Mobility and Transport Connectivity Series

Planning for Transit-Oriented Development in Emerging Cities

WORLD BANK GROUP

1818 H Street NW, Washington DC 20433
Telephone: 202-473-1000; Internet: www.worldbank.org

Internet: https://www.worldbank.org/transport

Table of Contents

List of Figures

List of Tables

List of Boxes

Acknowledgments

This book was written by Arturo Ardila-Gomez (Lead Transport Economist), Ok Stella Namkung (Consultant), Karla Dominguez-Gonzalez (Senior Gender Specialist), He He (Economist), and Nada Bona (Consultant), with contributions to the concept stage from Nouhayla Boubekri (Consultant), Daniel Ernesto Moser (GIZ), Arturs Danilovs (Consultant), and Joanna Moody (Transport Specialist). Salma Kably (Consultant) helped with the figures in chapter 8. The authors thank the peer reviewers for their guidance: Gerald Paul Ollivier (Lead Transport Specialist), Joanna McLean Masic (Lead Urban Specialist, SURDR), Chen Yang (Senior Transport Specialist, ILCT1), Shigeyuki Sakaki (Senior Transport Specialist, IEAT1), Somik V. Lall (Economic Adviser); Harris Selod (Senior Economist, DECSI); and Shomik Raj Mehndiratta (Practice Manager, IECT1).

The authors thank Nicolas Peltier (Director, ITRGK) and Binyam Reja (Practice Manager, ITRGK) for their guidance in preparing the book. Jonathan Davidar (Senior Knowledge Management and Learning Officer, ITRGK) guided the design, infographics, editing, and production of this publication. Thanks to RRD GO Creative for editing and design.

Foreword

In the rapidly evolving landscape of emerging cities, the concept of Transit-Oriented Development (TOD) is a beacon of sustainable urban growth. As cities expand and populations surge, the need for efficient, accessible, and environmentally friendly transportation systems becomes paramount. TOD offers a visionary approach, integrating residential, commercial, and recreational spaces within walkable distances of public transit. This not only reduces reliance on private vehicles, thereby decreasing traffic congestion and pollution but also fosters vibrant, inclusive communities. By prioritizing mixed-use developments and pedestrian-friendly environments, TOD enhances the quality of urban life, making cities more livable and resilient.

For emerging cities, embracing TOD is not just a strategy but a necessity. It represents a commitment to smart growth, where economic development and environmental stewardship go hand in hand. By leveraging the benefits of TOD, these cities can attract investments, create jobs, and improve public health outcomes. Moreover, TOD can help bridge social divides by providing equitable access to opportunities and amenities for all residents, regardless of their socioeconomic status.

As we look to the future, the adoption of TOD principles will be crucial in shaping growing cities that are not only sustainable but also dynamic and inclusive, paving the way for a brighter urban future that is walkable and transit-oriented.

Nicolas Peltier-Thiberge
Global Director, Transport
The World Bank

Foreword

Urbanization is accelerating at an unprecedented pace, making sustainable and efficient urban planning critical. "Planning for Transit-Oriented Development in Emerging Cities" offers a comprehensive guide to transforming rapidly growing urban areas into vibrant, transit-oriented communities.

The book emphasizes the importance of integrating land use regulations with transport planning. By aligning these two elements, cities can promote higher densities, mixed land uses, and pedestrian-friendly environments, which are essential for effective public transport systems.

An innovative sandbox model is introduced to simulate the impact of various land use regulations on transit ridership. This model provides valuable insights into how changes in regulations, such as floor area ratios and parking requirements, can significantly influence public transport use and walkability.

Highlighting the importance of designing for gender differences in mobility and accessibility, the book advocates for land use regulations that enhance safety and accessibility for all, particularly women, by promoting "eyes on the street" and ensuring well-designed public spaces.

Practical recommendations on improving Transit-Oriented Development (TOD) practices include adopting market-friendly zoning, allowing mixed land uses, allowing higher densities, promoting Multi-Modal Streets with wide sidewalks and proper traffic management, and ensuring adequate public space to support a walkable and transit-oriented urban environment.

This book is an essential resource for urban planners, policymakers, and anyone interested in creating sustainable, livable cities. By following the principles and recommendations outlined in this work, emerging cities can embark on a path toward a more connected, efficient, and inclusive urban future.

Binyam Reja
Global Practice Manager for Transport,
The World Bank

Acronyms

3V	3-Value Framework
ASA	Advisory Services and Analytics
BRT	Bus-Rapid Transit
CBD	Central Business District
CCTV	Closed-Circuit Television
FAR	Floor Area Ratio
FBC	Form-Based Codes
GHG	Greenhouse Gas
GPS	Global Positioning System
GTFS	General Transit Feed Specification
HITS	Hierarchically Integrated Transit System
ITDP	Institute for Transport and Development Policy
ITF	International Transport Forum
LUR	Land-Use Regulations
MMS	Multimodal Streets
NACTO	National Association of City Transportation Officials
NEDUM-2D Model	Non-Equilibrium Dynamic Urban Model
NIMBY	Not-In-My-Backyard
NGO	Non-governmental Organisation
OECD	Organisation for Economic Co-operation and Development
OICA	International Organization of Motor Vehicle Manufacturers
PT	Public Transport
SDG	Sustainable Development Goal
SDSN	Sustainable Development Solutions Network
SFH	Single-Family-Home
TOD	Transit-Oriented Development
TDM	Transportation Demand Management
UNDESA	United Nations Department of Economic and Social Affairs
WHO	World Health Organization
WRI	World Resources Institute

ES

Executive Summary

Introduction: Land Use and Transport in Developing Cities

Cities account for more than 50 percent of the world's population and 80 percent of its economic output (International Energy Agency, 2021). The concentration of people in cities is expected to continue through 2050, adding an additional 2.3 billion urban dwellers. At that point, an estimated 70 percent of the world's population will reside in cities. Considering this rapid urbanization, a common pitfall is to focus only on the challenges faced by the world's megacities, which neglects the many growing small and mid-sized cities. Notably, about 75 percent of the world's urban population live in settlements of less than 500,000 people (Cities Alliance, 2019).

Cities and urban transport are increasingly critical frontiers for climate action. More than 70 percent of global carbon dioxide emissions come from cities, making their mitigation efforts an important contributor to decarbonization. Urban transport is a significant contributor to climate-warming greenhouse gas (GHG) emissions in cities, with most urban transport emissions coming from cars. Private vehicles and low-occupancy ride-hailing services are carbon-inefficient per passenger-kilometer served (Figure ES1). Additionally, car-centric transport systems are a significant contributor to sprawling, low-density settlement configurations that displace natural carbon sinks. Managing motorization and encouraging the use of more carbon-efficient modes such as walking, biking, and public transport is fundamental to a low-carbon development trajectory while supporting sustainable development goals for livable cities, social inclusion, clean air, and road safety.

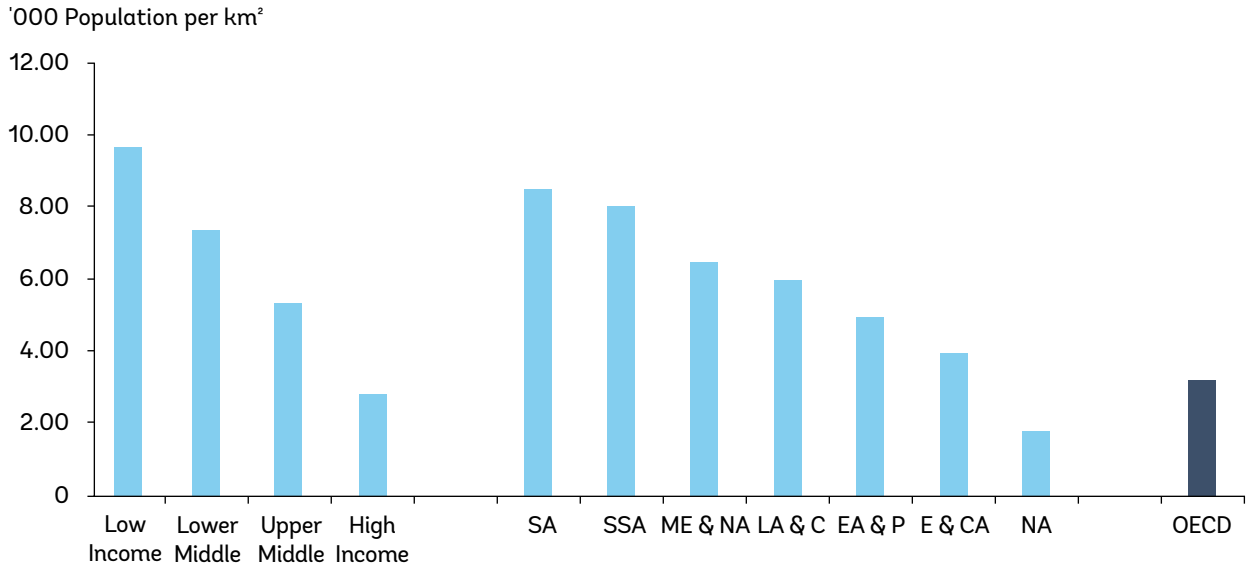
Figure ES1. Relative Carbon Efficiency of Urban Passenger Transport Modes

Source: Adapted from Figure 8.6 (Sims, et al., 2014).

Many cities in the developing world already have many elements of low-carbon passenger mobility. These include large modal shares of travel by public and active modes, low ownership and use of private cars, and high densities. Compared to cities in developed economies, more people walk, bike, or take public transport—formal or informal—and only a minority travel by car or motorcycle. Generally, motorization rates are still low or moderate. Indeed, developing countries currently have motorization rates that are four to eight times lower than developed countries (International Organization of Motor Vehicle Manufacturers, OICA, 2015).

Another advantage of cities in developing countries is their density. Demand for space tends to increase with income levels, resulting in an inverse relationship between density and income, as shown in Figure ES2 (OECD, 2020). Many informal settlements can be extremely crowded, with densities surpassing 60,000 inhabitants per km² (Kit, Ludeke, & Reckien, 2013). A lower density already supports public transport, walking, and biking.

Figure ES2. The Population Density in Cities by Country Income Class and Region, 2015



NA: North America, ME & NA: The Middle East and North Africa, LA & C: Latin America and the Caribbean, E & CA: Europe and Central Asia, EA & P: East Asia and Pacific, SA: South Asia, SSA: Sub-Saharan Africa.
Source: (OECD, 2020).

Despite land use patterns and apparent travel behavior that are supportive of transit-oriented development, few cities in developing countries have been unequivocally successful in building on these advantages. Rather, many emerging cities are on a trajectory toward extreme urban crowding without deriving the benefits of urban accessibility. Transportation and land use plans are often formulated independently. This lack of coherence contributes to inefficient cities with housing situated far away from employment centers (Suzuki, Cervero, & Iuchi, 2013). Urban expansion often happens in a scattered pattern with gaps between the built-up area—and public housing projects are frequently located in these remote areas. This increases the demand for motorized modes and generates congestion.

Problem Statement

What transport and land-use policies allow emerging cities without existing mass transit to develop into transit-oriented cities supported by low-carbon modes? To address this question, the book uses the lenses of urban economics and Transit-Oriented Development (TOD) literature. It applies theory, derives shared learnings, and examines empirical evidence from both perspectives—ultimately bridging the gap between the two. Additionally, the focus on developing solutions for emerging cities is critical. These cities account for 75 percent of the world's urban population and are also the most volatile, going through the most rapid change. They are often characterized by increasing population, expanding economic activities, and undergoing social, economic, and physical transformations. Formal or informal transit systems might serve them, but in many cases, they aspire to and struggle with the implementation of mass transit.

Land Use and Transport Planning through the Lenses of TOD and Urban Economics

The two dominant strands of thinking to address these problems are the TOD literature, which promotes land use planning around transit infrastructure, and the urban economics literature, which advocates a market-based approach. The TOD literature recommends planning to generate a "compact, mixed-use, pedestrian-friendly development organized around a transit station" (Suzuki, Cervero, & Iuchi, 2013). "TOD is a planning and design strategy that focuses on creating urban development patterns which facilitate the use of public transit, walking and cycling, as primary modes of transport and which supports vibrant, diverse, and livable communities. This is achieved by concentrating urban densities, communities, and activities within 5–10-minutes walking distance from mass rapid transit stations (high-capacity bus or rail), developing quality urban space, and providing convenient and efficient access to a diverse mix of land uses" (Ollivier G. , Ghate, Bankim, & Mehta, 2021). The TOD literature, however, could pay more attention to market mechanisms and price signals.

