines has also shown that emission zones can lead to increased congestion if many smaller vehicles circulate in the city to make the same number of deliveries (see Image 3.1). It is suggested that the implementations of LEZs be looked at holistically in the short, medium, and long term to ensure positive net results for decarbonization. It is important to also mention that LEZs require rigorous and consistent enforcement for better results.

Image 3.1. **Environmental Control Checkpoint in Medellín, Colombia**

Image source: Secretary of Mobility of Medellin (2018).

The provision and management of road infrastructure is a significant expense for public budgets; cities can better price use of roads to help recoup operating costs and shape mode choice. While very few cities around the world and even fewer cities in LMICs have implemented road pricing schemes,[11] many options exist, including tolling for access to urban arterials (see Box 3.2), road use charging schemes based on distance traveled, and congestion or emissions charging zones (Ivarsson, Canon Rubiano and Bianchi Alves 2022; Ivarsson and Stokenberga 2022). There are calls for the new pricing policies to be dynamic and customized to different trip, vehicle, corridor, timeframe, and destination types and for technology to be leveraged to introduce smart, distanced-based charging that help internalize the cost of driving (Ivarsson and Stokenberga 2022). However, in LMICs, pricing measures that have lower monitoring and administrative burden may be preferred. A review found that congestion charges, planned or implemented across more than a dozen global cities, decreased traffic, travel times, and congestion by 10–30 percent (Gouldson, Sudmant, Khreis and Papargyropoulou 2018) and congestion prices have been linked to reduction in CO_2 emissions (Domon et al. 2022).

[11] The only documented case of an LMIC city is Bogota, Colombia, where a license plate recognition scheme was slowly converted into a congestion charge.

Box 3.2. Urban Tolled Highways in Santiago, Chile.

The first network of electronic tolling (ET) highway concessions was implemented in Santiago, Chile in 2001 to combat congestion, using private sector financing. The system was free flow and interoperable (originally tendered to four operators), with variable fares dependent on vehicle type and time of the day. The system necessitated strong institutional capacity for planning and management to implement complex enforcement mechanisms. While initially envisioned as a measure to reduce congestion, the high economic growth and low elasticity of demand to tolls have diluted the measure's impact on reducing congestion. While the results of this project on decarbonization are not likely to be relevant, this project is seen as an example of financing urban roads with private capital paid directly by users, reducing the use of public budgets to finance private cars. Further, elasticity has been shown to grow with time, indicating a potential positive long-term effect. To further increase its effectiveness, complementary decarbonization measures such as integration with public transport, and regulatory measures must be used.

Source: World Bank's elaboration based on Batarce et al. 2023; Vassalo et al. 2020; PPIAF 2009.

Pricing policies, despite being less restrictive than access-based policies, tend to be less accepted by the public due to perceptions of unfairness (Blackman 2020). However, emerging evidence suggests that road pricing policies could be designed in ways to reduce inequality in accessibility (Haddad et al. 2018) and be more progressive than access restrictions in LMICs (Gohl and Schrauth 2022). The impact of these policies on welfare loss and low-income drivers with no alternative travel options needs to be carefully examined (Pojani and Stead 2015). Better stakeholder engagement during the early stages of policy consideration can help improve public awareness and facilitate acceptance. Another way to mitigate public acceptance challenges is to earmark revenues from vehicle/road taxation schemes for local public transport and public space improvements (Blackman 2020). Studies show that attitudes toward road pricing improve after programs are implemented or after people experience their benefits (Blackman 2020).

Free parking and curb access have high development and climate costs; cities can reclaim this abundant 'free' space given to parking by reversing minimum parking laws, making parking more expensive, and improving enforcement. Over the last decade, examples from cities in HICs and LMICs demonstrate that offering abundant and cheap parking induces more driving, leading to congestion and pollution. A survey of parking prices in 65 cities around the world found that middle-income cities of Istanbul, Bogota, Mexico City, Mumbai, Cape Town, Buenos Aires, and Delhi have some of the lowest consumer parking prices in shopping, city hall, and airport districts (Parkopedia 2019). More recently, cities have started reversing minimum parking requirements; reclaiming public space previously used for parking for other modes of transport, greenspace; and generating more revenue (ITDP 2022). For example, in Mexico City, a change in construction code was announced in 2017 to reduce off-street parking in new developments. With those changes, Mexico City can potentially remove 11,000-17,000 cars between 2017 and 2030 (ITDP 2022).

Reform of fuel subsidies or taxes is another critical way to 'level the playing field' between more space- and energy-efficient modes and single-occupancy/under-loaded vehicles. This initiative could also internalize the climate costs of inefficient transport modes. While these pricing policies are likely to be carried out at the national level, cities can collect and present data on local externalities to advocate for reform. In 2020, consumer fuel subsidies for gasoline and diesel were still prevalent in LMICs, costing USD 0.06 billion for LICs, USD 3.57 billion for LMICs, and USD 39.68 billion for upper MICs (IMF 2021). Such subsidies have proven ineffective in alleviating wealth inequality. Since fuel consumption subsidies typically do not vary by income, most of the benefits are accrued by wealthier households that already own cars and have higher consumption levels. In Indonesia, for example, the World Bank found that the richest decile of households consumed

40 percent of the subsidized gasoline, while the poorest consumed less than 1 percent (2012). Conversely, fuel taxes can be a significant source of income for many countries, especially when increased to better reflect the environmental and social cost of their consumption—implying an implicit rather than explicit subsidy.

3.2. Public Transport Service Improvements

Using pricing and access management to prioritize the use of transport infrastructure by public transport is best coupled with the expansion and improvement of public transport services so that they provide a quality and universally available alternative to private vehicles. Across LMIC cities, public transport services exist in many forms, often intermingled with one another and competing for passengers. In LMICs, public transport services do not just include the publicly-operated and highly-regulated, high-capacity services such as BRT or urban rail operating with fixed routes and fixed schedules that are common in HICs. They also include services such as two- and three-wheeled taxis operating on-demand and privately-operated minibus services that are typically only loosely regulated and organized by terminals and routes. This vibrant ecosystem of public transport services provides unique opportunities in LMICs to advance development and climate goals. There is significant room for improvement to ensure that these public transport services provide accessible, frequent, reliable, fast, safe, and affordable services for all users (see also Chapter 4). Expanding the coverage and frequency of public transport services is a first step but improvements to safety have also been found to be a major indicator of preference for public transport services, particularly among women (Gopal and Shin 2019). For example, a study of women's travel in Delhi found that women would trade-off as much as 27 minutes of additional travel time to take a safer route (Kouame 2023).

Integration and reform of 'informal' transport services operated by the private sector are important to make public transport more attractive. In LMICs, engaging the informal sector is a critical path to a "just transition" and decarbonization of urban transport (Tun et al. 2020). Any such reforms must start with data collection and dialogue with drivers, vehicle owners, and operator associations, to better understand existing routes, operating structures, and business models (Kumar, Zimmerman and Arroyo-Arroyo 2021). With information on existing routes or service coverage, policymakers can consider the rationalization of bus routes (see Box 3.3) and the provision of better infrastructure such as street lighting, benches, and shelters at terminals. Additionally, granular information on operating structures and business models can help city officials design programs to incentivize the organization of operators into companies and unlock greater access to commercial financing for fleet renewal and other service improvements.

Box 3.3. Mapping Informal Public Transport Routes in Africa

One of the main challenges with integrating informal services into a multi-modal system is the lack of data on their operations. This limits system-wide planning and good decision-making (Welle, Abubaker and Ali 2022). With the proliferation of GPS-enabled smartphone technology, newer and cheaper data collection methods are emerging to help fill this information gap and better inform public transport networks and service planning. Klopp and Cavoli (2019) compared two such mapping projects—Digital Matatus in Nairobi and the Mapa Dos Chapas in Maputo—and found that inclusive, collaborative mapping of informal transport services can help make minibuses more visible in planning and promote inclusive "planning conversations" on multimodal integration, passenger information, and minibus upgrading. In turn, this can promote safety, accessibility, inclusion, and climate-friendly transport in African cities.

Source: World Bank's elaboration based on Welle, Abubaker and Ali 2022; Klopp and Cavoli 2019.

As technological innovations bring down the cost of in-vehicle digital fare collection and vehicle monitoring/dispatching, LMIC cities can use these tools to promote the reform of 'informal' public transport services and make 'formal' public transport services more demand responsive. For example, onboarding operators into new fare payment systems has increased the transparency of services and prices for both policymakers and users in Africa (Arroyo-Arroyo et al. 2022). In Kochi, India, a new digital payment, and service platform has enhanced the complementarity between paratransit and city-run bus services (Musil et al. 2022; Bianchi Alves et al. 2022). The proliferation of digital 'ridehailing' platforms and 'super apps' that facilitate matching of riders and vehicles have been widely adopted by entrepreneurs in cities in South Asia, contributing to better integrated and demand-responsive services (Tun et al. 2020). For instance, in Jakarta, Indonesia, technology-enabled motorcycle taxis have been observed to act as feeders for short distances to the TransJakarta BRT and the Jakarta commuter train (Musil et al. 2022). In Mexico City, Jetty—a demand-responsive service for minibuses—has made women feel safer when using public transport (Tirachini, Chaniotakis, Abouelela and Antoniou 2020).

Multimodal information and integration can also significantly improve the user experience, encouraging greater use of public transport. Real-time transit information has also been shown to increase public transport ridership in HIC cities such as New York and Chicago (Canales 2016). Building on improvements to customer information and payment, the concept of Mobility-as-a-Service (MaaS) can help city governments organize how multiple transport options can work together to advance climate and development goals. Guidance and examples exist to help LMIC cities contextualize this concept for their realities (Bianchi Alves et al. 2022).

The affordability of public transport can also be a barrier to its use in some LMICs, but demand-side subsidies must be viewed through the lens of financial sustainability of services. User fares are the primary revenue source for public transport systems. In many cities, fares are a flat fee that are kept low to ensure access by lower-income users. Setting such low fares comes at a cost for city governments, who must cover the operating expenses not recouped by fare revenues through public subsidy. These simple fare schemes often fail to balance affordability by users and affordability for the city, leading to funding challenges that result in deteriorating quality of services (Estupiñán, Gómez-Lobo, Muñoz-Raskin and Serebrisky 2007). Due to this vicious cycle, some cities are experimenting with higher base fares but more targeted user subsidies (Hernandez and Peralta-Quiros 2016; Guzman and Hessel 2022; Börjesson, Eliasson and Rubensson 2020; Gohl and Schrauth 2022). For example, Guadalajara offered low-income women a subsidized public transport fare that included free access to the bikeshare system; the pilot saw strong uptake, with 12 percent of local women using the program (Gauthier 2022). As with any other case, the effect of these policies needs to be assessed carefully, considering all potential losers and winners, local and network effects, and fiscal implications over time. Further, they need to be flexible and adaptable, and reassessed often. As subsidy policies can be expensive, and backtracking is politically costly, detailed studies are necessary and pilots are encouraged before expanding to permanent strategies.

3.3. Clearly Prioritized Infrastructure Investment

Even when maximizing the use of existing assets through the appropriate allocation and pricing of infrastructure and improving the operations of public transport systems, LMIC cities will still need to invest in infrastructure for urban transport. The infrastructure stock in LMICs is often insufficient to provide decent mobility and well-being. The type of infrastructure investment needed depends on the local context and can vary from core necessities (such as ensuring that the city has paved roads and sidewalks) to the implementation of high-capacity public transport systems that require strong planning and implementation capacity.

Most cities in LMICs need to scale up investments in dedicated infrastructure for public transport on highly traveled corridors. High-capacity public transport services can be provided in different forms—including urban railways or metros, tramways, or LRT, BRT, cable cars, or dedicated bus lanes. The choice of the most appropriate form will depend on the local context and should be informed by an alternative analysis (Darido, Moody and Mitrić 2018). What they have in common is dedicated right-of-way free from the congestion of urban streets, which allows for more frequent and reliable service more competitive with private vehicles. Any of these mass transit systems can bring significant benefits for cities and their passenger transport when well-designed to meet the needs of local citizens (Darido and Moody 2018). Investments in mass transit have been linked to greater economic growth (Alam, Herrera Dappe, Melecky, and Goldblatt 2019), greater accessibility for low-income residents, women, children, and the elderly (Ravensbergen et al. 2022; Martinez et al. 2018), improvements in road safety (Litman 2014), and improvements in air quality (Beaudoin and Lawell 2015). Public transport can increase the accessibility of the bottom 40 percent and others who cannot afford to own a car.

High-capacity public transport improvements offer decarbonization benefits when they provide high-quality service that attracts trips away from private cars or motorcycles. For example, 18 percent of riders of the Hubli-Dharwad BRT in India switched from personal vehicles while 50 percent of the BRT's ridership were users who had used the previous public bus service (World Bank BRT Synopsis). The Metrobus in Mexico City removed 80,000 tons of CO_2 between 2005 and 2010 mainly due to modal shifts, as users of paratransit microbuses or private vehicle travelers switched to the BRT services (ITF 2019). Other urban rail, BRT, and cable car projects in India, China, and Colombia have demonstrated measurable GHG emission reductions that have been used to unlock climate financing through carbon crediting mechanisms (see Table 3.1). Transit-oriented development (TOD) policies further boost the ridership and environmental gains from these infrastructure investments (as discussed in Chapter 2). Lastly, a counterfactual study that estimated CO_2 emissions with and without subways for 192 global cities found that urban rail systems reduced population-related CO_2 emissions by about 50 percent (Dasgupta, Lall and Wheeler 2023). Extending the analysis to future subways for other cities, the researchers estimated the magnitude and social value of CO_2 emissions reductions with conservative assumptions about population and income growth as well as a range of values for the social cost of carbon and investment costs. Even with these conservative estimates, they found that hundreds of cities realize a significant climate benefit, along with benefits from reduced traffic congestion and local air pollution, which have traditionally motivated subway construction (Dasgupta, Lall and Wheeler 2023).

Table 3.1. **High-capacity Public Transport Infrastructure Projects Registered under the Clean Development Mechanism and their Achieved Emission Reductions**

High-capacity Public Transport Infrastructure Project (and CDM ref. number)	Certified Emission Reductions (tCO_2e)	Crediting Period
Metro Delhi, India (4463)	3,835,703	2011-2018 (7 yrs); renewed 2018-2025 (7 yrs)
BRT Bogotá, Colombia: TransMilenio Phase II to IV (0672)	511,423	2006-2012 (6 yrs); renewed 2013-2019 (6 yrs)
BRT Zhengzhou, China (4744)	287,915	2011-2018 (7 yrs)
BRT Chongqing Lines 1-4, China (3760)	159,516	2010-2017 (7 yrs)
BRT Metrobus Insurgentes, Mexico (4945)	69,525	2012-2019 (7 yrs)
Cable Cars Metro Medellín, Colombia (3224)	68,493	2010-2017 (7 yrs)
BRT Lines 1-5 EDOMEX, Mexico (3869)	27,876	2011-2018 (7 yrs)

Source: Original table produced for this publication with data from CDM project documents accessed via. https://cdm.unfccc.int/Projects/projsearch.html.

Since almost every trip in an LMIC city involves walking, investments in infrastructure for walking and biking are fundamental for development and should not be an afterthought. In many cities in LMICs, walking is the primary mode of travel. Improving the quality and safety of walking and biking infrastructure helps ensure that trips made by these modes are "by choice" rather than "out of necessity" (Pojani and Stead 2015). Cities that encourage walking and biking have lower emissions, better quality air, and healthier residents. Studies show that walking or biking every day for 30 or 20 minutes respectively, can cut mortality risk by at least 10 percent (WHO 2022). Sidewalks must be developed as seamless and connected infrastructure networks to ensure access for all users, including the elderly, children, and those with mobility impairments. The COVID-19 pandemic has accelerated investments in biking infrastructure in cities in Latin America and Africa (Vital Strategies 2020; Arroyo-Arroyo and Frame 2021). The better protected the bike lane, the greater the modal shift, so cities should seek to build connected and protected cycling networks with lanes wide enough to include slow riders, cargo bikers, or riders traveling as a family (Gauthier 2022; Adriazola-Steil et al. 2021). Besides investing in bike lanes, cities can invest in a bikeshare system to increase access to bikes, include bike parking at public transport stations, and allow bikes on buses (Venter, Mahendra and Hidalgo 2019). Many of these measures can also support urban freight deliveries; for example, New York City allows pedal-assisted cargo bikes operated by Amazon, UPS, and DHL to park in existing commercial loading areas typically reserved for trucks and vans (Sibilski and Targa 2020). In LMICs where bicycles and bicycle rickshaws often serve both passenger and freight purposes interchangeably throughout the day (Image 3.2), the opportunities for synergies could be even greater.

Image 3.2. **Cycle Rickshaw Transporting Drinks and a Woman in Phnom Penh, Cambodia**

Source: Amaury Laporte (2016).

Reducing (implicit and explicit) subsidies of more polluting modes and reallocating these funds to more equitable and efficient modes could address, at least partially, the issues of funding transport infrastructure and services. Many infrastructure investments cannot be monetized at their full cost and require governments to pay a viability gap or subsidy. Clearly, projects that make economic sense and have the best value-for-money and are socially fair will be the priority for any of such subsidies. Examples from countries such as the Netherlands show that national commitments to greener infrastructure are both critical and prioritizable. Dutch municipalities receive up to 80 percent subsidies on the construction costs of urban cycling infrastructure, and provinces and other municipalities receive 50 percent subsidies on the costs to upgrade and expand bicycle paths along secondary and tertiary roads (Zhang 2020). The Dutch experience is an example of a balanced incentive structure when making the case for investment in cycling infrastructure, combining decision-making at the local level with a clear financial commitment at the national level. Results confirm that investments in bicycle-promoting policies (such as improved bicycle infrastructure and facilities) is likely to yield a high cost–benefit ratio in the long term.

3.4. Deciding on SHIFT Measures

Cities have many measures available to them to encourage individual travelers as well as shippers and receivers to use the most space- and energy-efficient mode available to them for a given trip. The lowest-hanging fruit are measures that make better use of the city's existing public space and transportation infrastructure. Re-allocating street, curb, and parking space to better reflect sustainability goals can help shift passengers from private vehicles to walking, biking, and public transport and can help freight operators have the space needed for efficient loading and unloading (see Figure 3.3). To make additional improvements in service or infrastructure, cities will need funds. Updating pricing mechanisms related to passenger and freight transport can help unlock new revenue sources for further investment in sustainable transport and help better reflect the environmental and other externalities of mode choice in decision-making. With the increased funds, cities can improve and expand high-quality shared transport services and invest strategically in new infrastructure.

Image 3.3. **A Heavily Loaded "Beca" in Surakarta, Indonesia**

Image source: Shankar S. (2018).

Figure 3.3. Guiding questions for determining SHIFT measures for Decarbonizing urban transport

Does your city know the share of passenger and freight trips taken by different modes, by type of user and trip purpose?	No	Conduct travel surveys that disaggregate travel patterns by gender, income, age and other characteristics of users as well as trip distance, time, mode, and purpose
Does your city have a high-quality, uninterrupted network of sidewalk?	No	• Improve existing sidewalks by removing barriers and by providing shade, appropriate lighting and places to rest, particularly around public transport stops and terminals • Install missing sidewalk links
Does your city allocate street space based on complete streets principles and a clear prioritization of road users?	No	• Reform existing street design guides to reflect complete streets principles • Piloting low-cost interventions using paint ad bollards to re-allocate street space for more sustainable models (e.g. tactical urbanism) at key intersections and along key corridors
Does your city manage and price parking and curb access across modes?	No	• Inventory curb and parking spaces • Implement paid access, potentially through public-private partnership • Ensure adequate space is reserved for freight loading/unloading
Does your city have adequate, high-quality public transport services?	No	• Formal: Expand coverage and frequency of service; consider fleet upgrade • Informal: Engage operator associations in business planning, service contracts; consider support in fare collection technology, terminal upgrades, etc as public-private partnership; provide guarantees for fleet renewal • Investing in high-capacity public transport infrastructure on key corridors
Does your city have a high-quality, uninterrupted network of bike lane?	No	• Invest in a network of bike lanes considering topography and climate of the city • Promote integration with public transport
Does your city have policies and digital tools to promote multimodal integration of fares and services?	No	• Reform fare policy and public expenditure to reflect priorities across modes • Consider the design of a MaaS platform

Source: Original figure produced for this publication.

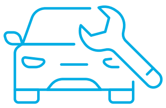
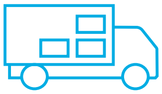
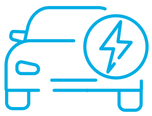
Chapter 4
IMPROVE Measures: Enhancing Efficiency of Vehicles and Operations

Measures at the IMPROVE level of the ASI framework target the vehicles, operations, and fuels used by each urban transport mode. This chapter focuses on the IMPROVE measures for road-based passenger and freight transport (although similar concepts can be applied to urban rail and waterway transport) and covers:

- lower vehicle energy intensity, measured through a vehicle's emission per unit of distance travelled. Vehicle energy intensity typically depends on vehicle and engine design, regulations, and management of the vehicle from start of life to exit (including maintenance).
- fuel carbon intensity, measured through the quantity of GHG emission by specific fuel types. Fuel carbon intensity depends on the type and specifications of fuels used in the engine.

IMPROVE measures consist of motorization management, vehicle loading and flow optimization, and electrification and alternative fuel vehicles (see Figure 4.1). Across the three measures, SHIFT efforts should seek to improve energy efficiency of transport operations.

Figure 4.1. **Decarbonization Measures for Urban Transport at the IMPROVE Level**

Motorization management 	Strengthen institutions and processes for a comprehensive motorization management
	Consider adoption of fuel standards and the use of fiscal instruments to encourage the cleanest and safest vehicles at point of sale
	Put in place robust vehicle emission inspection systems for in-use vehicles
	Consider vehicle scrappage or other programs to encourage exit of the most polluting vehicles from the fleet
Vehicle loading and flow optimization 	Use the latest, proven technologies for intelligent transportation systems (ITS) when modernizing urban transport infrastructure
	Use off-hour deliveries (OHDs) and designate loading and unloading areas for urban freight
	Encourage load consolidation, collaboration, and freight brokerage via digital platforms
	Consider urban consolidation centers (UCCs) and collection and delivery points (CDPs)
Electrification and alternative fuel vehicles 	Prioritize what vehicles to electrify first
	Consider pricing/incentive schemes and promote a network of coordinated charging infrastructure to increase adoption of electric vehicles (EVs)
	Consider leasing schemes and demand pooling
	Coordinate between the transport and electricity sectors

Source: Original figure produced for this publication.