The urban economics literature finds that markets determine city density and uses. This literature builds from the trade-off between travel costs and rent costs to derive the spatial layout of cities. For example, the standard monocentric city model presents an extremely useful understanding of the interactions between mobility and land development.

Integrated land use-transport planning marries the learnings of both literatures. Market forces shape cities, and urban planning and land-use regulations (LUR) have important roles to play in guiding and facilitating those forces. Public transport needs demand, and so does mass transit. Higher densities lead to demand for public transport. This is the first part of the theoretical framework used in this book.

The basic function of urban and transport planning is to allocate space for the city's road network, parks, public schools, and hospitals. Market forces cannot allocate spaces for these items because they are public goods (Bertaud, 2018). However, urban markets need information on the location of the public goods to function properly. Investors want to locate buildings by roads to benefit from the mobility they provide, which helps access opportunities in the city.

The 3-Value Framework (3V) (Ollivier et al. 2021) complemented the theoretical framework by indicating the elements of node, placemaking, and market potential values. Node value refers to potential ridership. Place value refers to the quality of the surrounding space and induces walkability. Finally, market potential value is explained by the potential to develop real estate with mixed land uses.

Transport infrastructure attracts urban development because people want to live close to the mobility they provide, since it allows access to opportunities. For the urban market to work, agents need to know the location of the future road network. Without this information, developers imagine the roads, resulting in haphazard road patterns. Urban development is increasingly informal. Cities are investing less in arterials—at least 16 m wide—which are critical for public transport. The share of 4m wide roads is increasing. These roads are unsuitable for regular buses. Mini-vans barely fit but in one direction. Reversing these trends will require improvements in municipal public finance so municipalities can afford better road networks. In addition, LUR can play a positive role.

Used properly, zoning and LUR can improve urban design and the quality of life in cities. In addition to being demand responsive, zoning and land use regulations can support public transport by mixing land uses, allowing higher densities, and promoting walking. An important example of this joined-up approach comes from Japan, where mixed land use and reasonable floor area ratios allowed by zoning are best practices for TOD. The TOD literature recommends relaxing land use regulations to allow higher density and mixed land uses around transit stations. Zoning in Japan allows these features in all zones. Housing costs are lower, allowing densification around transit stations and creating affordable housing for people who need public transport. This zoning also allows market forces to generate suitable densities before a transit line is built.

Land use regulations and urban planning are also important levers to make cities gender inclusive and not gender-blind. Women's travel patterns are different from those of men, and they have safety considerations that are not considered by standard practice. To improve women's accessibility to employment opportunities and services, planners should consider the needs and concerns of women while designing urban spaces and transport systems. To that end, gender-responsive regulations and environmental design to improve zoning, walkability, and safety perception are all important tools. Although the importance of enhancing women's travel experiences and enjoyment of the public space is clear, the evidence to quantify these tends to be limited. Hence, more data needs to be produced on the impact of land use regulations on women's mobility and accessibility. Zoning and LUR should be more frequently brought to the discussion on women's usage of public space, including transport systems and access to economic opportunities and services.

A Sandbox Model: Simulating the Impact of Land Use Regulations on Transit Ridership

The book develops a sandbox model to simulate the impacts of land use regulations on transit ridership. Public transport, to a much larger extent than private modes, depends on the surrounding built environment. Not only is density necessary to provide the scale that enables mass transit but accessing transit is a last-mile problem—typically solved by walking. Both these components,

density and walkability, can be heavily influenced by land use regulations. To test the impact of different land use regulations on transit ridership, the authors built a sandbox simulation model. The model represents a stylized city block centered around a bus stop or mass transit station entrance. It shows the number of people who are willing to walk to access the transit system and how this number changes depending on the land use regulations in place in the city block.

The model shows that public transport ridership increases with increasing plot coverage ratio and FAR and decreases with more setbacks and parking requirements. Increasing the FAR is critical, validating the emphasis the TOD literature places on this regulation. The model also showed an inverse relationship with the setback requirement. Large setback requirements generate a car-oriented pattern because they lower density and increase the distance people must walk to access the sidewalk and then walk to the transit stop. The model shows how on-the-street parking requirements occupy land that could be used for housing. Reducing these requirements will increase the housing supply. Off-the-street parking requirements reduce space for people due to the need to allocate space for cars. The nascent trend to reduce and even eliminate parking requirements is reasonable and will improve housing affordability. However, reducing and eliminating parking requirements should happen in the context of a sound parking policy that includes better pricing and incentivizes the private sector to invest in formal parking (Ardila-Gomez, Bianchi Alves, & Moody, 2021).

The sandbox model predicts that increasing or liberalizing the FAR has the largest benefit, followed by increasing the plot coverage ratio. Parking policy also matters because it takes scarce road and housing space. Proximity to arterial roads wide enough to allow public transport vehicles is critical, as shown by Barcelona's example. The desired pattern is shown in Figure ES3, which resembles Barcelona's superille plan. This pattern requires transit-friendly urban regulations throughout.

Leveling the playing field between public transport and private cars is important to incentivize public transport use and disincentivize car use. The main objective of a modern parking policy is to promote economic activity, followed by leveling the playing field to generate an adequate parking supply. Chapter 10 also discusses the interaction between the parking entrance or garage and the sidewalk. Parking garages can have good design and respect the eyes on the street principle.

TOD for Emerging Cities and Cities that Want Transit

What transport and land-use policies allow a city without transit to grow into a transit-oriented city supported by public transport and walking? This book's entry point was a 500,000-person emerging city. Emerging cities house 75 percent of the urban population. Their population will grow into the millions, particularly in Africa and Asia, where the urban population is expected to increase by over two billion people by 2050. Developing country cities are already dense, so the recommendations must preserve and enhance this advantage.

Emerging cities have public transport but no mass transit yet. This entry point required the analysis to be agnostic regarding public transport modes. The assumption is that public transport will respond to increased demand.

The book analyzed and modeled land use regulations considering the theoretical framework. On the economic side, markets ultimately determine city form. However, Land Use Regulations (LUR) play a role because they can promote urban development that supports public transport—or that locks in car dependency. LUR can limit the supply of floor space, leading to sprawl. LUR that allows supply to meet demand results in an adequate supply of built floor space, making it affordable by increasing density. Dense cities are suitable for public transport.

The analysis in this book is also from the point of view of a pedestrian, following TOD literature that correctly states that riders walk to the bus stop and metro station. This literature also says people should access most destinations by walking—analogous to the 15-minute city—hence the need for mixed land use, good sidewalks, frequent road intersections, and low setbacks. The model measures willingness to walk as a function of distance. Twenty percent of the people are willing to walk up to 300m, and another 30 percent will walk up to 500m. After this threshold, the willingness to walk plummets.

The 3V (Ollivier et al. 2021) complemented the theoretical framework by indicating the elements of node, placemaking, and market potential values and, et al. 2021) complemented the theoretical framework by indicating the elements of node, placemaking, and market potential values, showing how land use regulations (LUR) can enhance each. For instance, increasing FAR and plot coverage boosts node value by raising density.

Emerging cities that wish to grow transit-oriented, supported by public transport and walking, should craft a Transit-Oriented Development (TOD) strategy that maximizes the three values—node, placemaking, and market. This strategy will integrate transport and land use aspects (Table ES1).

LUR that require wide sidewalks, short setbacks, and mixed land use improve placemaking value and create transit-supportive spaces. Form-based codes provide additional guidance by focusing on the interaction between façades, sidewalks, and streets. LURs that enable developers to meet the demand for floor space maximize the market potential value.

The TOD strategy should include the future road network and information on the location of parks, public schools, hospitals, and community centers. The information on the future location of public goods is critical because markets need this information to work. Developers want to build by a road, not on the site of a future road. The latter scenario means authorities will have to demolish the building.

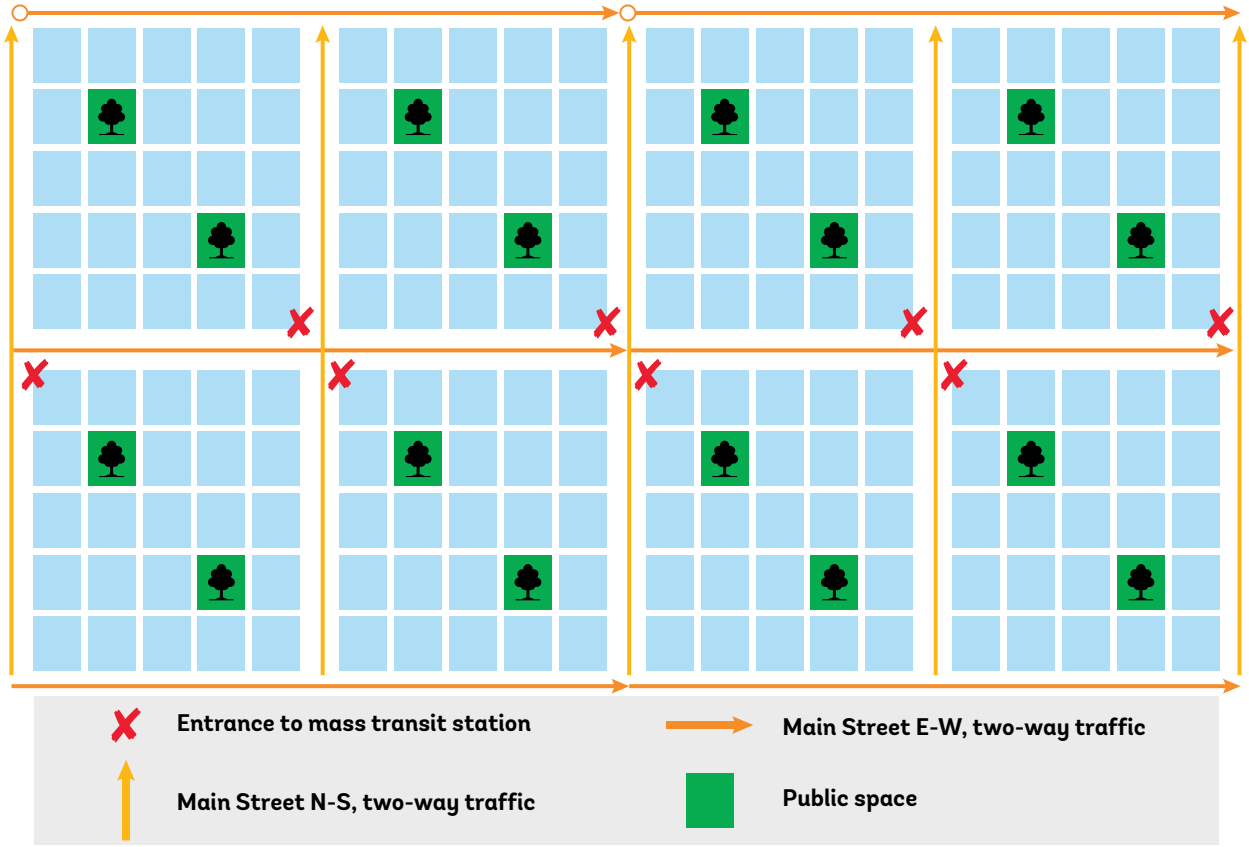
The planned road network should plan a grid with secondary roads every 100m and arterial avenues every 500m to maximize walkability and the willingness to use public transport. Arterials are critical because they allow buses to operate and can be upgraded to mass transit if demand increases (Figure ES3).