4.1. Motorization Management

In LICs and, to a lesser extent, MICs, private vehicle ownership is concentrated in urban areas where per capita incomes are higher. This means that policies surrounding the sale and ownership of vehicles in a country disproportionately affect the country's urban areas. Yet these "motorization management" policies are often implemented at the national level, outside of the control of cities. Cities need to be their own advocates by gaining awareness of how better vehicle fleet management can impact the efficiency and environment-friendliness of their urban transport systems.

The term "motorization management" encompasses programs that control the entry of vehicles (including imported new, imported used, and domestically-produced vehicles), their active use, and their end-of-life) (Gorham et al. 2022; World Bank 2021). Vehicle entry programs include first-use certification as well as quality assurance of vehicle parts and vehicle construction. Programs during active use consist of periodic technical inspection (PTI), on-road enforcement initiatives, fuel quality assurance, and a strong preventative maintenance and repair industry. Vehicle exit programs consist of end-of-life vehicle initiatives that dictate how vehicles are replaced and retired.

Motorization management is especially critical in LMICs, where vehicle fleets are often older and more polluting. Given the reliance of many LMICs on the import of second-hand vehicles from HICs, most countries have focused on vehicle entry policies such as:

- *Used vehicle import bans*: Bans are a blunt measure that do not consider the possibility that used vehicles can be cleaner and more energy-efficient than the existing vehicle stock and new vehicles sold in LMICs (UNEP 2020). Domestically manufactured vehicles or new vehicles sold in LMICs may be produced under weak vehicle standards and policies and include fewer environmental and safety features than imported used cars. For example, Ecuador, Uruguay, and Venezuela ban the import of used cars but have very low emission standards for new vehicles (Euro 3, 2, and 1, respectively). On the other hand, countries such as Argentina impose both a used vehicle import ban and a Euro 5 vehicle emission standard for new registered vehicles (UNEP 2020).
- *Imported vehicle age restrictions*: While age does not always worsen vehicle quality, vehicle age limits are simple and widely adopted tools for LMICs to keep their fleet relatively new. At least 60 LMICs have implemented import age restrictions. For example, Kenya's age limit restriction of eight years makes its fleet relatively young, clean, and emit 24 percent less CO_2 than neighboring Uganda and Rwanda, which similarly import used vehicles from Japan (UNEP 2020).

More comprehensive approaches to motorization management that include vehicle standards on new and second-hand vehicles and complementary processes of vehicle registration and inspection have proven much more effective. Vehicle standards, such as the Euro standards,[12] work by setting limits on emission and requiring specific safety features (UNEP 2020). Such standards are used extensively in HICs for passenger cars, delivery vehicles, and even cargo bikes (like in Germany and France). When combined with good fuel quality locally, vehicles that meet emission standards can promote decarbonization, cleaner air, and safety. For example, the requirement for vehicles to adhere to Euro 4 emission standards can potentially reduce the average CO_2 emissions per km by 5–16 percent, depending on the vehicle technology being replaced and other aspects of motorization management that affect vehicle performance and maintenance (World Bank 2021). In OECD countries, Euro 4 gasoline vehicles that do not have the most advanced emissions control can decrease ozone-forming pollutants by more than 90 percent from uncontrolled levels (Gorham and Darido 2021).

In implementing vehicle emission standards, LMICs must also consider fuel standards to reach the cleanest and most efficient fleet. Fuel standards set limits on the quantity of sulfur, lead, manganese, and other metal additives in gasoline and diesel fuels. The quality of fuel is critical as vehicles that meet Euro 6 emissions and/or age restrictions of five years or less are required to use low sulfur fuels to operate, but these fuels are not available in all counties (UNEP 2020). LMICs are making progress in adopting fuel standards. In 2020, 15 West African countries cooperating in Economic Commission of West African States (ECOWAS) adopted harmonized fuels and vehicle standards in line with Euro 4 standards for used LDVs starting 2021 and agreed to implement a five-year age limit in 10 years (World Bank 2021).

[12] Euro standards, for example, regulate emissions from nitrogen oxides (NOx), hydrocarbons (HC), carbon monoxide (CO), particulate matter (PM), and particle numbers (PN). These regulations vary between light vehicles (under 3.5 tonnes) and heavy-duty vehicles (tonnage?) and exist for two- and three-wheelers. Compliance is determined by running the vehicle or the engine in a standardized test cycle (World Bank 2021).

In addition to standards, fiscal instruments can be effective in rationalizing and enhancing the quality of vehicles entering national markets. These instruments can include custom duties to surtax, VAT, registration fees, circulation taxes, and feebates.[13] Incremental fees and taxes on age, engine size (higher rates for higher cylindrical capacity), and emissions ratings are the most highly utilized measures globally (UNEP 2020). Lower duties or exemptions for hybrid and EVs are becoming more popular worldwide, including in LMICs. Fiscal instruments can promote efficiency and generate revenue. In Malaysia, importing a used vehicle can be up to 300 percent more expensive than the value of a new vehicle and in Nepal, vehicles are taxed so heavily (288 percent import duty) that they can cost up to three times more than in neighboring India, generating revenue for Nepal. Mauritius also shows how strong standards and accountability processes can be reinforced by fiscal motorization management measures (see Box 4.1).

Box 4.1. The Complementarity of Standards and Fiscal Incentives in Improving the Quality of Used Vehicles in Mauritius

Mauritius is a small island country with many urban transport challenges such as congestion, air pollution, and traffic accidents. It is an illustrative example of a comprehensive approach to motorization management that includes:

- **Standards and processes**
  - Age restriction that only allows used vehicles no older than three years
  - A verification and inspection scheme for used vehicles upon entry demanding multiple documents to verify legitimacy and date of import; required documents include an import permit and export certificate issued by the designated authority, previous inspection certifications, and proof from the export company that the vehicle is not a product of theft
- **Fiscal measures**
  - A vehicle progressive excise taxation scheme for used vehicle imports based on engine size, capacity, and CO_2 emissions, with vehicles up to 550 cc exempt from excise tax; used hybrid and EVs are exempt from this excise tax.
  - Vehicle owners are required to pay a yearly road tax based on the type of vehicle and the engine displaced.

This program of policies has seen strong compliance and resulted in a younger and cleaner fleet of vehicles. The average age of the fleet is now below five years. The average vehicle fuel efficiency improved from 7 liters per 100 kilometers (l/100km) in 2005 to 6.6 l/100 km in 2013 and 5.8 l/100km in 2014. Hybrid vehicle sales also increased from 43 units in 2009 to 14,754 units in May 2020.

Source: UNEP 2020.

LMICs must also focus on the exit of vehicles from their fleets if they want to facilitate full fleet renewal. Vehicle retirement or scrappage programs (such as AVRPs) are mechanisms by which individuals are paid to stop using highly polluting or inefficient motor vehicles (World Bank 2021). In LMICs, the lack of credit is one of the reasons why people delay changing their vehicles. Noncompliance and the high residual value of even very old vehicles in LMICs are additional challenges. Government programs, like the scrappage program for taxis and other vehicles in Egypt (see Box 4.2), can help address these market failures and speed up fleet turnover. fleet turnover.

[13] when the customs fees are dependent on the vehicle's performance in terms of pollution, safety and GHG emissions.

Box 4.2. Vehicle Scrappage Program for Vehicle Fleets in Egypt and in Peru

Egypt

The objective of the vehicle scrappage program was to reduce GHG emissions and air pollution associated with the aging fleets of taxis, microbuses, minibuses, and buses in Egypt. In 2010, the average age of the motor vehicle fleet was high and many intensively used fleet vehicles were poorly maintained, contributing to excessive emissions, breakdowns, and road traffic accidents. The capital, Cairo, was the source of 40 percent of the country's GHG transport emissions, exposing residents to as much as 20 times the acceptable level of air pollution daily. A significant share of these emissions came from older or poorly maintained vehicles, including taxis as old as 40 years old. In 2008, the Government of Egypt adopted a new law mandating that fee-based transport vehicles (taxis, buses, trucks) over 20 years old would no longer be eligible for new operating licenses or license renewals. As the law did not specify how the eligible vehicles should be taken out of use, owners could sell them in regions where the law did not apply, convert them for private use, or dismantle them and sell the engines for use in other cars. Without a national scrapping and recycling program, the law did not have the intended effect.

The Government designed a vehicle-scrapping program to improve compliance with this new traffic law. The Egypt Vehicle Scrapping and Recycling Program was registered as a Clean Development Mechanism program of activities (PoA) in 2011 to receive results-based climate finance. At that time, vehicle registration data provided by the Ministry of Interior showed that more than 49,000 vehicles in the Greater Cairo Region's taxi fleet were more than 20 years old. The program supported a fleet renewal mechanism through which owners of taxis, microbuses, trailer trucks, and buses could voluntarily surrender their vehicles for managed scrapping and recycling. In exchange, they would receive financial incentives that are used towards the purchase of new vehicles from participating pre-registered vehicle dealers at a discounted price and with financing facilities. Certified recycling and scrapping ensured that old vehicles are permanently taken off the roads and components such as tires, oils, and batteries are disposed of and recycled in an environmentally safe manner. By October 2018, 45,000 of these taxis have been replaced; the new vehicles, which now represent over 90 percent of Cairo's taxi fleet, have reduced GHG emissions by 310,000 tons of CO_2 between 2013 and 2017.

The project implementation succeeded due to strong internal technical capacity and in-house program and administrative design, including the "One Stop Shop" for owners of eligible taxis. The One Stop Shop's design was essential so that taxi drivers did not lose their source of income while waiting for the new taxi to arrive, a factor that otherwise would have discouraged taxi drivers from joining the program. The entire process, from application to surrendering the old vehicle and receiving the new taxi. took, on average, five to seven working days. The efficiency of the One Stop Shop and the incentives by the Ministry of Finance (MoF) made the program so successful that the scrapping site was overwhelmed. As a result, the Government had to create a reservation system for a maximum of 120 vehicles per day for timely processing at the scrapping facility. As part of the project design, the MoF was authorized to disburse a subsidy of up to EGP 5,000 (about USD 270) per eligible surrendered vehicle. and to waive the taxes due from the sale of the new taxis. For the sale of the new replacement taxis, MoF waived vehicle sales taxes and customs fees for the import of vehicles parts and even negotiated lower interest rates for car loans.

Peru

In Peru, a vehicle scrappage program was adopted in February 2021 as a measure to address air pollution associated with old and poorly maintained fleets. Through this program, the Government provides economic incentives to freight and passenger vehicle owners who cannot afford to renew their fleet. Incentives are either given to *remove* or *renew* the vehicle. The goal of the first phase of the program is to scrap 1,000 old trucks nationwide, with economic incentives estimated at USD 20 million. This program is highlighted in the country's Nationally Determined Contribution to the Paris Agreement, in which it is estimated that the program could avoid approximately 0.105 million tons CO_2-equivalents per year by 2030 for a cumulative 0.992 million tons CO_2-equivalents by 2030.