Table ES1. How LUR Maximize the Node, Place, and Market Values and their Benefits

3 Values and their definition	LUR that maximizes the values	Benefits
Node value: passenger traffic volume, intermodality	• High FAR • High Plot Coverage Ratio • Wide sidewalks • Low setback • Parking policy • No minimum plot or unit size • No maximum height	• Higher density • Higher demand for public transport • Mass transit eventually • Walkable and vibrant urban development • Shade from trees • Enhanced economic activity
Place or placemaking value: schools, plazas/ open spaces representing the urban fabric around the station.	• Allow mixed land uses • Plan that shows public goods layout: - road network with arterial and secondary roads with frequent intersections. - Parks, schools, hospitals, libraries • Wide sidewalks • Low setback • Parking policy	• Markets have the information to function efficiently • Street level floor with restaurants and shops, especially on arterials • Walkable and vibrant urban development • Day-care centers close to housing areas • Enhanced economic activity • Polycentric city
Market potential value: *demand for* residential and employment.	• Mixed land uses • High FAR • High Plot Coverage Ratio • Wide sidewalks • Low setback • Parking policy • No minimum plot or unit size • No maximum height	• Demand supply for floor space match • Developers target market segments • More formal and affordable urban development • Less or no area developed informally • Higher density that justifies public transport, eventually mass transit • Enhanced economic activity

Source: Authors.

Figure ES3. Public Transport would be more Feasible if there were Transit-friendly LURs in All Blocks



Source: Authors.

Moreover, the road network plan should consider modern approaches to extract higher capacity from an urban road—the multimodal approach shown in Figure ES4 (Global Designing Cities Initiative, 2016). Thinking about the different users of an urban road results in higher throughput. Moving people is what matters, not moving cars. Multimodal streets (MMS) also contemplate universal access and include gender considerations.

Therefore, a road grid that uses MMS is the seed that should result in a virtuous cycle. An MMS improves the travel experience for all users, including public transport vehicles. The MMS should have ample sidewalks with even and non-slip surfaces, trees for shade, benches for pedestrians to rest, and inclusive signage to favor women, men, children, the elderly, and disabled people.

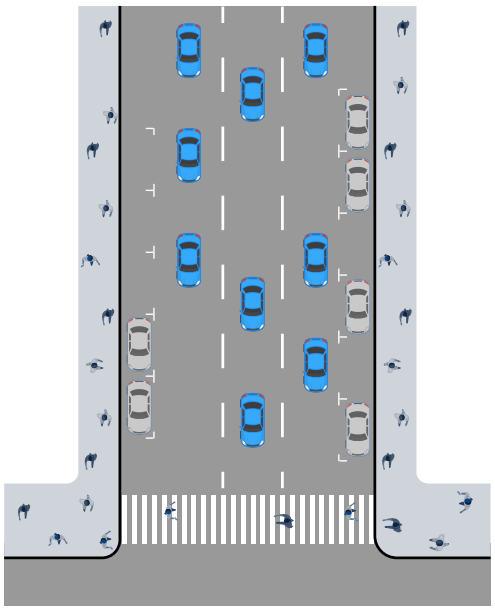
The lower travel costs will attract people who want to live closer to the improved urban road. The TOD plan will contemplate LUR that accommodates this increased demand for built space around this multimodal arterial—to maximize the market value in the 3V Framework. The proposed approach will allow developers to identify demand by segment and provide floor space accordingly. Analysis shows that the LUR that allows more built space should extend beyond the vicinity of the arterials because people are willing to walk, particularly if the density of MMS is high—about every 500 m. A compact city is more likely if the TOD plan has transit-friendly LUR throughout so that arterials—multi-modal corridors—support public transport.

As demand increases, the city can upgrade the MMS to technology with higher capacity, such as a bus rapid transit, light rail, or metro, on corridors that justify the upgrade. Curitiba and Bogota are examples of cities that started with arterials with good sidewalks that attracted people and increased density. These cities upgraded the arterials to busways and then to bus rapid transit. Compact cities occupy lower areas and require shorter mass transit networks.

Figure ES4 also shows improved parking management. A parking policy is needed to level the playing field between private car use and public transport. Private car use is subsidized. A critical subsidy is free parking. It is free to the user, not to society because cars use road capacity or park on sidewalks. A parking policy generates economic activity, promotes public transport use, and generates a supply of parking. The updated Zoning and LUR should let market forces decide how much parking to supply.

Figure ES4. Multimodal Street Example that Improves Space Allocation and Throughput

Car-Oriented Street



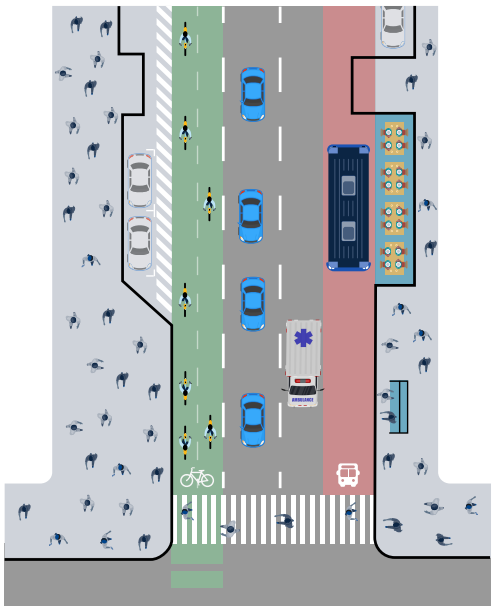
The capacity of car-oriented streets and multimodal streets. These two diagrams Illustrate the potential capacity of the same street space when designed in two different ways. In the first example, the majority of the space is allocated to personal motor vehicles, either moving or parked. Sidewalks accommodate utility poles, street light poles and street furniture narrowing the clear path to less than 3m, which reduces its capacity.

Hourly Capacity of a Car-Oriented Street

	4,500/h	x2	9,000 people/h
	1,100/h	x3	3,300 people/h
	0	x2	0 people/h

Total capacity: 12,300 people/h

Multimodal Street



In the multimodal street, the capacity of the street is increased by a more balanced allocation of space between the modes. This redistribution of space allows for a variety of non-mobility activities such as seating and resting areas, bus stops, as well as trees, planting and other green Infrastructure strategies. The Illustrations show the capacity for a 3m wide lane (or equivalent width) by different mode at peak conditions with normal operations.

Hourly Capacity of a Multimodal Street

	8,000/h	x2	16,000 people/h
	7,000/h	x1	7,000 people/h
	6,000/h	x1	6,000 people/h
	1,000/h	x1	1,100 people/h
	0	x1	0 people/h

Total capacity: 30,100 people/h[29]

Source: (Global Designing Cities Initiative, 2016).

Recommendations for Improving TOD Practice

The book has five concrete recommendations for planners to improve TOD practice:

1. **First, carry out accessibility analyses.** The parent analytical work for this book, Low-Carbon Mobility and Efficient Urban Form (P178294), developed a software tool for this purpose. Although relatively simple, the accessibility indicators can be adapted to create a variety of useful analyses to show the impact of transport investments and efficient urban form. For example, the impact of a new mass transit line can be shown as a difference in accessibility between two scenarios, one with transit available and one without. Alternatively, in a context where private motorized vehicles are primarily available to men, women in households have considerably poorer accessibility. This gap in access to opportunities can be shown as the difference in accessibility with the car mode toggled on and off.

2. **Second, measure the number of beneficiaries from transport projects.** The parent analytical work also developed the software tool to measure this indicator. The "Project Beneficiaries" indicator captures the number of people who live near new transport infrastructure projects and are likely to benefit directly from their use. It was developed as an indicator for the World Bank Corporate Scorecard that aligns with the existing rural accessibility index and is universally applicable—even in data-poor environments.

3. **Third, track housing affordability through the ratio between median income and median housing price.** The city's property tax system includes a cadastre that registers properties' characteristics, including the price or value. Planners can extract the median housing price from the cadastre. Ideally, they should track several income groups in different locations. Household surveys can indicate the median income. This indicator will show the need to change LUR to allow developers to build more housing to make it affordable again.

4. **Incorporate economic analyses as part of their integrated plans.** Understanding the market forces, which urban plans must facilitate and guide, is fundamental to developing efficient urban planning. Land use-transport interaction models, such as quantitative spatial equilibrium models, are useful tools for this purpose. Transportation infrastructure is the backbone of cities, facilitating production, trade, learning, and much more. Hence, it is crucial to quantify the wider impacts when evaluating transport projects. The parent analytical work also developed the software tool to measure this indicator.

5. **City-wide TOD to get to the Compact City:** The model showed that a compact city is possible if plans adopt city-wide LUR that promote transit, such as high FAR, plot coverage, and low setback. Adopting these LUR only around a mass transit corridor or station leads to a larger urbanized area and zones that become car-oriented. The TOD literature, therefore, should recommend relaxing LUR beyond the mass transit corridor and its stations. Market forces will concentrate urban development around the transit line because of the time savings the line generates. Yet some developers will see opportunities for densifying areas outside the 500 or 1000 m around the corridor. The result is that another mass transit corridor can be implemented in the future on a nearby corridor because it has enough demand. No area in the city should have low-density LUR because it results in a car-oriented urban development. A transit-oriented future is more likely if the entire city adopts transit-supportive LUR because, over time, densification will happen, justifying public transport and, eventually, mass transit.

A Virtuous Cycle Toward a Transit-Oriented City

Emerging cities—and cities that want to generate transit corridors—can generate a virtuous cycle toward a transit-oriented city that results in a walkable, livable, vibrant, transit-oriented, inclusive, compact, and low-carbon city.

This strategy will inform the market about where roads, parks, schools, hospitals, and all public goods will be located and integrate transport and land use considerations. The road network should have arterials every 500 m and secondary roads—some of which can be pedestrianized.

The TOD strategy should adopt LURs that maximize the node, place, and market value (Table 11.1). These LURs enable a high floor area ratio (3.0 to 4.0), high plot coverage ratio (0.6 to 0.85), low setbacks (0.5m), especially facing arterial streets and a parking policy that promotes enhanced economic activity.

LUR that limit the supply of floor space lead to economic and welfare losses, for example, by pricing out the lower income groups and by occupying more space than a compact city. The right LUR can lock in a transit-oriented future. Adopting these regulations only around arterials or transit corridors will lead to sprawl because they lock in the areas with restrictive LUR into a car-dependent future when a transit-oriented one is possible.

Mixed land uses should be allowed in all areas, like the Japanese zoning system, except for heavy industry. Market forces will materialize the mixed land uses on the arterials first because they will have public transport and more pedestrians. A polycentric city could emerge.

The arterial and secondary roads should follow Multi-Modal Street (MMS) design principles (Figure 11.1) to maximize the travel experience for all users, from pedestrians to public transport users to cars and trucks. MMS benefit all users because they should have ample sidewalks with even and non-slip surfaces, trees for shade, benches for pedestrians to rest, and inclusive signage to favor women, men, children, older people, and disabled people.

Due to mixed land use, sidewalks, and low setbacks, people can walk to many destinations and use public transport services within walking distance when they wish to access other opportunities. Public transport providers can increase their services. Mass transit can materialize on high-demand corridors that pass the cost-benefit analysis, plus environmental and social criteria.

By allowing mixed land uses, the 15-minute city is possible for many aspects of life, such as education for children, shopping, leisure, and recreation. However, public transport is needed for the labor market to work. Some people will find jobs within the 15-walking area; most will need public transport to access the jobs they want. The resulting urban development locks in a transit-oriented pattern (Figure 11.4).

Finally, the sidewalks along the road network will future-proof the expansion area for emerging cities. This research used an average walking speed of 3.7 km per hour. As people age, they walk slower. The sidewalks, coupled with mixed land uses, will allow older people to walk to most services they need.

People who walk —and who use public transport—have lower weight and better health than car users. Emerging cities can grow healthily by adopting LUR that maximize the node, place, and market values that allow people to walk to many destinations and use public transport to access opportunities beyond their neighborhoods—the virtuous cycle.

The 15-Minute City

Drive transit-oriented development in emerging cities through efficient land use and transport policies

By 2050, 70 percent of the world's population will live in cities. Imagine a future where these urban centers are designed for accessible living. They prioritize pedestrians, public transit, and policies that promote efficient land use and modes of transport. The resulting multimodal streets encourage urban living where job opportunities, education, recreation, and lifestyle needs are all within a 15-minute radius.

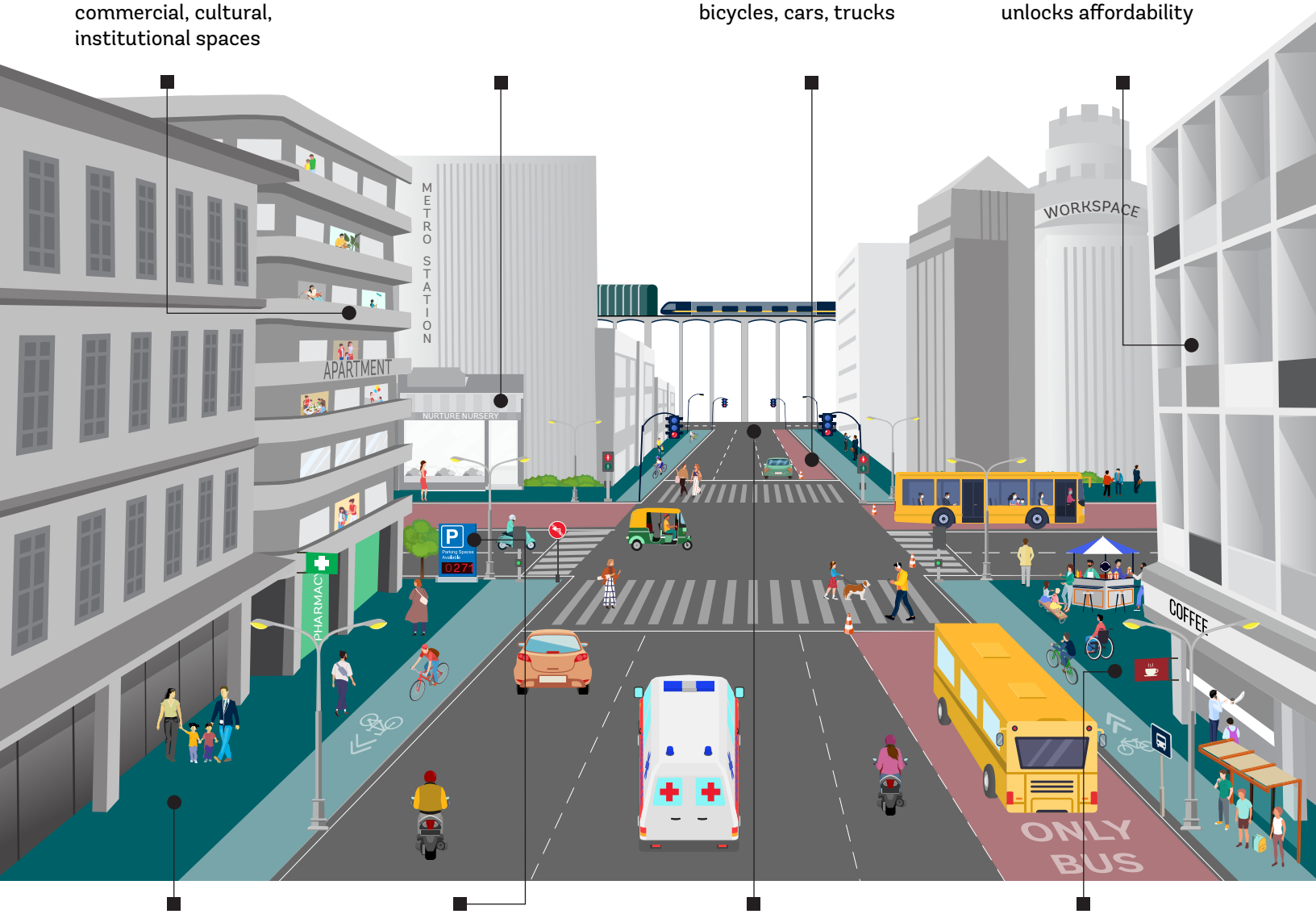
Efficient Corridor and Intersection Design enables safe and optimal flows for all users

Mixed Land Use
to combine residential, commercial, cultural, institutional spaces

High Floor Area Ratio
promotes densification

Multimodal Streets
for pedestrians, buses, bicycles, cars, trucks

High Plot Coverage Ratio
promotes density and unlocks affordability



Lower Setbacks
promote walkability and improve pedestrian safety

Parking Policies
promote economic activity

Arterial Roads
every 500 meters promote urban development and mobility

Wider Sidewalks
from 1.5 meters to 10 meters enable two wheelchairs in parallel

Policy Key: Enable land use regulations (LUR) to unlock the **virtuous cycle** for emerging cities to maximize opportunities for citizens through transit, walking, and biking.

1

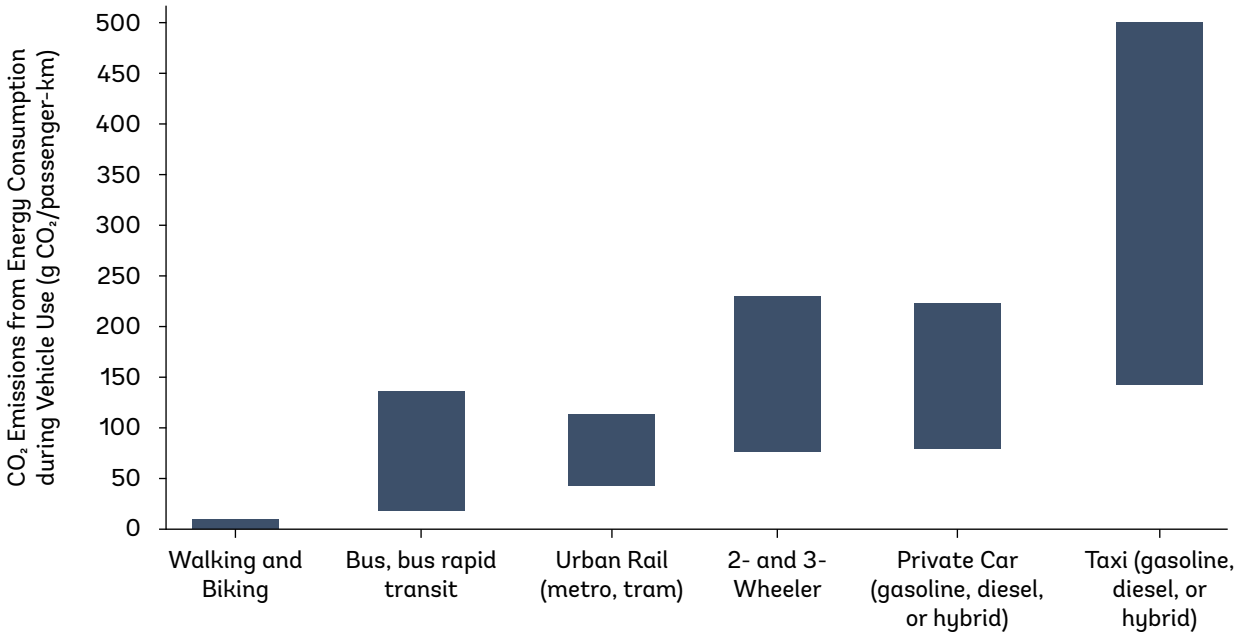
Introduction

Understand the fundamental elements that can be combined to create the 15-minute city. This includes a deep dive into the specifics of land use and transport regulations, and how they impact urban expansion in developing cities. This chapter also defines the problem statement that this book intends to address: What are the transport and land-use policies that allow emerging cities without existing mass transit to develop into transit-oriented cities supported by low-carbon modes?

Cities account for more than 50 percent of the world's population and 80 percent of its economic output (International Energy Agency, 2021). The concentration of people in cities is expected to continue through 2050, at which point an estimated 70 percent of the world's population will reside in cities. Between 2020 and 2050, 2.3 billion people will be added to urban areas, and 90 percent of this increase will take place in Asia and Africa (UNDESA, 2018). Considering this rapid urbanization, a common pitfall is to focus only on the challenges faced by the world's megacities. This focus neglects the many growing small and mid-sized cities. Notably, about 75 percent of the world's urban population live in settlements of less than 500,000 people (Cities Alliance, 2019).

Cities and urban transport are also increasingly critical frontiers for climate action. More than 70 percent of global carbon dioxide emissions come from cities, making their mitigation efforts an important contributor to decarbonization. Urban transport is a significant contributor to climate-warming greenhouse gas (GHG) emissions in cities, with most urban transport emissions coming from cars. Cars and low-occupancy taxis (including ride-hailing and other newer service models) are carbon-inefficient per passenger-km served (Figure 1.1). Car-centered transport systems are also a significant driver of sprawling, low-density settlement configurations that displace natural carbon sinks. Managing motorization and encouraging the use of more carbon-efficient modes such as walking, biking, and public transport is fundamental to a low-carbon development trajectory while supporting sustainable development goals for livable cities, social inclusion, clean air, and road safety.

Figure 1.1 Relative Carbon Efficiency of Urban Passenger Transport Modes

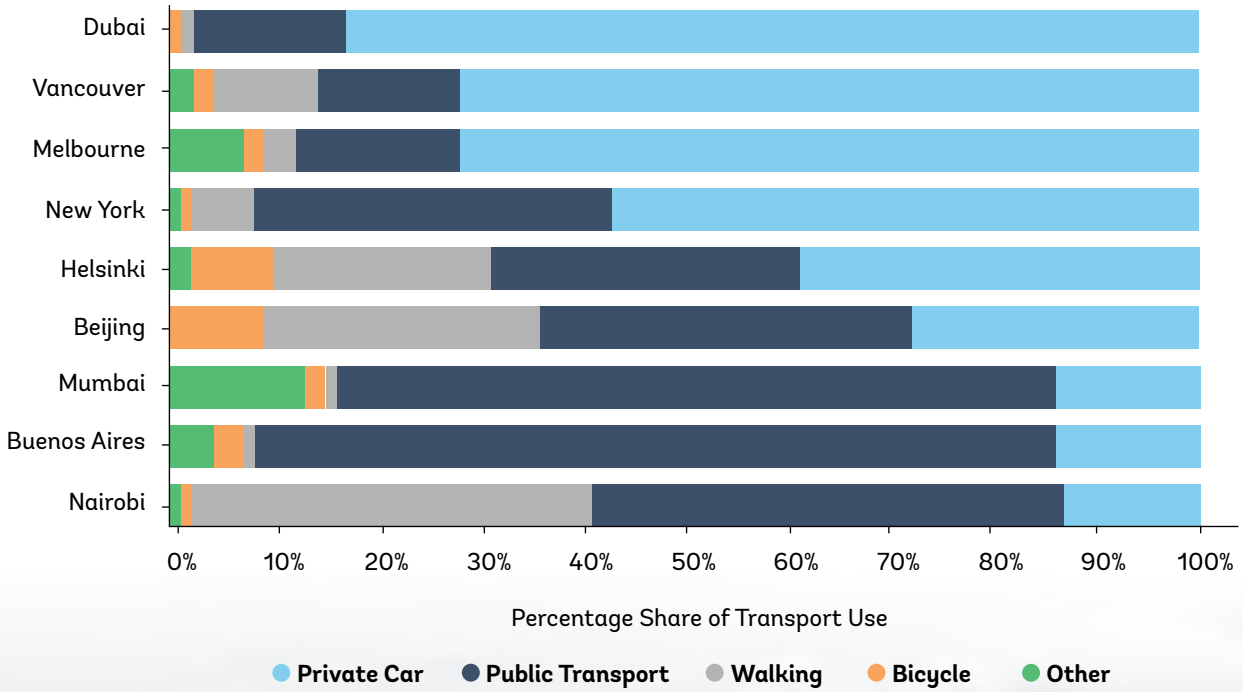


Source: Adapted from Figure 8.6 (Sims, et al., 2014). Note: Ranges provide an indication of CO_2 emissions from fuel combustion (and electricity in the case of urban rail). They exclude emissions arising from vehicle manufacture, infrastructure, and other sources of emissions included in lifecycle analyses.