Source: World Bank's elaboration based on WB 2018; WBG 2022c.

4.2. Vehicle Loading and Flow Optimization

Road infrastructure, vehicle and traffic management technology, and behavior influence vehicle flow (how much time a vehicle spends on the road) and vehicle flow acceleration. Key measures that can optimize the loading and flow of vehicles and unlock decarbonization benefits include (Agarwal 2014):

- improving the road intersection design to enable the slow movement of vehicles
- investing in traffic signals where there are none in countries such as Mali and Niger (Arroyo-Arroyo and Frame 2021)
- investing in intelligent transportation systems (ITS) that can decrease vehicle idling at intersections
- switching to off-hour deliveries (OHD) to optimize flow during uncongested times
- optimizing loading and unloading zones
- promoting driver training, especially for freight

Cities in LMICs can leapfrog to the latest technologies in ITS as they modernize their infrastructure to improve efficiency. Cities that have few sets of traffic signals with simple phasing can upgrade their systems to the latest technologies (Arroyo-Arroyo and Frame 2021). ITS technologies can include traffic signals and on-street Area Traffic Control (ATC). A prior World Bank report suggested that ITS traffic integration is achievable and affordable in developing cities and that cities can deploy such technologies incrementally and benefit from its functionalities gradually (Arroyo-Arroyo and Frame 2021). For example, cities can start by deploying signals in isolation and tackle coordination functionalities later before reaching full adaptive ATC functionality. Success stories of ATC adoption from around the world has shown a decrease in journey time (as much as 28 percent in Sydney, Australia); the number of stops (25 percent); air pollution from nitrogen oxide (NOx) (13 percent) and PM10 (15 percent); and in and CO_2 emissions (15 percent). Cities in LMICs (Wuhan, China and Hanoi, Vietnam that are still struggling to integrate different suppliers) should avoid getting locked into legacy systems that limit their potential for leapfrogging (Arroyo-Arroyo and Frame 2021).

OHD can be an effective tool to decarbonize the freight sector by rescheduling deliveries to outside business hours (and also beyond peak traffic periods), allowing vehicles to operate closer to their most fuel-efficient speeds. This tool is suitable for LMICs due to many factories, warehouses, and shops operating on a 24x7 basis, allowing OHD during early morning or at night. Moreover, in some cities such as New Delhi, Kolkata, and Mumbai in India, as well as Dhaka in Bangladesh, local regulations require night-time deliveries for trucks to combat traffic congestion in city centers during the day (Humphreys and Dumitrescu 2021). In Mexico City, large vehicles can only deliver from 9:00 p.m.to 9:00 a.m. of the following day (Fransoo and Mora-Quiñones 2021). OHDs make it easier for vehicles to find a parking spot, reduce time, driving distance, and hence, carbon emissions. Cities can put in place programs to incentivize OHD. Programs tested in LMIC cities such as Bogota, Colombia, and São Paulo, Brazil, showed important carbon emission reductions (Fransoo and Mora-Quiñones 2021) (see Box 4.3). 'Staggering receivers' delivery hours is another strategy that could help to reduce traffic during peak hours and its associated emissions, but real-world applications in LMIC cities is lacking.

Programs that facilitate the design of dedicated loading/unloading areas for freight vehicles can improve urban traffic and thus reduce carbon emissions, particularly in dense areas with a fragmented market. Such programs can decarbonize through increased vehicle utilization, shorter route time, reduced cruising time, and fewer number of trips by foot from the parking to the end destination due to a dedicated and shared space (Fransoo and Mora-Quiñones 2021). Apps can also be introduced for locating available bays. Enforcement is key, especially in LMICs.

Load consolidation can limit the extent to which freight vehicles run empty, thus reducing the number of trips needed for the same quantity of cargo. This can be achieved through:

- bundling: shipments with similar origins and destinations share the same trip
- backhauling: shipment routes in the opposite direction can share the same vehicle
- roundtrips: routes that tie in with each other can be combined into a single tour
- collect & drop: routes with spatial-temporal overlaps can be combined by enabling logistics operators to alternate pickups and drop-offs (Jacquillat 2021)

Collaboration and the use of freight brokerage digital platforms and analytics can facilitate load consolidation. Finding opportunities for load consolidation is challenging due to the fragmentation of the logistics industry, which is pronounced in LMICs. Mitigating such limitations requires horizontal and vertical collaboration, which entails bringing together firms operating at the same supply chain level and operating at different levels of the supply chain (for example, shippers and carriers). Digital platforms and analytics that facilitate planning, prediction, communication, and coordination among stakeholders can enable those collaborations (Jacquillat 2021). For example, Box 4.3 illustrates how two newspapers in São Paulo, Brazil collaborated and consolidated loads to make shipment more efficient and promote decarbonization.

Box 4.3. Impact of Horizontal Collaboration and OHD on Emissions from Urban Freight in São Paulo, Brazil

Horizontal collaboration

Two newspapers, *Folha de São Paulo* and *O Estado de São Paulo,* established a joint third-party logistics provider (3PL) to achieve load consolidation and routing optimization. By this method, they printed the newspapers at two different printing sites but combined all the logistics steps that followed. This included using a joint fleet of trucks, vans, and motorcycles to transfer newspapers to joint distribution centers, or sometimes to joint transit points for cross-docking, and jointly distributed across the city. Such coordinated efforts necessitated new analytical methods to optimize facility location, scheduling, and routing. The result was that they could reduce fleet size and decrease VKT by a factor of two, benefitting shippers and cities/societies. This was achieved through horizontal collaboration that enabled the pooling of supply chain networks instead of doubling the operations.

OHDs

Bogota, Colombia and São Paulo, Brazil implemented pilots of partial (6PM-10 PM) and full (7PM to 6AM) OHD programs respectively by shifting deliveries from regular business hours to off-hours for midsize freight vehicles (manufactured between 2005 and 2008). Data collected in 2009 over two to four weeks showed that Bogota and São Paulo's OHD programs were, respectively, able to achieve 43 percent and 15 percent of CO_2 emission reduction, respectively, compared to the same deliveries during regular hours. This highlights the efficacy of OHD as a decarbonization measure as well as its dependency on the extent of shift in delivery hours.

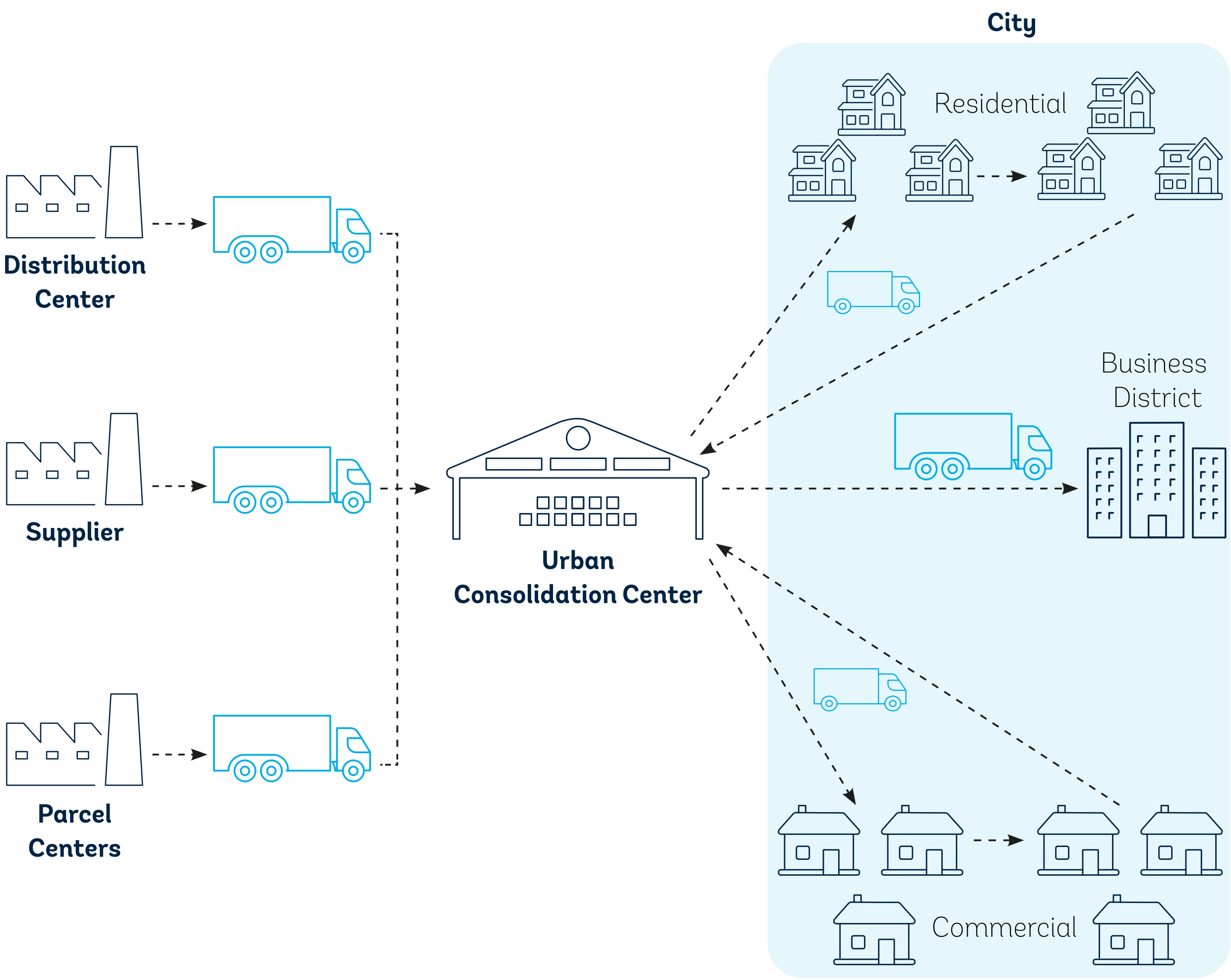
Source: Jacquillat 2021; Holguin-Veras et al. 2018.

Urban Consolidation Centers (UCCs) are another way cities are trying to enable more efficient last-mile deliveries by increasing the average load. UCCs are also referred to as city logistics hubs, urban distribution centers, and city consolidation platforms, among others. UCCs are located near city centers and enable the consolidation of goods from multiple sources or companies in one location before they are shipped to final destinations on smaller delivery vehicles, performing more efficient last-mile delivery (see Figure 4.2). These centers have high operational expenditure due to the cost of real estate and labor and are commonly dependent on public subsidies for financial sustainability. On the other hand, they lead to less freight activity and can increase the average load factor of freight vehicles (Fransoo and Mora-Quiñones 2021). A UCC application from Yokohama, Japan underlines the importance of the following factors in the success of UCCs (Mejia 2021):

- regulations that give carriers using UCCs priority access to city center
- basing consolidation scheme on a profitable business plan
- the use of public private partnerships (PPP) for the experiments
- final delivery operations assigned to a new logistics provider that aided UCC user acceptability

This highlights the role governments can play, despite the private sector-driven nature of logistics operations.

Figure 4.2 Urban Consolidation Center Schema



Source: Original figure produced for this publication.

Mini or micro hubs are a special case of urban consolidation centers that are closer to the delivery point and service a smaller area. These are less costly but are more dependent on collaboration and the specific location within the city (Mejia 2021). Creating mini-hubs can help logistics providers decarbonize operations by reducing distances, as shown by an example in São Paulo, Brazil (see Box 4.4). The value of mini-hubs is also in their ability to promote shifts to smaller, less carbon-intensive vehicles for last-mile delivery, hence providing decarbonization benefits under the shift pillar.

Collection and delivery points (CDPs) are a flexible alternative to home deliveries and offer an important opportunity to reduce failed deliveries within urban areas. Failed deliveries represent a sunk cost for shippers and carry externalities in terms of the number of trips, congestion, and air pollution. An increasingly used strategy is the CDP system, which is "a network of facilities where carriers deliver orders, and e-customers collect the online purchases as an alternative to home delivery" (Oliveira et al. 2019). CDPs can be manned (called "click and collect" or "service point") or unmanned, where parcel lockers and stations are used (Oliveira et al. 2019). The main disadvantage of lockers is space requirement and the potentially limited capacity (Fransoo and Mora-Quiñones 2021). To promote sustainability, CDPs have to be in locations where customers can access them through sustainable modes (Fransoo and Mora-Quiñones 2021). CDPs require collaboration among logistics providers and local businesses.

CDPs have applicability in LMICs and can bring environmental benefits if located in high-access areas. A study on accessibility of CDPs in Belo Horizonte concluded that drugstores, gas stations, and post offices might serve as best locations for CDPs due to their increased accessibility (Oliveira et al. 2019). The study suggests that the Government should encourage the installation of CDPs in those areas. In Belo Horizonte, CDPs are included in their Urban Freight Mobility Plan as a strategy to decarbonization (without any operational facilities yet), highlighting the important role that governments can play in promoting such measures (Oliveira et al. 2019). In India, in 2014, Amazon launched the 'I have space' program, where it partners with local shopkeepers to provide pickup and delivery services within 2-4 km of the store. The program grew in 2021 to close to 28,000 stores in 350 cities (Amazon 2022). It makes the most of the existing infrastructure and unutilized capacity of shopkeepers for delivery outside peak hours.

Image 4.1. **Bicycle Vendor on the Sidewalks of Lanzhou, China**

Image source: Carsten ten Brink (2018).

Box 4.4. Simulated Environmental Impacts of Pick-up Points on E-Commerce Urban Last-mile Distribution: A Case Study in São Paulo, Brazil

A simulation study investigated the conditions in which a network of pick-up points could be more operationally and environmentally efficient than home deliveries in urban last-mile distribution of e-commerce purchases. The study models one day's business-to-consumer e-commerce last-mile delivery system in a 93 km^2 region of São Paulo, Brazil, with known fulfillment center and delivery locations. The region is home to 1.2 million people and has a population density of 12,500 people/km^2. Multiple demand scenarios were considered from 500 deliveries (equivalent to 5.4 stops/km^2) to 3,000 deliveries (equivalent to 32.2 stops/km^2). A heterogeneous fleet of urban small delivery vehicles of different sizes and types is available to perform the deliveries, including motorcycles, light commercial vehicles, and delivery vans. Routes are subject to vehicle capacity (weight and volume) and time duration constraints, however urgent or on-demand deliveries are not captured.

Results were compared against baseline simulations without any pick-up points to simulations with the percentage of deliveries destined for pick-up points at 20%, 40%, 60%, and 80%. The study finds that increasing the share of deliveries to pick-up points reduces the number of vehicles needed to fulfill deliveries by 12.4% to 56.7%. In almost all scenarios, light commercial vehicles dominated the delivery fleet; however, when demand was very high and a large share of deliveries were made to pick-up points, larger vans were assigned to some routes as their higher capacity could be efficiently utilized. The average CO_2 reduction ranged from 11% (with 20% of deliveries at pick-up points) to 56% (with 80% of deliveries at pick-up points), with intermediate reductions in CO_2 emissions of 25% and 40%. These results show that pick-up points can be a promising alternative for reducing the environmental externalities of e-commerce home deliver operations in terms of both congestion and GHG emissions.

Source: Masteguim and Cunha 2022.

4.3. Electrification and Alternative Fuels

The global expansion and decrease in the costs of EVs is increasingly making electrification of transport relevant and achievable for LMICs. A recent report by the World Bank on the economics of e-mobility argues that LMICs' transition to e-mobility is no longer a question of 'if' but 'how' and 'when' and lays out feasible and cost-effective entry points for that transition (Briceno-Garmendia, Qiao and Foster 2023). Decarbonization gains from electrification depend on the size of countries and their vehicle fleet composition but can be as high as an average annual CO_2 emission reduction of 28 percent in a realistic EV adoption scenario in Vietnam (Briceno- Garmendia, Qiao and Foster 2023). Shifting to EVs can also diminish emissions of the most harmful particulate matter by tenfold per passenger kilometer traveled (Briceno-Garmendia, Qiao and Foster 2023). Therefore, all cities need to plan to incorporate EVs into their strategies for low-carbon and inclusive urban passenger and freight transport.

Cities should prioritize what to electrify first. Cities should target the segments that provide the largest decarbonization benefits with the fewest externalities, in the most cost-effective way. Electrification is more attractive and viable for less expensive, higher mileage, and more intensive use. This means that cities need to start promoting electrification efforts for two-wheelers, followed by buses (especially those with high-use routes), and then four-wheelers (Briceno-Garmendia, Qiao and Foster 2023). Among four-wheelers, taxis, ride-sharing vehicles, and other commercial fleets may become suitable for electrification ahead of less-intensively used private family cars (Briceno-Garmendia, Qiao and Foster 2023).

The freight sector can also gain emission benefits from electrification with pilot programs globally providing encouraging results. One such example is the Validating Freight Electric Vehicles in Urban Europe or FREVUE project, which deployed 100+ electric freight vehicles across eight large European metropolitan areas (Amsterdam, Lisbon, London, Madrid, Milan, Oslo, Rotterdam, and Stockholm) between 2013 and 2017 to test performance in terms of fulfilling logistical operations and associated emission reductions. The overall results showed a reduction of approximately 45 percent in carbon emissions (Fransoo and Mora-Quiñones 2021). Replicating such a program in cities in LMICs would require significant public sector support to surmount the barriers that small-scale private freight vehicle owners face in accessing the capital necessary for fleet renewal, especially given the capital cost premium on EVs today and low operating margins of many freight operators. Such efforts will take significant time and resources to achieve change at scale, particularly in cascading to the second-hand vehicle markets prevalent in many LMICs.

Cities should not seek to electrify the status-quo and should instead include electrification efforts as part of a comprehensive low-carbon and inclusive transport policy that requires significant interventions at the AVOID and SHIFT levels of the ASI framework. Electrification alone should not be considered a silver bullet for decarbonization and development because, while electrification brings significant GHG emissions benefits, it does not solve other urban transport challenges such as congestion and road safety. If it is not integrated in a comprehensive strategy, electrification at-all-costs is challenging to achieve and likely to be counterproductive with regard to affordability, accessibility, and economic productivity. Equity and affordability considerations need to stay at the heart of the transition to e-mobility as EVs are still considerably more expensive to purchase than internal combustion engine vehicles (ICEVs).

Image 4.2. **Charging an Electric Bus in Santiago, Chile**

Image source: IMF Photo/Tamara Merino (2021).

E-mobility has a large ecosystem, which provides several touch points for cities to impact production and adoption of EVs (see Figure 4.3). These include customer awareness and preference, the technology, its cost and the infrastructure needed to deploy it, energy to power it, and standards and regulations. Governments have a key role to play in:

- promoting personal adoption and public sector uptake
- promoting imports, production, and an efficient supply chain
- scaling the charging infrastructure

Figure 4.3. **Key Interventions for Governments along the EV Ecosystem**

Accelerated adoption of cleaner vehicle technology by the public and private sectors

- Direct incentives, such as consumer rebates, tax exemptions, and purchase subsidies
- Indirect incentives, such as preferential parking or access to infrastructure, demonstration programs, and road tax reductions
- Public procurement programs or demand pooling for taxis and commercial vehicles
- Mandates for fleet electrification

Vehicle production, supply chain, and imports

- Standards and incentives for production and import of EVs
- Improvements to aftermarket repair and services sector for EVs, including job transition programs for those engaged in aftermarket services for ICEVs
- Protocols for disposal or second-life use of batteries and recycling of EVs
- Structural change facilitation in full value chain for vehicles—original equipment manufacturers (OEMs), dealers, and aftermarket networks

Charging and electricity infrastructure

- Public charging infrastructure development programs
- Financial incentives and expedited procedures for private sector-led installation for both public and private use
- Redesign of electricity tariff to lower operating costs of EVs

Source: Original figure produced for this publication with content adapted from Alam and Lee 2021.

Several interdependent factors impact customers' choice and preference, an essential element of EV uptake. These include (Alam and Lee 2021):

- *vehicle technology aspects* such as range, reliability, performance, and battery life
- *economic factors* like EV purchase costs, battery replacement costs, and electricity prices
- *awareness and preference* or individual heterogeneity
- *infrastructure* factors like availability of charging stations and EV repair and maintenance workshops

Decisions are also influenced by various standards and regulations including pricing and incentives, as well as the state and cost of other sectors such as electricity.

LMICs can use multiple pricing schemes to increase the adoption of EVs. For example, countries in Latin America have used purchase incentives, import and property tax, as well as electric fee differentiation (see Table 4.1). Due to the substantial upfront cost of EVs and its impact on limiting adoption, different taxation rates for EVs versus ICEVs can even out the upfront cost and significantly influence adoption levels. Moreover, over the lifetime of a vehicle, relative differences in fossil fuel and electricity prices significantly increase the attractiveness of EVs. Therefore, solving the initial cost challenge can unlock more widespread adoption. Taxes or subsidies on electricity prices have also influenced these prices.

Table 4.1. Types of EV Incentives Used to Stimulate EV Adoption in Latin American Countries

Incentive Type	Latin American Countries Using the Incentive
EV purchase incentives	Colombia, Costa Rica, Ecuador, México, and Paraguay
Import tax reductions	Antigua and Barbuda, Argentina, Brazil, Colombia, Costa Rica, Dominican Republic, Ecuador, Mexico, Paraguay, and Uruguay
Other property tax or toll or both taxes, parking, and other exceptions	Colombia, Costa Rica, Ecuador, and Uruguay
Differentiated electric fees	Chile, Costa Rica, Ecuador, and México

Source: Original table produced for this publication with incentive types based on Alam and Lee 2021.