1.1 Background: Land Use and Transport in Developing Cities

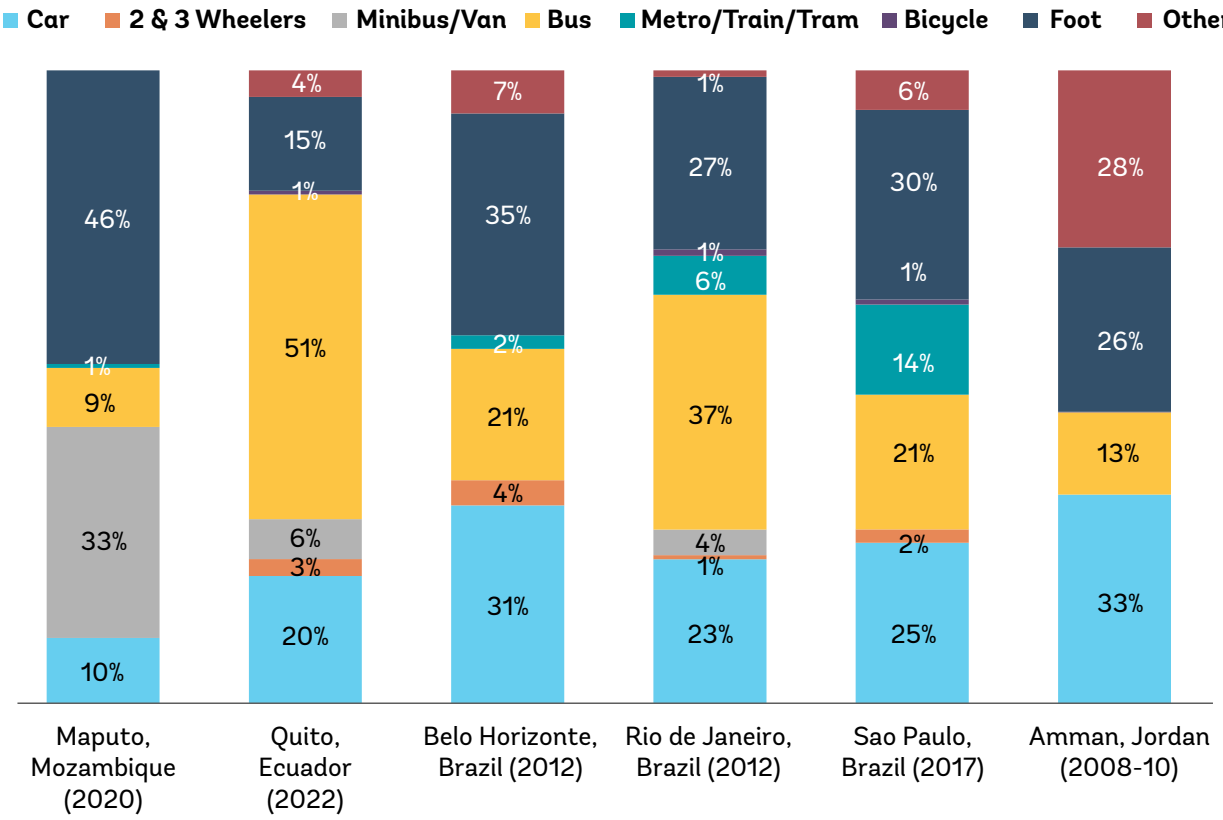
Many cities in the developing world already have many elements of low-carbon passenger mobility. These include large modal shares of travel by public and active modes, low ownership and use of private cars, and high densities. Compared to cities in developed economies, more people walk, bike, or take public transport—formal or informal—and only a minority travel by car or motorcycle (Figures 1.2 and 1.3). Generally, motorization rates are still low or moderate. Indeed, developing countries currently have motorization rates that are four to eight times lower than developed countries (International Organization of Motor Vehicle Manufacturers, OICA, 2015).

Figure 1.2 Modal Split of Passenger Transport in Selected Cities in Developed and Developing Countries



Source: Statista https://www.statista.com/statistics/1010740/passenger-transport-mode-selected-cities/

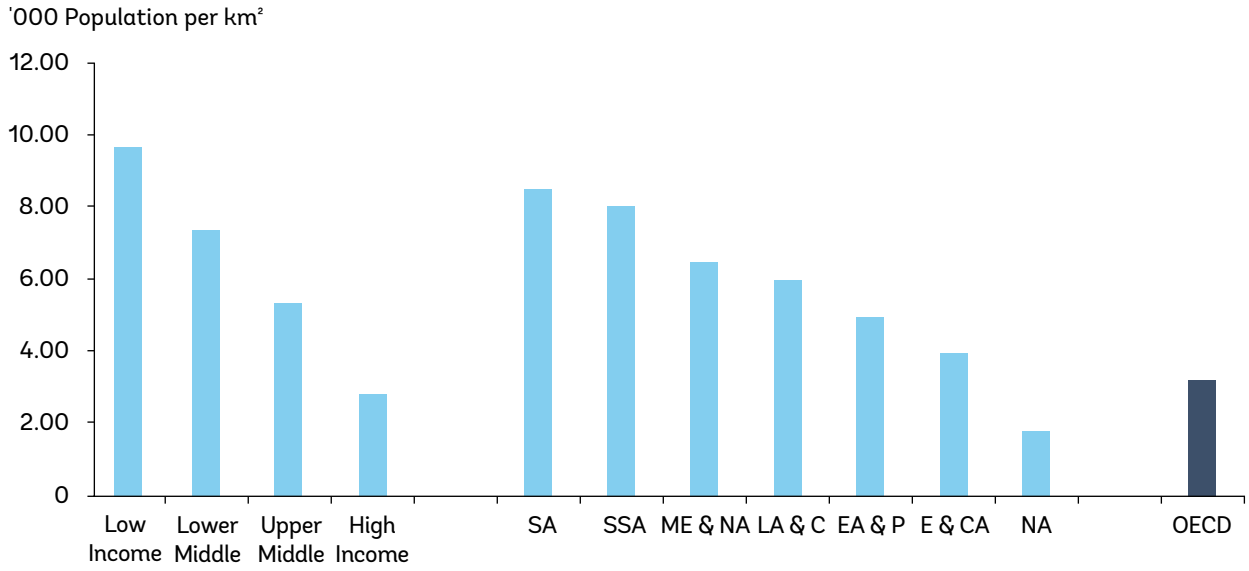
Figure 1.3 Modal Split in Select Cities in Developing Countries



Source: (Bianchi Alves, Bou Mjahed, & Moody, 2023).

Another advantage of cities in developing countries is their density. Demand for space tends to increase with income levels, resulting in an inverse relationship between density and income, as shown in Figure 1.4 (OECD, 2020). Many informal settlements can be extremely crowded, with densities surpassing 60,000 inhabitants per km^2 (Kit, Ludeke, & Reckien, 2013). A lower density already supports public transport, walking, and biking.

Figure 1.4 The Population Density in Cities by Country Income Class and Region, 2015



Source: (OECD, 2020).
NA: North America, ME & NA: The Middle East and North Africa, LA & C: Latin America and the Caribbean, E & CA: Europe and Central Asia, EA & P: East Asia and Pacific, SA: South Asia, SSA: Sub-Saharan Africa.

Capitalizing on these advantages requires investment in infrastructure and sensible space management. Otherwise, many emerging cities are on a trajectory toward extreme urban crowding without deriving the benefits of urban accessibility. Despite land use patterns and apparent travel behavior that are supportive of transit-oriented development, only some cities in developing countries have yet to be unequivocally successful in building on these advantages.

Consequently, maintaining this low-carbon footprint requires improving public transport, sidewalks, and bike lanes, as well as preserving and managing urban density while improving urban design, including the quality of the streetscape and the built-up space. See Box 1.1 for key definitions used in this book. Improving mobility allows the population to access jobs, education, and health opportunities in less time. Efficient and reliable public transport is therefore critical to making cities work. Mobility brings together supply and demand for labor, making the urban labor market work efficiently to the benefit of employees and employers (Bertaud, 2018).

Box 1.1 Key Terms Defined

Built environment: "…The human-made environment that provides the setting for human activity, including homes, buildings, zoning, streets, sidewalks, open spaces, transportation options, and more. It is defined as 'the human-made space in which people live, work, and recreate on a day-to-day basis.'" Source: https://en.wikipedia.org/wiki/Built_environment

Built-up area: The houses and buildings used for housing, commercial, and industrial activities. 'Floor space' is a similar term. See (Lall S., Lebrand, Sturm, & Venables, 2021)

Streetscape: "…Urban roadway design and conditions as they impact street users and nearby residents. Streetscaping recognizes that streets are places where people engage in various activities, including but not limited to motor vehicle travel. *Streetscaping* (programs to improve streetscape conditions) can include changes to the road cross-section, traffic management, sidewalk conditions, landscaping (particularly tree cover), street furniture (utility poles, benches, garbage cans, etc.), building fronts, and materials specifications. It also involves improving signage". Source: TDM Encyclopedia https://www.vtpi.org/tdm/tdm122.htm

However, transportation and land use plans are often formulated independently. The lack of coherence contributes to inefficient cities (Suzuki, Cervero, & Iuchi, 2013). Housing areas lie far away from employment centers, resulting in radial travel patterns. Because of the high congestion level that disproportionately affects public transport, travel times for the majority can be long. In some cities, urban expansion happens in a scattered pattern with big gaps between the built-up area and the new developments. Public housing projects are frequently located in these remote areas. Other areas adjoin the main urbanized area, but areas with jobs are distant.

The two dominant strands of thinking to address these problems are the urban economics literature, which advocates a market-based approach, and the Transit-Oriented Development (TOD) literature, which promotes land use planning around transit infrastructure. The urban economics literature finds that markets determine city density and uses. This literature builds on the monocentric model, which predicts the observed urban form well because downtown has a higher density. Density and building height drop as the distance from downtown increases because people trade commuting time for land. The land is more expensive downtown and cheaper in residential areas (Bertaud & Malpezzi, 2003), (Glaeser, 2011), (Bertaud, 2018), (DiPasquale & Wheaton, 1996), (Blair, 1995). This literature also shows that transport improvements can generate urban development around them—the idea is explained in the next chapter. This literature recognizes that land use regulations (LUR) can price out lower income groups but does not explicitly recognize the role LUR has in promoting urban development that supports public transport—or that locks in car dependency.

The TOD literature, in contrast, recommends planning to generate a "compact, mixed-use, pedestrian-friendly 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" (Suzuki, Cervero, & Iuchi, 2013). Further, "TOD is a planning and design strategy that focuses on creating urban development patterns which facilitate the use of public transit, walking and cycling, as primary modes of transport and which supports vibrant,

diverse, and livable communities. This is achieved by concentrating urban densities, communities, and activities within a 5–10-minute walking distance from mass rapid transit stations (high-capacity bus or rail), developing quality urban space, and providing convenient and efficient access to a diverse mix of land uses" (Ollivier G. , Ghate, Bankim, & Mehta, 2021).

A third definition emphasizes these points: TOD "means integrated urban places designed to bring people, activities, buildings, and public space together, with easy walking and cycling connection between them and near-excellent transit service to the rest of the city" (ITDP, 2017). Finally, "Transit-oriented development (TOD) has emerged as a concept to describe the coordination of land development with investments in mass transit. This integrated approach is mutually beneficial because certain patterns of land development increase the demand and the attractiveness of sustainable travel options in which mass transit is included, along with pedestrian and bicycle modes. Simultaneously, mass transit supports urban development that is compact and dense" (Rodriguez, 2021).

In sum, the TOD literature explains what should be done around transit stations for existing or planned transit lines. Recommendations include improving sidewalks and public space, increasing the floor area ratio to increase density, and promoting mixed land uses (Ollivier G. , Ghate, Bankim, & Mehta, 2021)

These recommendations apply to cities without mass transit that are planning mass transit lines (Ardila-Gomez, Bianchi Alves, & Moody, 2021). The TOD literature, however, could pay more attention to urban economics and price signals. As seen, urban economics states that urban plans play little role because markets determine densities and city form. Bertaud (2018), an urban economist, summarizes the situation: "Planners use TOD to increase FAR around transit stations. If FAR had not been regulated around stations in the first place, they would have reached the level corresponding to demand in these areas. TOD is a good example of the arbitrariness that characterizes modern land use planning: a new regulation to correct the effect of an older regulation to obtain the exact outcome that would have been achieved if the first regulation had not existed." Still, transit lines are built on alignments that justify the investment because of demand, which is caused by high density.

1.2 Problem Statement

This book attempts to bridge the urban economics and TOD bodies of literature because each contributes to answering the question: What are the transport and land-use policies that allow emerging cities without existing mass transit to develop into transit-oriented cities supported by low-carbon modes?

The entry point is emerging cities—where 75 percent of the urban population lives—that aspire to grow, having corridors that support public transport and even mass transit. Emerging cities typically refer to urban areas that are in the process of rapid growth and development. They have around half a million people and are often located close to rural populations. These cities are often characterized by increasing population and expanding economic activities and are undergoing social, economic, and physical transformations. They may be experiencing a transition from rural to urban economies.

Emerging cities are usually in the developing world but can also be found in developed countries where new areas are urbanizing. They are often seen as having the potential to become major economic and cultural centers in the future if they continue their growth trajectory (Paller, Kherigi, Lust, Bob-Milliar, & Post, 2024).

The book is agnostic regarding public transport modes. Emerging cities in developing countries might have formal or informal public transport, but they could still need mass transit as their population increase. As the cities grow with the correct pattern, public transport will respond to the demand. If demand is higher, public transport operators will increase their fleets to provide frequent service. If demand is high, plans can justify mass transit lines—cost-benefit analysis, for example. The book focuses on cities in the developing world.

The book uses a theoretical framework based on urban economics and the TOD literature. On the urban economics side, the framework uses the Standard Urban Model: urban density decreases as distance from downtown increases as a function of transport costs and other urban economics insights. On the TOD side, it uses the 3V. "The 3-V Framework is a methodology for identifying economic opportunities in areas around mass transit stations and optimizing them through the interplay between the node, place, and market potential values. It provides a typology to cluster stations based on the three values. It equips policy and decision-makers with quantified indicators to better understand the interplay between the economic vision for the city, its land use, its mass transit network, and its stations' urban qualities and market vibrancy" (Ollivier G., Ghate, Bankim, & Mehta, 2021). The book uses examples from the developed and developing world.

The book also uses an innovative stylized model to understand how land use regulations promote—or hinder—public transport and walking. The model shows the interplay between LUR and offers recommendations. The stylized model has no prices, but urban economic insights are necessary to interpret the results.

In sum, this book seeks to help planners understand how urban economics complements and improves the recommendations in the TOD literature to allow a city without transit to grow into a transit-oriented city that relies on public transport and walking. It is organized in two parts. The first part discusses public transport, land use regulations, and planning for future transit-supportive urban development. The appendix presents a detailed description of the critical land-use regulations. The objective is to help transport practitioners understand these regulations and their impacts so they can discuss them with their counterparts to improve land use planning to lead to a walkable and transit-oriented future.

2

Theoretical Framework: Urban and Transport Economics and the 3-Value Approach

An explanation of the theoretical framework used in this book. It blends insights from urban and transport economics with TOD literature and answers these questions. What is the fundamental approach in urban economics to understanding cities with insights from transport economics? How are these parameters linked to the 3-Value approach to promote transit-oriented development? And what does this mean for impactful development in emerging cities?

2.1 The Standard Urban Economics Model

The standard model represents the city as a circle located on a plain, with a central business district (CBD) that concentrates all jobs—a monocentric city—and a transport system that generates costs for the traveler (Bertaud, 2018). Commuting travel costs are lower the closer a worker resides to the CBD. Conversely, their willingness to pay to reside close to the CBD is commensurately higher. Consequently, rents are the highest in the CBD at the center of the circle and decrease with distance (and travel cost) to the CBD. People make a trade-off between travel costs to the CBD and their rents (Bertaud, 2018), (Jaramillo-Gonzalez, 2009), (Glaeser, 2011).

Additionally, in the CBD, where rents are high, people consume less housing, resulting in higher densities. Equation (1) presents the standard urban economics model based on (Wheaton, 2008) and (DiPasquale & Wheaton, 1996). This section explains the equation in detail, showing its predictions and usefulness. Here is an explanation of the term in the model that bridges the urban economics literature and the TOD literature via the LUR.

Equation (1) $$R(d) = R(a) + c + k(b - d)$$

Where:

R(d) is the rent for urban land located a distance d from the CBD.

R(a) is the agricultural rent or opportunity cost of urbanizing agricultural land.

c is the cost of constructing buildings, assumed constant for all building types.

k is the average commuting cost per unit of distance traveled.

b is the city's radius or frontier, where the urbanized area ends and agricultural land begins.

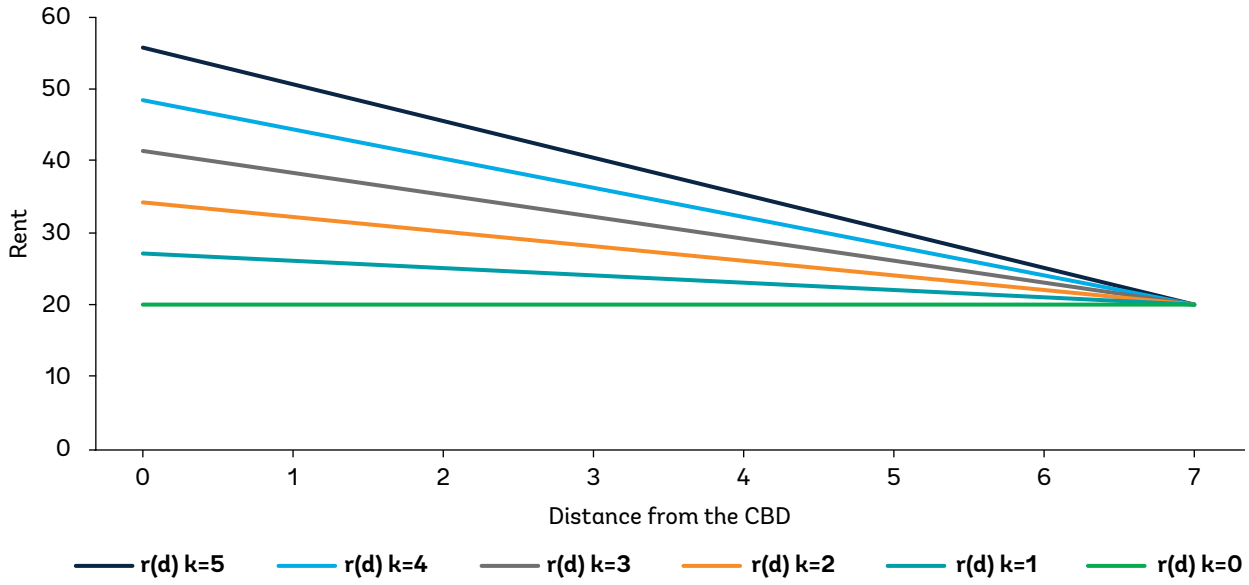
This equation slopes negatively with respect to distance (d) from downtown at a rate equal to k, the unit transport cost. Figure 2.1 shows the rent profile when k changes from 5 to zero. The other parameters remain constant, including the location of the city frontier, b. The section below explains the model's expression for b. Higher values of k mean walking or high congestion for buses and trucks. Transport projects reduce the value of k. The urban rent is lower at the same distance from the CBD for a given city extent, b.

The same line of reasoning applies at a local rather than city-wide scale. Transport projects reduce travel costs and attract activity around them. This insight is behind the cost-benefit analysis of transport projects, explained in the next section. It is also the reason TOD argues that mass transit projects will generate higher demand for land around the stations, thus justifying higher-density LUR. When transport costs are zero (k=0), people telework. Their rent is agricultural rent plus the construction cost—the same value as if they were in the city's frontier because of the term (b-d=0). The model correctly predicts, moreover, that teleworkers can live anywhere in the city—they must pay for internet access instead.

Property prices are the net present value of the rent at the location in question, including the construction cost. Land prices are the net present value of the rent minus the construction cost. Figure 2.2 shows how urban rents vary as a function of b, the frontier. The transport cost is constant at k=2.

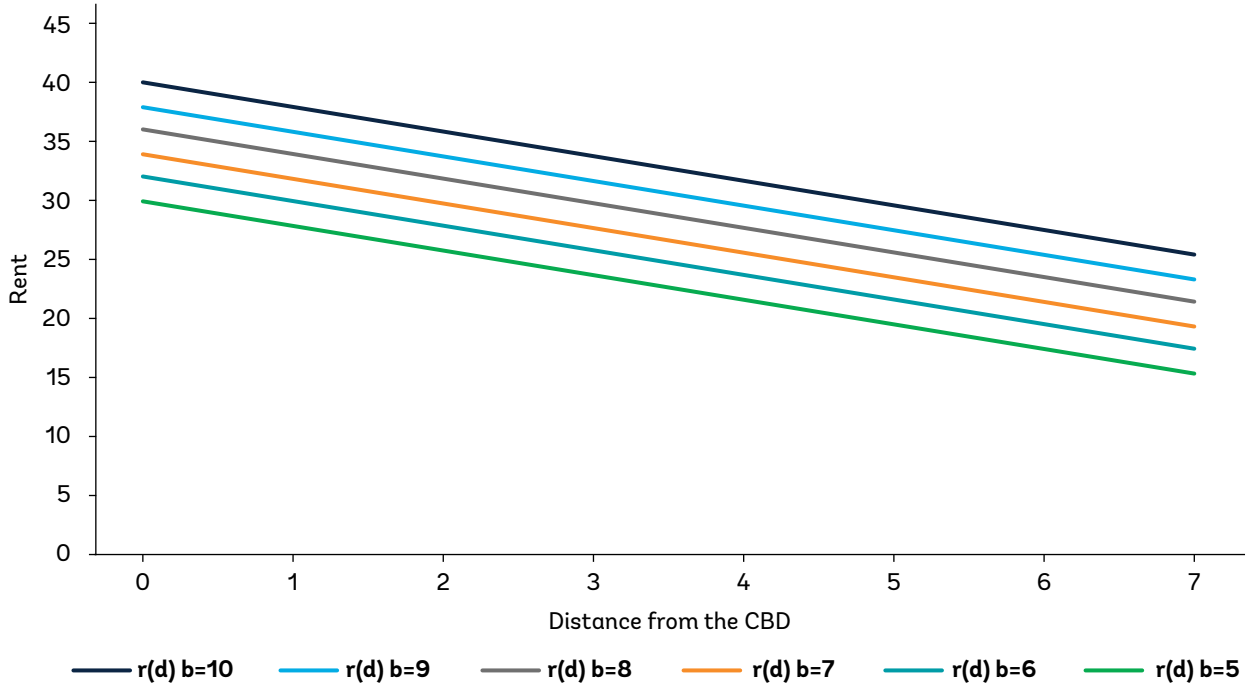
Larger cities have higher rents than smaller ones because the commuting costs are higher. Because higher rents translate into higher densities, larger cities have more high-rise buildings in the CBD than smaller cities.

Figure 2.1 Urban Rent Profiles as Function of Travel Costs (k)



Source: Based on equation (1).

Figure 2.2 Urban Rent Profiles as a Function of City Radius, b. Transport Cost Constant



Source: Based on equation (1).

The model predicts that the city will extend until the rent equals the agricultural rent. However, land is finite within the city frontier, but it can be used more intensely. Equation (2) captures this insight by expressing the city's radius, b, as a function of the number of households (N), average lot size (q), and the fraction of the land available for urban development (V). Each household occupies one lot. The square root appears because the city is a circle with an area of πb^2.

Equation (2) $b=\sqrt{[Nq/\pi V]}$

Equation (2) links the economic model for urban rent with LUR because b is a parameter in Equation (1). First, the LUR can demand a large lot size, increasing the radius and area needed to house the same population. Second, cities need public goods such as roads, parks, schools, hospitals, libraries, and utility buildings that occupy land, thus reducing the value of V. LUR can also reduce the value of V by mandating front yards and backyards, for example. The lower the land available for housing and jobs, the larger the city radius and area. More importantly, increasing b (for fixed k) increases rent. In turn, those who cannot afford the higher rents will be displaced to informal settlements—that do not adhere to the LUR (World Bank, 2020).

Equation (2), therefore, links urban economics and urban planning via the LUR. Urban planning can use the LUR to allow more people to live close to transit stations, for example. If a segment of the population prefers living close to the transit station, then they will demand floor space close to the metro station. Developers will build it because the LUR allows it. On the other hand, if a market segment prefers to live away from the metro, then they will live in another neighborhood. The market always determines the outcomes, but urban planning plays a role, as this book explains.