A network of charging infrastructure is a necessary and cost-effective driver of early EV adoption and should be introduced as soon as possible (Alam and Lee 2021). Investing in EV charging infrastructure can be up to six times more effective at driving EV purchases than subsidies (Briceno-Garmendia, Qiao and Foster 2023). They are also more cost-effective. The subsidy cost per additional EV is USD 4,000 for charging stations, versus USD 12,000 for vehicle purchase incentives (Briceno-Garmendia, Qiao and Foster 2023). Charging can range from regular power sockets for two- and three-wheelers to more specialized charging ranging - from private chargers located in homes and offices to public charging stations on the road, to specialized charging arrangements at bus depots (Briceno-Garmendia, Qiao and Foster 2023). Buses naturally require more significant power and charging investment. On average, investments in charging infrastructure amount to USD 2,500 per four-wheeler and USD 25,000 per electric bus (Briceno-Garmendia, Qiao and Foster 2023). Public charging has important implications for public space and availability of land. Cities need to incorporate charging infrastructure into city planning to account for factors such as housing, demand, and parking, where EV charging stations may require more space than gas (petrol) stations (CCFGP 2022).

Leasing schemes can be introduced to mitigate ownership risks and fleet-wide turnover costs and promote e-bus adoption One way to mitigate ownership, vehicle maintenance, and up-front cost burdens faced by consumers could involve shifting to leasing of the vehicles or some of its costlier components. Battery-as-a-Service (BaaS) has been seen in China, India, Thailand, and several countries in Africa. It unbundles the purchase of the costliest element of the EV—the battery—from the EV purchase decision. A combination of battery leasing and swapping reduces the upfront vehicle cost and make EVs more affordable to low-income populations. Similarly, leasing schemes have been introduced for electric buses to mitigate fleet-wide turnover costs by separating service provision from fleet ownership. For instance, in Chile, the electric utility owns the electric bus fleet and leases to transit agencies/local government (see Box 4.5). Indeed, these models provide a practical way of shifting the burden of higher capital costs to firms with potentially easier access to credit and lower cost of capital. Consumers and fleet operators would then pay gradually per trip or via monthly installments (or a recurrent leasing fee in the case of a fleet).

Box 4.5. PPP and an Innovative Leasing Scheme Helps Promote E-bus Adoption in Chile

Chile does not have local e-bus manufacturing. E-buses were supplied through a PPP between the Ministry of Transport and Communication and the energy companies, Enel and Engie. Enel and Engie financed the initial purchases of Chinese-made e-buses and electric charging infrastructure as well as electricity through leasing contracts with the private bus operator companies. This involved monthly payments for fleet provision, charging infrastructure, and energy supply. The Government played an important role in transitioning to e-buses by facilitating the process, reducing approval and authorization times, and supporting the planning and regulation of the buses. While the Government collected and distributed revenues, six private operators ran the bus lines. Two types of contracts were used for operations, infrastructure, and assets, reflecting the decoupling of fleet provision and depot ownership and operation and maintenance of buses.

Source: World Bank's elaboration based on Briceno-Garmendia, Qiao and Foster 2023; WB 2020a.

Demand pooling mechanisms can also be essential in promoting adoption by decreasing the procurement cost of buses. Similar challenges arise for public transport authorities, which may struggle to afford the capital cost associated with e-buses. While leasing is an option discussed previously, another is the aggregation of demand across multiple urban jurisdictions to form larger procurement lots and benefit from increased buyer leverage. This can be an effective way of reducing the unit cost of purchasing e-buses. In India, for example, a new program aggregated demand for electric buses across cities, standardized their procurement specifications, and carried out a tendering process to procure 5,450 electric buses on a gross cost contract basis. The per-km prices realized by this combination of economies of scale and contractual improvements were 23–27 percent lower than the current cost of diesel buses in the cities without any subsidy (Convergence 2022). Such demand pooling often involves national-level coordination of procurement across cities, or in smaller countries, even supranational coordination, potentially facilitated by regional or multilateral institutions.

Promoting e-mobility requires an integrated approach between the transport and electricity sectors. The overall energy demand associated with adopting EVs is not large compared to the scale of the power system in most countries, but electrification of passenger transport will certainly create additional demand for electricity. Demand growth can be managed in most cases due the relatively slow transformation of the vehicle fleet. Across the 20 LMICs studied in a recent World Bank report (Briceno-Garmendia, Qiao and Foster 2023), the adoption of a 30-percent target for new vehicle electrification by 2030 was found to boost electricity demand by no more than a fraction of 1 percent. Nevertheless, exceptions may arise in some LICs where power infrastructure is limited or is already strained, especially around peak demand hours. Simulations conducted for several countries in the Sahel suggest that modest electrification of the two-wheeled fleet could place pressure on scarce electricity supplies (Arroyo-Arroyo and Vesin 2021). These conflicts can be mitigated with proper planning, expertise, and governance.

Coordinated charging should be a strategic priority when tackling EV infrastructure. Charging management can significantly impact the burden on the electricity grid, which is especially important in countries with limited generation capacity, like LMICs. Left unmanaged, the time profile of EV charging at large scale could potentially exacerbate peak demand, typically in the evenings, for private vehicles. Pricing tools with incentives for day-time charging, widespread availability of charging infrastructure at workplaces and recreational venues, and other such mechanisms can help mitigate this trend to some extent.

Looking to alternative fuels and electrification can fast-track decarbonization but require legwork to ensure hurdles are addressed. Developed countries and some LMICs such as China are accelerating towards the ambitious expansions of their EV and alternative fuel vehicle fleets, with all major OEMs now looking towards this future when introducing new models. However, EVs and other alternative fuels such as hydrogen, while providing clear decarbonization benefits, require significant infrastructure investment and regulatory frameworks to enable adoption at scale.

Hydrogen-fueled vehicles can also reduce emissions significantly but require technological maturation and mass adoption before they are affordable and scalable in LMICs. There is an ongoing global push towards hydrogen as a potentially larger component of the energy mix in the coming decades (IEA 2021), bringing the possibility of fuel-cell EV (FCEV) and hydrogen ICEs (H_2ICE) as alternatives to ICEVs (EY 2023). Large-scale adoption in LMICs requires significant infrastructure investment, policy adaptation, and cost declines. LDV adoption requires widespread development of hydrogen refueling stations to increase consumer confidence, but further inroads in developed countries is likely to be required to bring costs and prices down. FCEVs may become an attractive alternative for applications that require high uptime, have long-range capabilities and heavy payloads, and transit through areas with limited grid access such as heavy-duty vehicles (Pardhi et al. 2022). FCEVs are a promising decarbonization pathway for the heavy-duty sector (long-haul freight) but will also have to be more cost competitive to be a viable one. Policy incentives will be needed for vehicles, fuel, and refueling infrastructure, and ultimately, vehicle incentives (price) too may be necessary for consumers. While hydrogen remains a promising alternative, its adoption will depend on the domestic context, and more importantly, on the state of the technology and costs.

It is important to acknowledge and mitigate conflicts between electrification and other decarbonization measures. Electrification efforts can compromise SHIFT efforts, whereby EVs become so attractive that people switch to private vehicles over public transport, walking, or biking. If people replace travel with more space- and energy-efficient modes than private EVs, their net emissions reductions may only be marginal (if any). Furthermore, research has shown that IMPROVE measures, such as electrification, can drive more travel demand (Zhang and Hanaoka 2022).

Image 4.3. Freight by bike on road of Hôi An, Vietnam

Image Source: Fiona Campbell (2015).

4.4. Deciding on IMPROVE Measures

There are many ways to IMPROVE the energy and operational efficiency of urban transport and freight vehicles and their fuels. Choosing among these measures often requires a fundamental knowledge of the passenger and freight vehicle fleets operating in a city and the adoption of appropriate measures to manage these motor vehicles (see Figure 4.4). With fundamental databases and processes in place, cities can think about regulatory and pricing measures to encourage the transition of fleets to alternative fuels.

Figure 4.4. **Guiding Questions for Determining IMPROVE Measures for Decarbonizing Urban Transport**

?

Does your city have processes for ensuring vehicle emissions and safety standards at point of sale (licensing and registration) during use (inspection), and at end of life (scrappage)?

No

- Put in place appropriate vehicle licensing/registration systems
- Adopt and enforce vehicle fuel standards
- Consider the use of fiscal instruments such as vehicle registration fees and feebate systems, that differentiate by vehicle fuel efficiency
- Implement robust vehicle inspections and emissions monitoring systems for vehicles in-use
- Consider scrappage programs to register and control exit of vehicles from the fleet

?

Does your city have data on urban freight movements that can be used to design regulatory, pricing and infrastructure measures to improve loading and unloading?

No

Convene stakeholders - including shippers, receives, and operators - to understand opportunities to better facilitate urban freight movements

?

Does your have an alternative fuel vehicle analysis that coonsiders both energy supply and demmand and identifies financial, economic and environmental feasibility of different uses of aternative fuel vehicles (e.g., EVs, FCEVs)?

No

Conduct an analysis of the benefits and costs of alternative fuel vehicles for different urban passenger and freight market segments using an integrated approach between the transport and energy sectors

Yes

- Design potential pricing schemes and incentives to increase the adoption of alternative fuel vehicles in priority market segments
- Consider leasing scheme, demand pooling, guarantees and other strategies to help overcome upfront cost hurdle for passenger and freight fleet renewal
- Promote a network of coordinated charging/refueling infrastructure

Source: Original figure produced for this publication.

Chapter 5
Enabling Avoid-Shift-Improve

To effectively implement any measure under the AVOID-SHIFT-IMPROVE framework for urban transport, cities in LMICs will need to augment their institutional, human, and financial capacities in both the public and private sectors.

5.1. An Effective Governance System

The institutional capacity required to address decarbonization start with setting up strong institutions to deliver and manage urban freight and passenger transport. Urban transport is a complex system requiring the effective functioning of the individual parts of the system as well as of the system overall (World Bank 2023). Managing this system requires an understanding of the issues relating to affordability, disability, gender, livelihoods, political economy, human psychology, local culture, energy security, air quality (Kumar and Agarwal 2013). Normally, these capabilities cut across several agencies within a level of government (transport, land, environment) and across different levels of government (municipal, state, federal). As presented in this report, there is a strong correlation between delivering high-quality and inclusive urban transport systems and achieving decarbonization of the sector. Therefore, the basics principles of delivering good governance in urban transport are the main foundations necessary to deliver on decarbonization.

There is a need for an effective governance system that allows for coordination among stakeholders. The size and characteristics of this governance system will depend on context. Regardless of the exact institutional framework in place, public sector institutions should be able to work together to manage urban transport systems strategically and at a city-wide or metropolitan scale (World Bank 2023). They must pursue policies in the broad public interest, develop technical capacity and a secure financial basis for carrying out their tasks, coordinate transport infrastructure, service, and regulation over the entire metropolitan area that often goes beyond municipal boundaries, as well as develop strong support at the political level (Kumar and Agarwal 2013). They must also carry out the management of the system with a multimodal and integration-focused Mobility-as-a-Service approach, relying on strong data analytics to assess impacts on each part of the system and be empowered to innovate, conduct pilots, and propose regulations (Bianchi Alves et al. 2022). In many cases, especially in large urban agglomerations a "Metropolitan Transport Authority" may be necessary to achieve such coordination.