2.2 Transport Economics and Cost-Benefit Analysis

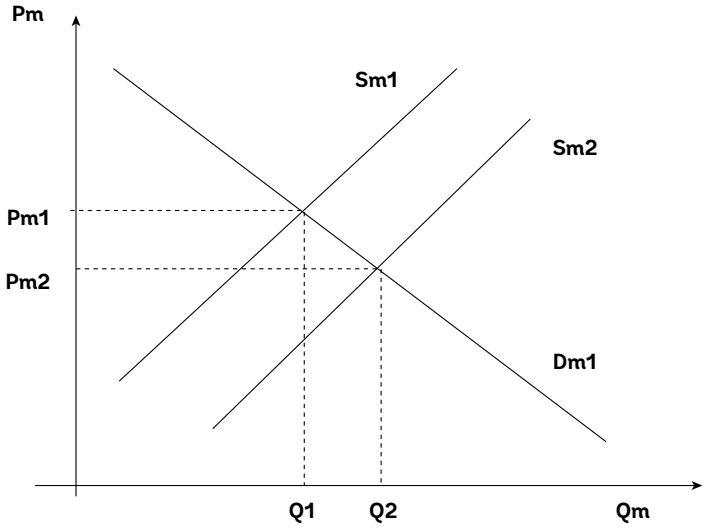
Transport projects, such as a metro line, supply additional mobility and reduce the cost of traveling. In economic terms, transport projects expand the supply of mobility services. If the benefits are larger than the costs, the project is justified. Figure 2.3 uses standard economic theory applied to a transport project that expanded the supply of mobility services. The vertical axis represents prices and the horizontal one quantity, like trips per day. The curve Sm1 is the without project supply, and Sm2 is the supply with the mobility project operational. Dm1 is the demand for mobility services.

The project's benefits are reducing the cost of traveling from P1 to P2 and increasing the amount traveled from Qm1 to Qm2. A metro line significantly expands the capacity to travel. The metro will also save time for its users—part of the price reduction in Figure 2.3. The metro will also attract some car users who do not incur the cost of traveling by car. The metro project has other benefits that, added up, represent the change from Pm1 to Pm2. The difference of Pm1 minus Pm2 is the change in the transport cost, k, in the urban economics model.

The transport project's benefits attract people who want to live close to its stations—this is the economic foundation of TOD because people demand more floor space near the metro. Figure 2.4 shows the mobility project's economic impact on the real estate market by representing the demand and supply for floor space. The initial demand is Dfs1, and the initial supply is Sfs1. The mobility project draws interest, shifting the demand for floor space to the curve Dfs2. People are willing to pay

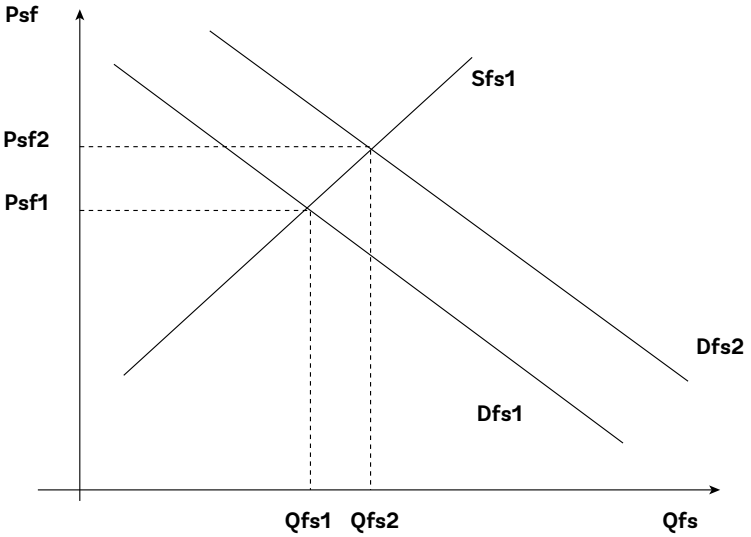
more to live close to the metro. This willingness is the difference between Psf2 and Psf1. The critical assumption is that the floor space supply can increase to meet the additional demand. In this case, the cost-benefit for the mobility project could be done using the information in Figure 2.4. The change in prices and quantities will result in the same benefits as the ones in Figure 2.3. Market forces capitalize the mobility benefits into the floor space prices—provided real estate developers can build more floor space. The cost-benefit analysis can count only once as the project's benefits.

Figure 2.3 The Economic Impact of a Transport Project that Expanded the Supply of Mobility



Source: Authors.

Figure 2.4 The Economic Impact of a Transport Project on the Real Estate Market



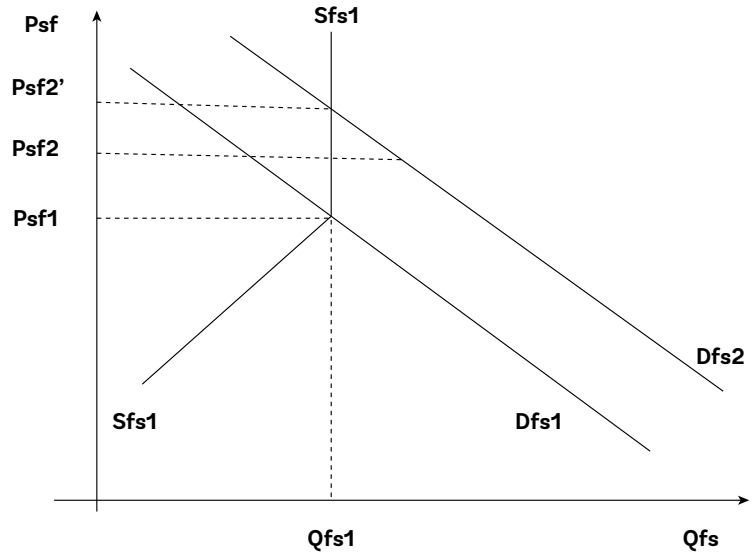
Source: Authors.

What happens if the supply of floor space cannot increase? Assume that the LURs do not allow developers to build additional floor space. This means Qsf1 is the maximum floor space allowed. The supply cannot increase, no matter the price. The supply curve becomes vertical at Qfs1 (Figure 2.5). The price increases to Psf2', which is higher than when the floor space supply could increase, Psf2.

In this case, consumers must pay a high price for living close to the mobility project. This price increase should guide planners in correcting the situation by relaxing the LUR to allow developers to build additional floor space. Absent this change in LUR, the area will gentrify because wealthier people can afford to live close to the mobility project. In extreme cases, these people travel by car because of their high income and do not use the metro. The metro users were priced out. Alternatively, property owners can rent out rooms in their apartments. (Bertaud, 2018) describes nine and 11 square meter units in Paris, where the supply of floor space cannot increase, selling for US$17,945 per square meter, compared to US$1,944 in downtown Chicago for a one-bedroom apartment. Density increases in this case because of the smaller unit size. Sometimes, city authorities set minimum areas for the unit's size, aggravating the gentrification. To prevent gentrification, the solution is to increase the allowed floor area developers can legally build by adopting generous LUR.

(Bertaud, 2018) states, "Regulations may decrease the total area of floor space that can be built on a given area of land. These types of regulations would, of course, change the price and density profiles that the standard urban model would project for unconstrained markets. For instance, regulations routinely restrict the heights of buildings or impose a maximum limit on the number of dwelling units that can be built per hectare. If these regulations are binding—that is, if the regulations reduce the number of dwellings that developers would have built to respond to consumer preferences for these areas—then the regulations will create a shortage of floor space in areas of high demand".

Figure 2.5 The Economic Impact of a Transport Project on a Supply-constrained Real Estate Market



Source: Authors.

2.3 The 3-Value Framework

The link via Equation (2) between the economic model of an urban area and land use regulations suggests that urban and transport planning play a role. LUR can help create a dense city with diverse land uses suitable for public transport—or induce a car-oriented pattern. The authors of the 3V explain that it is a methodology that "considers the node, place, and market potential value of each station. The 3V Framework outlines a typology to facilitate TOD implementation at the metropolitan and urban scale in various contexts as part of a methodology that aims to:

- Identify the economic development potential of different transit corridors and different areas around mass transit stations in terms of type, scale, and timing, considering the level of connectivity and market demand through quantified indicators
- Develop planning and implementation measures and prioritize limited public resources to create such value through coordinated interagency measures
- Develop and communicate with residents, government agencies, and private developers a vision for the city that articulates development around its mass transit network

By doing so, the 3V Framework can facilitate an alignment of TOD strategies at the metropolitan, city, network, and local levels" (Salat & Ollivier, 2016).

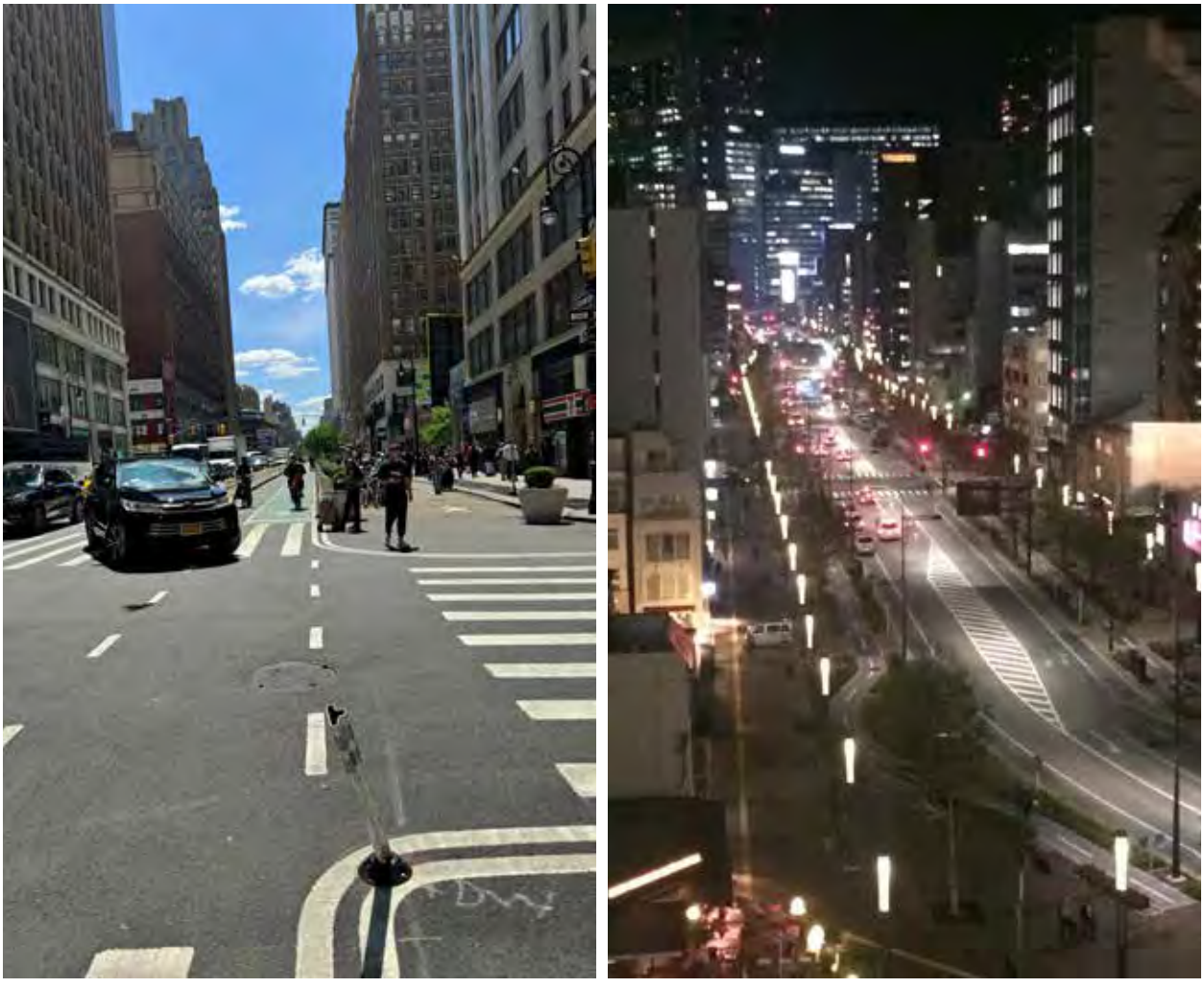
The 3 values are node, place, and market potential. (Ollivier G. , Ghate, Bankim, & Mehta, 2021)

- "**Node** value describes the importance of a station in the public transit network based on its passenger traffic volume, intermodality, and centrality within."
- "**Place** or placemaking value describes the urban quality of a place and its attractiveness in terms of amenities, including schools, plazas/open spaces representing the urban fabric around the station."
- "**Market potential** value refers to the unrealized market value of station areas. It is derived through market analysis measured by analyzing major drivers of *demand*, including current and future human densities (residential plus employment)."