5.2. The Role of the Private Sector

The private sector is the main provider of urban freight and passenger transport services in LMIC cities. These can be informal, whereby no permitting/concession agreement is held between the providers and the government; or formal, whereby the government issues rights to operate with geographical/temporal boundaries and varying levels of accountability on service quality requirements, sharing of risks (demand, supply) and financing. Private sector providers can be large companies, like Grupo CCR in Brazil or Transport Corporation of India Limited in India. Or, as in most cities in LMICs, be small firms or individuals operating small two- to three-wheelers, minivans, or mini-truck=. Further, the private sector also serves as financiers and equity holders, with varying levels of complexity, from individual investors to large commercial banks.

Cities in all contexts need to acknowledge these private players and make decisions on regulations and risk sharing mechanisms that will support the delivery of high-quality and green transport systems. To improve the quality of service, it is likely that governments will need to issue regulations, for example, road and time restrictions for freight vehicles, minimum intervals, and coverage of remote areas for passenger service providers, among others. As these regulations are likely to increase the cost of providing service, they must be accompanied by an assessment that decides on what costs (risks) will be borne by the user, the private sector, and the public, according to affordability constraints and the capacity/jurisdiction that each party has in resolving those issues (for example, political risks such as setting fares are often borne by the public sector). If set right, these regulations can improve the quality of service and level the playing field to allow for a better balancing of externalities of transport modes.

5.3. Funding and Financing Decarbonization

Cities in LMICs are stuck in an underfunding and underfinancing trap. Funding refers to the transport system's capacity to either directly or indirectly raise funds from its users—ranging from public transport passengers to car drivers—or to use public sector revenues (Benitez and Bisbey 2023). In LMICs, the upfront capital investments needed for new transport infrastructure are extensive, and the revenue generated is often insufficient to cover operations and maintenance (O&M), let alone infrastructure (Ardila-Gomez and Ortegon-Sanchez 2016). This is further compounded by implicit subsidies towards the use of private cars.

Breaking the underfunding and underfinancing trap is necessary to implement ASI measures and enable a transition to low-carbon and inclusive transport systems. To do so, cities need to optimize their funding mechanisms, ensure efficient public spending, and finance the transition toward low-carbon and inclusive modes. This can only be successful if integrated within efficient governance where specific climate action goals are devised, and green transport-specific regulation and institutional frameworks are in place (Benitez and Bisbey 2023).

Optimizing Funding Mechanisms and Ensuring Efficiency of Public Spending

Cities have several revenue-generating mechanisms at their disposal to fund ASI measures. (see Table 5.1). Several of these have been discussed as decarbonization levers under the SHIFT pillar. The blend of funding governments use in the transport sector varies by country and data on government expenditure on transport in LMICs is largely missing.[14] Trends across LMICs reveal that (Benitez and Bisbey 2023):

- general budgets are the main source of funding for large infrastructure investments
- public transport fares are insufficient to cover capital expenditures
- grants constitute a minor source of funds
- transport-related taxes are not necessarily being directed back into the sector

Investments in urban freight come primarily from the private sector with opportunities for revenue generation through fiscal measures. Fiscal measures such as pricing and taxation can be used as levers for decarbonization and revenue generation mechanisms. For example, with the adequate allocation of curb space, parking pricing can generate revenue and promote decarbonization by enhancing traffic conditions, increasing turnover, and reducing parking dwell times (Holguin-Veras et al. 2020).

To optimize funding mechanisms and ensure efficiency of public spending, cities can (Benitez and Bisbey 2023):

- combine revenue sources and channel resources into low-carbon transport infrastructure and services
- find a sustainable revenue stream to support public investments and transport policies
- review fuel tax schemes and phase off subsidies and look into new funding schemes to compensate for missing tax fuel revenues
- consider land value-based financing instruments

[14] One review of transport-related revenue for Bogota in 2010 showed that capital gains, gasoline surcharge and transfers from the national government are the three main sources of revenue, accounting for 36, 21.8 and 14.7 percent of the total revenue, respectively (Ardila-Gomez and Ortegon-Sanchez 2013).

Table 5.1. Funding Source and Revenue Type for Urban Transport and Typical Use on ASI Measures

Type of Source	Type of Revenue	A, S or I
Public Sector	General budget funded through general taxation	ASI
	Grants from international funding agencies or bilateral aid	ASI
Users	Ticket fees by public transport users	S
	Payments by users of individual motorized vehicles: • tolls for the use of infrastructure (bridges or urban motorways), • congestion charges to access areas such as city centers • parking charges, • taxes on fuels, • fines (if earmarked) • carbon pricing	S, I
	Vehicle ownership tax (allocated to transport when permitted by legislation).	S
	Payments by users of soft modes of transport, such as bicycles (for example, rental charges when using self-service systems or secure lockups).	S
Other People	Payroll tax for private companies that have employees who make use of the public transport system (such as the "Versement Transport" in the Paris region)	S
	Contributions in the form of direct assistance to the employee when a firm covers a share of employees' daily transport costs (such as the "Vale Transporte" in Brazil)	S
	Land values capture (LVC) instruments used by the municipality of São Paulo and betterment levies in Columbia	A
	Recovery of a share of capital gains to fund transport	A, S, I

Source: Adapted from Ardila-Gomez and Ortegon-Sanchez 2016.

Financing the Transition Towards Low-Carbon and Inclusive Modes

Cities have different financing needs[15] and financing mechanisms at their disposal to invest in ASI measures. Financing refers to the capacity to leverage equity or loans to finance large projects, such as the construction of a metro line, which have high upfront capital expenditures (Benitez and Bisbey 2023). Financing needs for major urban transport investments are often significant and require multiple financiers or sources of finance. In LMICs, most of the financing for low-carbon transport comes from Development Finance Institutions (DFIs), followed by public domestic finance and the private sector (Benitez and Bisbey 2023). Among DFIS, Multilateral Development Banks (MDB) play a crucial role and accounted for a quarter of the funding for low-carbon solutions in LMICs. In addition to direct or traditional financing through loans, DFIs can play a critical role in de-risking the sector and mobilizing private capital. They can set up facilities by bundling their convening power, concessional lending terms, and significant country or sectoral knowledge with domestic stakeholders (Benitez and Bisbey 2023).

[15] Urban transport infrastructure needs depend on a city's size and level of existing network development. Taking the example of BRT development, World Bank calculations show that a mega city of 500 square blocks would need 400 kms of BRT (or USD 40,080 million) compared to 25 kms of BRT (USD 2,505 million) for a medium-sized city of 250 square blocks. In general, cities still developing their urban transport systems require substantial capital investments, but lower relative O&M spending. As networks grow, capital investments go down, while O&M increase both in absolute and as a share of relative spending needs. Bogota—a city at a moderate state of network evolution—needs USD 258.3 million for BRT, almost USD 6,000 million for arterial roads, and USD 2,654 million for intermediate and local roads. Maintenance needs are similarly large (Ardila-Gomez and Ortegon-Sanchez 2016).

Although private sector participation in urban transport service provision is high, its participation in infrastructure investment is lagging. Private investment accounts for nearly 30 percent of the overall investment in low carbon transport, much less than its relative share of the renewable energy sector at 80 percent. Domestic household financing through EV purchases is picking up and amounted to USD 32 billion in 2020, accounting for 68 percent of private investment in transport (Benitez and Bisbey 2023; Negreiros et al. 2021). Given the large scale of financing needed and the limited capacity of MDBs to offer loans and de-risking instruments, there is a need for innovative pilots, an enabling environment, and a predictable revenue stream from the private sector. A non-exhaustive list of financing approaches is provided in Table 5.2. ASI measures decrease emissions and can therefore unlock climate financing such as emissions trading.

Table 5.2. Selected Financing Approaches for ASI Measures

Financing Approaches	Example(s)	A, S or I?
PPPs for urban transport projects	Metrobús BRT in Mexico and Transantiago, Chile	SI
Innovative leasing and procurement models for e-mobility	Brazil, Chile, and India are leading examples in innovative financing and procurement models	I
Bond market financing, packaging smaller-scale transportation infrastructure interventions as an asset to raise capital market financing	The City of Austin's Mobility Bond program to finance sidewalks, bikeways, urban trails, and transportation safety projects	S
Carbon pricing and emissions trading to facilitate a green and socially just transition	California's Cap-and-Trade program, the European Union, and Quebec, Canada	A,S,I
Blended finance models to supporting local bus operators	Mozambique's Transport and Communications Development Fund blending-to-lease model	S,I

Source: Benitez and Bisbey 2023; Negreiros et al. 2021; Briceno-Garmendia, Qiao and Foster 2023.

Governments need to address the fundamental bankability issues in projects, which are more pronounced in green transport projects. It is easier to mobilize private financing for a bankable green project. Building a balanced risk-return profile for public and private sector stakeholders is critical to bankability. This could be done through (Ardila-Gomez and Ortegon-Sanchez 2016):

i building an enabling environment to draw fair and transparent private sector competition

ii robust regulations for contract management

iii government's commitment in the concessions contracts

By building a portfolio of bankable green projects, cities can tap into new financial and capital markets investors that are focused on transport sustainability. Adding climate mitigation and adaptation features to feasible projects will increase its marketability and economic value in the long term. Additionally, including transport-specific climate action targets through a green transport taxonomy and standards to package transport projects can be an important starting point for governments (Benitez and Bisbey 2023).

5.4. Communicating with the Public

As urban transport affects the daily lives of people, it can be a sensitive topic. Transport directly affects people's productivity, mental and physical health, and quality of life (Dora et al. 2021; Meyer and Elrahman 2019; Conceição et al. 2022). While measures to promote decarbonization of urban transport often have other positive effects on individual wellbeing, such as reduction in air pollution and travel times, these benefits are not equally distributed and individual and societal optimums may not match. When individuals seek to optimize their own commuting time, the result is often a higher commuting time for everyone (Prieto Curiel et al. 2021). On the other hand, reducing road space for cars to prioritize public transportation may lead to longer travel times for car travelers, while a reallocation of a bus stop to improve the network efficiency may lead to longer walks to that bus stop.

Commitment to a climate change agenda involves engaging in difficult conversations. More stringent vehicle emission standards, higher fuel standards, city tolling, improved public transit (with potentially higher public transit fares), and low emission zones raise costs to users and companies and there are extremely sensitive political economy considerations and questions of affordability and how best to protect lower income and vulnerable groups. Three important sets of policies illustrate this challenge. The first is a more balanced approach to space and infrastructure use, which implies taking away space or demand from private vehicles, upsetting some citizens and stakeholders, especially in LMICs (Venter, Mahendra and Hidalgo 2019). A good strategy is to build trust when framing and sharing an integrated long-term strategic plan that involves everyone and shows the benefits of a more balanced policy package to multiple constituencies (Venter, Mahendra and Hidalgo 2019). For example, show how improvements like transit or bike lanes can help ease congestion for car users or how improving sidewalks eases the burden on the senior population. The second, more specific to LMICs, is the integration of the informal sector, which remains a core service provider. Ignoring informal transport providers when implementing reforms in the transit system or aiming to remove them altogether can have adverse implications for accessibility and affordability of public transport. With adequate planning, incremental reforms, and increased communication, there could be wins for operators, governments, and societies.[16] The third is to promote compact cities that need to include more equitable policies such as affordable housing or slum upgrades. In this case as well, cities need to present the benefits of inclusivity for the greater good. Addressing the political economy can help scale up support for the climate-friendly, multimodal policy agenda. In the decarbonization agenda, a big part of policymaking and governance is the need to engage on such themes and break the impasse. Many policies suggested as part of the ASI—especially in the short run—call for important changes to the status quo.

[16] Minibus renewal and professionalization service in Senegal (Dakar), resulted in wins for operators (access loans previously denied for them), government and society (creation and consolidation of more than 1,250 formal, professional jobs; improved public transport quality and safety of service, reductions in travel time and air quality) (SSATP 2023)

A successful communication campaign requires involving all stakeholders in the complex urban ecosystem and conveying the goals of decarbonizing transport and development in a consistent and trustworthy manner. The stakeholder ecosystem in urban transport is complex, with various groups and conflicting interests. End users—passengers or receivers and shippers of goods—make transport decisions based on objective constraints such as affordability and quality of service of the different transport alternatives, depending on a series of socioeconomic and behavioral variables. Providers of service encompass a wide range of firms, from public to private sector, licensed or unlicensed, small to large carriers or passenger modes, all of which depend profoundly on city policies and regulations on the use of the shared city space. Communicating well means addressing people's needs through meaningful and wide consultations, mitigating potential negative impacts, and increasing awareness of the trade-offs between individual gains versus societal gains of different measures. This "social marketing" for transport can focus on the wider overall benefits on health, communicating for instance, that:

- people who use public transport have better physical and health profiles than those who drive (Noorbhai 2022)
- cities that focus on sustainable transportation are also more productive (Graham 2007; Chatman and Noland 2013)
- transport plays a role in ensuring equality of opportunities (McQuaid 2021)

More importantly, a successful communication campaign must address the issue of trust, with consistency in policy objectives, clear, understandable information, and reassurance of the shared values and norms proposed by these policies (Pridmore and Miola 2011).

Image 5.1. **Sprawling Development Outside of Kigali, Rwanda**

Image source: Francisco Anzola (2017).

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Appendix A
ASI Decarbonization of Urban Transport Measures

Appendix A. ASI Decarbonization of Urban Transport Measures

Cities in LMICs can and should follow their own trajectory towards decoupling by making strategic choices from a wide range of possible policies and investments. Considerations should be given to where they can most effectively encourage social and economic development via low-carbon and inclusive urban transport—all given available resources. Tables A1, A2, and A3 summarize key measures that the public sector can take to help achieve decarbonization of urban transport, organized using the ASI framework. The table indicates whether measures are typically adopted at the national or local of government, and over what time frame decarbonization impacts will be realized: short-term (ST), medium-term (MT), or long-term (LT).

Table A1. **AVOID Measures: Promoting Access with Fewer or Shorter Trips**

Category	Measure	Passenger or freight	Level of government	Impact timeframe	Implementation cost (monetary)
Land use measures	Increase collaboration among urban/ land and transport departments	Both	Local	LT	Low
	Re-evaluate existing land use policies and adopt land-use policies that promote mixed use	Passenger	Local	LT	Low
	Encourage dense, compact, and mixed-use urban development, particularly along highly traveled public transport corridors (e.g., transit-oriented development)	Passenger	Local	LT	High
	Ensure that affordable housing is well-connected to transport infrastructure services	Passenger	Local	LT	High
	Integrate informal housing/ settlements into the city	Passenger	Local	LT	High
	Re-evaluate existing land use policies to promote freight efficient land use policies (FELU)	Freight	Local	LT	Low
	Integrate freight into land use planning and development	Freight	Local	LT	Low
	Earmark land for new development	Freight	Local	MT	Low
	Facilitate the re-use of underused urban facilities for logistics	Freight	Local	MT	Low
	Encourage proximity logistics	Freight	Local	LT	Low
Tele-activity measures	Build guiding policies for firms on implementing telework policies	Passenger	Local	MT	Low
	Incentivize firms to adopt teleworking policies when it makes sense	Passenger	Local and national	MT	Medium
	Monitor the distributional impacts	Passenger		LT	Medium
	Ensure that all households are well-connected to electricity and Internet services	Both		LT	High

Table A2. **SHIFT Measures: Encouraging the Use of More Carbon-Efficient Modes**

Category	Measure	Passenger or freight	Level of government	Impact timeframe	Implementation cost
Pricing and Management of Shared Infrastructure	Reduce subsidies of cars and shift funds to low-carbon and inclusive modes	Both	National	MT	Low
	Re-purpose the infrastructure to adequately and fairly allocate space for road users through multimodal and complete streets	Both	Local	MT	High
	Reform of fuel subsidies or taxes	Both	National	MT	Low
	Use road access restrictions (e.g., license plate schemes and low-emission zones, permit to buy a personal car, vehicle registration charges, required demonstration of owned parking space to buy a car)	Both	Local	MT	Low
	Use diesel or gasoline taxes and subsidy-reduction schemes	Both	National	ST	Low
	Provide e-bike subsidies	Both	National	MT	Medium
	Use tolling for access to urban arterials, road use charging schemes based on distance traveled, and congestion or emissions charging zones road	Both	National	ST	Low
	Implement and enforce curb management schemes	Both	Local	ST	Low
	Incentivize pro-environmental behaviors, through habit formation, social influence, information sharing, and eco-labeling	Both	Both	LT	Medium
	Car labeling based on fuel emissions	Both	National	LT	Low
	Use behavioral science and marketing campaigns to break habits, change perceptions	Both	Local	ST	Low
	Designate "pedestrian zones" in core areas	Passenger	Local	MT	Low
	Increase the purchase tax of a personal car	Passenger	National	ST	Low
	Require a permit to buy a personal car	Passenger	National	ST	Low
	Increase vehicle registration charges	Passenger	National	ST	Low
	Increase parking charges for personal cars	Passenger	National	ST	Low
	Implement parking policies that reduces incentives to drive	Passenger	Local	ST	Low
	Reverse minimum parking laws and make parking more expensive and improve enforcement	Passenger	Local	ST	Low
	Use vehicle access restrictions such as license plate schemes	Passenger	National	ST	Low
	Implement outreach and commuter programs	Passenger	Local	ST	Low
	Raise awareness on alternative modes	Passenger	Local	ST	Low

Category	Measure	Passenger or freight	Level of government	Impact timeframe	Implementation cost
	Help train interested travelers in alternative modes – e.g., biking	Passenger	Local	ST	Low
	Promote car-free days	Passenger	Local	ST	Low
	Partner with delivery companies to pilot cargo bikes as an alternative	Freight	Local	ST	Low
	Encourage environmentally friendly sourcing, product design and packaging	Freight	Both	LT	Medium
Public Transport Service Improvements	Perform continuous management and monitoring of the infrastructure	Both	Local	ST	Medium
	Expand the coverage and frequency of public transport services	Passenger	Local	MT	High
	Improve the safety on public transport	Passenger	Local	ST	Low
	Utilize technology to enhance the user experience and inclusion (e.g., RTTI)	Passenger	Local	MT	Medium
	Encourage open data standards and data sharing	Passenger	Both	ST	Low
	Invest/encourage data collection and utilize mapping to enable more efficient planning and better service	Passenger	Local	MT	Medium
	Integrate and reform the informal sector through rationalization of routes, education/training	Passenger	Local	MT	Medium
	Onboarding operators into new fare payment systems	Passenger	Local	MT	Medium
	Enable micro-transit, MOD when they are complementary	Passenger	Local	ST	Low
Prioritized Infrastructure Investment	Identify the basic infrastructure needs missing	Both	Local	ST	High
	Invest in infrastructure for urban transport	Both	Local	MT	High
	Develop sidewalks and build connected and protected cycling networks	Both	Local	MT	High
	Implement more, better, and safer crossing facilities and calming measures	Both	Local	MT	Medium
	Enhance pedestrian and bike access to PT	Both	Local	MT	Medium
	Build high-standard Intermodal Facilities	Both	Local	MT	Medium
	Create more space for pedestrians on footways	Both	Local	MT	Medium
	Utilize Inland waterway transport	Freight	Both	MT	Medium
	Implement Multiuse Lanes	Freight	Both	MT	Medium

Table A3. IMPROVE Measures: Enhancing Efficiency of Vehicles and Operations

Category	Measure	Passenger or freight	Level of government	Impact timeframe	Implementation cost
Motorization Management	Promote fleet renewal schemes and accelerated vehicle retirement or scrappage programs (AVRPs)	Both	Local	ST	Low
	Adopt Vehicle and fuel standards on imports and domestic production	Both	National	MT	Low
	Introduce first-use certification, quality assurance of vehicle parts and of vehicle construction	Both	Local	MT	Medium
	Introduce periodic technical inspection (PTI), on-road enforcement programs, fuel quality assurance and a strong preventative maintenance & repair	Both	Local	MT	Medium
	Introduce end of life programs	Both	Local	MT	Medium
	Strengthen systems and programs for managing motorization throughout the lifecycle of vehicles	Both	Local	MT	Medium
	Invest in and use (MVIMS)	Both	National (and local)	MT	Medium
Vehicle Loading and Flow Optimization	Leapfrog to the latest technologies in ITS	Both	Local	MT	Medium
	Improve the quality of the road surface	Both	Local	MT	High
	Improve road and intersection design	Both	Local	MT	High
	Use synchronized traffic light signaling to reduce vehicle idling at intersections along a corridor	Both	Local	MT	High
	Promote off hour deliveries (OHD)	Freight	Local	MT	Low
	Dedicated loading/unloading areas for freight vehicles	Freight	Local	MT	Medium
	Utilize driver training and eco-driving	Freight	Local	ST	Low
	Encourage the private sector to collaborate, use freight brokerage platforms, use consolidation centers and micro hubs and delivery points	Freight	Local	MT	Low

Category	Measure	Passenger or freight	Level of government	Impact timeframe	Implementation cost
Electrification and Alternative Fuels	Introduce leasing schemes for e-bus procurement	Passenger	National	ST	Medium
	Pool demand for e-bus procurement when possible	Passenger	Regional or national	ST	Low
	Use direct incentives: consumer rebates, tax exemptions and reductions	Both	National	ST	Low
	Use indirect incentives: special license plates, preferential access or incentives on roads, demonstration programs, and road tax reductions.	Both	Local	ST	Low
	Prioritize what to electrify first	Both	Both	ST	Low
	Launch public procurement programs, private fleet purchase programs for taxis and commercial vehicles, and mandates for fleet electrification	Both	Local	ST	Medium
	Establish standards and incentives for production and imports of EVs	Both	National	MT	Medium
	Nurture the aftermarket repair and services sector for EVs	Both	National	ST	Medium
	Support job transition programs for those engaged in aftermarket services for internal combustion engine vehicles (ICEVs)	Both	National	ST	Medium
	Establish protocols for disposal or second life of batteries and recycling for EVs	Both	National	ST	Low
	Launch public charging infrastructure development programs	Both	Both	ST	Medium
	Provide financial incentives for private sector-led installation programs for public and private use	Both	Both	ST	Medium
	Establish expedited procedures for installation	Both	Local	ST	Low
	Support the reduction and redesign of electricity tariffs to lower the operating costs of EVs	Both	Both	ST	Low
	Use energy taxes and subsidies	Both	National	MT	Medium
	Integrate the approach for e-mobility with electricity supply	Both	National	ST	Low
	Use carbon financing	Both	Both	MT	Low

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