Daily ridership is a critical indicator of node value. LURs that promote public transport demand will increase the node's value. Critical indicators for place value are walkability around the station, and mixed land uses that allow housing, commercial, office, schools, and hospital uses in the area near the station. LURs that segregate land uses will lower the place value. The market potential value is measured by indicators such as residential and employment density growth potential and average personal income. Another indicator of the market potential value is the number of jobs accessible by public transport from that point. LURs that allow developers to build buildings that increase density will increase the market value (Figure 2.6).

The market potential value should be linked to economic models, such as the one explained in the previous section, because it predicts prices. These models can consider an entire city, even a polycentric one.

Figure 2.6 High-density Urban Development in Manhattan and Tokyo



Source: Arturo Ardila-Gomez.

Box 2.1 Markets Need Information to Work: Roads, Parks, and Public Goods

The analysis validates that urban and transport planning's basic function is to allocate space for the city's road network, parks, public schools, and hospitals. Market forces cannot allocate spaces for these items because they are public goods (Bertaud, 2018). However, urban markets need information on the location of the public goods to function properly. Investors want to locate buildings by roads to benefit from the mobility they provide, which helps access opportunities in the city.

An example of this approach is the Commissioners Plan in New York City in 1811. This plan defined the rectangular grid for Manhattan, which still exists today, including parks (Wikipedia, 2024). Chicago, which, in 1834, had only 1800 inhabitants, generated an extensive road plan with arterials and local roads plus alleys that split some blocks (Encyclopedia of Chicago, 2005). Chicago has the best-organized grid in the world (Geoff, 2019) (The Economist, 2022). Chicago also allocated space for public schools. In 1860, Barcelona adopted the Plan Cerda, which defined the road network. The plan had 20-, 30- and 60-meter-wide streets (Wikipedia, 2024). Washington D.C.'s initial urban design, conceived by Pierre L'Enfant, features avenues stemming from rectangular spaces, enabling both open areas and aesthetic landscaping. Influences for this design were drawn from L'Enfant's collection of European city plans, including notable cities like Amsterdam, Paris and Aranjuez. The design boasted a proposed grand avenue, now known as the National Mall, framed by natural boundaries including the Anacostia and Potomac Rivers and Rock Creek (Wikipedia, 2024). Figure 2.6 shows the road plans for these cities: New York City, Chicago, Barcelona, and Washington D.C.

Box 2.1 Markets Need Information to Work (cont.)

Figure 2.7. Road Plans of New York City, Chicago, Barcelona, and Washington D.C.

New York

Chicago

Barcelona

Washington DC

Sources: Wikipedia, Commissioner's' Plan of 1811, 2024; Encyclopedia of Chicago, 2005, Wikipedia, The Cerda Plan, 2024 and (Wikipedia, 2024), Sources: (Wikipedia, 2024), (Encyclopedia of Chicago, 2005), (Wikipedia , 2024), (Wikipedia, 2024).

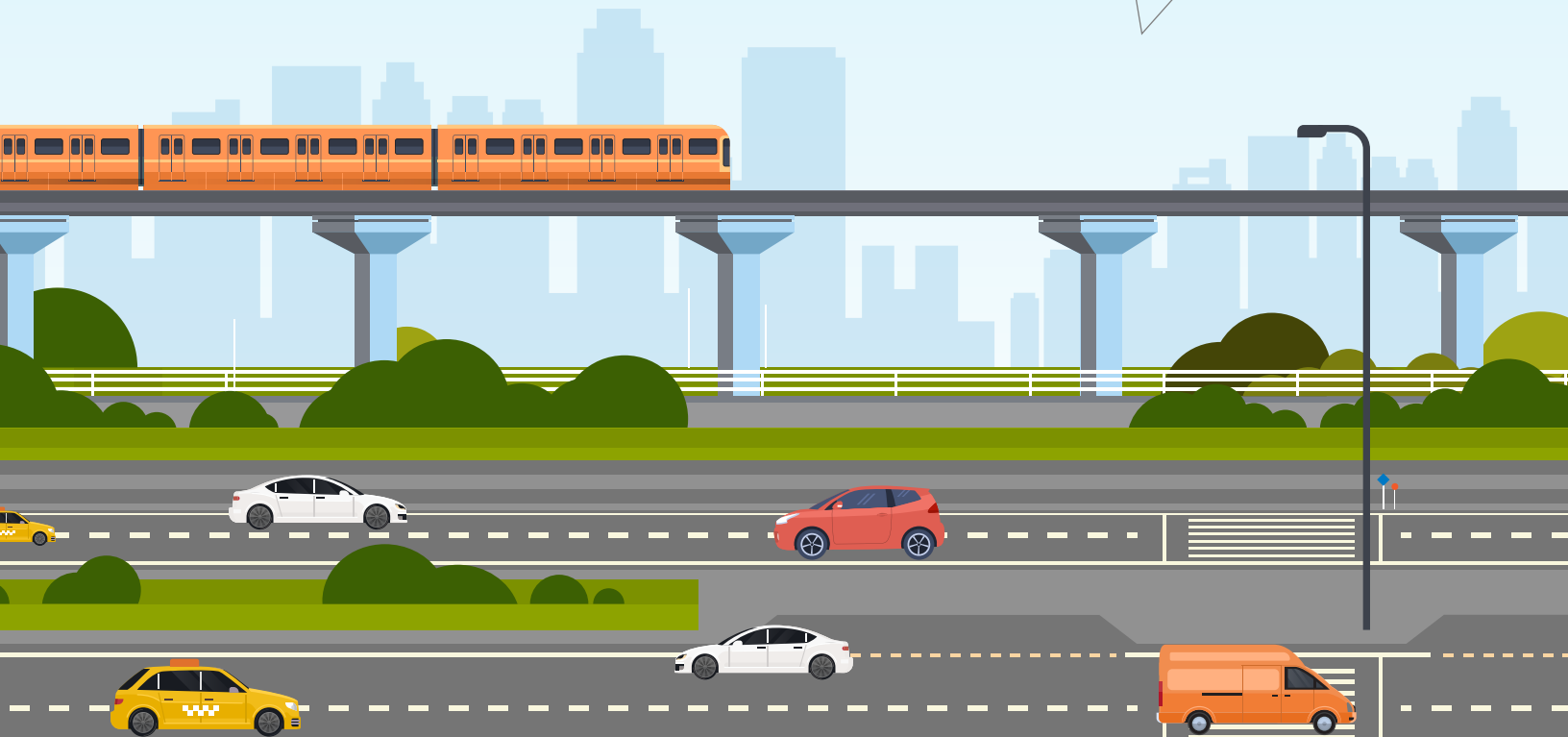
2.4 Conclusion

This chapter built a theoretical framework using the standard urban economics model, insights from transport economics, and the 3-Value approach. The framework recognizes that market forces shape cities and that urban planning and LUR have important roles to play in guiding and facilitating those forces. This market-oriented claim is aligned with the node, place, and market value. LUR can maximize these values so that TOD is feasible. Public transport needs demand, and more so mass transit. The node and market potential values are higher if density is higher, which generates more demand for public transport. In turn, the place-making value increases by LUR that promote walkability, mixed land uses, and provide public goods. The framework allows for an understanding of the impact of LUR on public transport demand.

3

Transport and Urban Growth: Urban Road Network and Development

How a comprehensive network of roads and transport infrastructure can lead to widespread development and increased mobility. Plus, it provides insights into the impact of urban growth in formal and informal areas, the resulting road patterns in various cities, and the 3-D pattern of urban development: Distant, Dispersed, Disconnected.



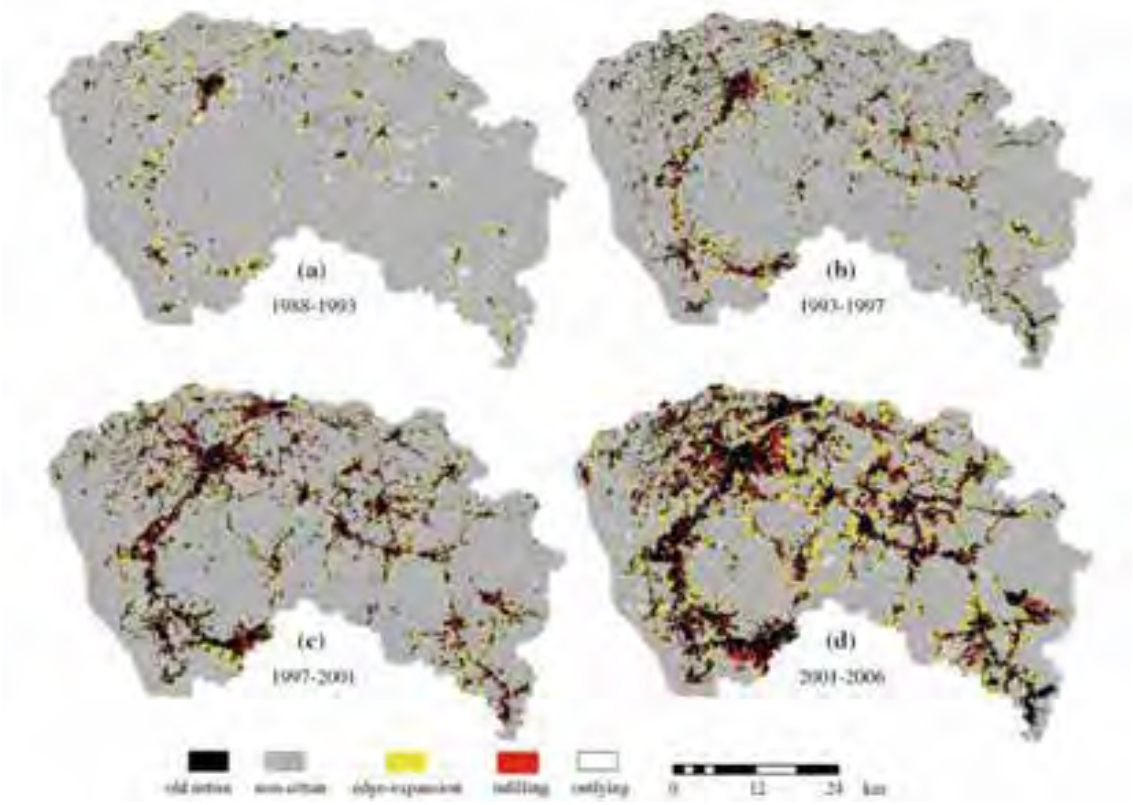
3.1 The Link Between Roads and Development

People must live close to a transport system so they can access opportunities, from jobs to health to education. Local and arterial roads are basic elements of a city's transport system. Arterial roads attract urban development around them because they offer good mobility. Studies have tracked and mapped the spatiotemporal pattern of urban development in Dongguan, China, from 1988 to 2006 (Liu, et al., 2010). "New development mainly occurred along the major transportation networks, exhibiting a disordered and scattered pattern," with subsequent infilling. Figure 3.1 illustrates that urban growth followed the arterial roads. Roads attract urban development, as predicted by the urban economics model in Chapter 2. This city later introduced its first metro line on its highest-density corridor, as shown in Figure 3.2.

The roads attracted development, generating edge expansion, but there were patches of empty lots that developers developed later—infill development. The book *Pancakes to Pyramids* (Lall S. , Lebrand, Park, Sturm, & Venables, 2021) validates this pattern by examining urban expansion for 10,000 cities from 1990 to 2015 across income levels. The study found that, "In low-income and lower-middle-income countries, 90 percent of urban built-up area expansion occurs as horizontal growth. Nevertheless, there is a silver lining: in high-income and upper-middle-income country cities, a larger share of new built-up areas is provided through infill development. For example, a city in a high-income country that increases its built-up area by 100 m^2 will add about 35 m^2 through infill development and 65 m^2 through the horizontal spread. But a similar city in a low-income country will add about 90 m^2 through horizontal spread and only 10 m^t from infill."

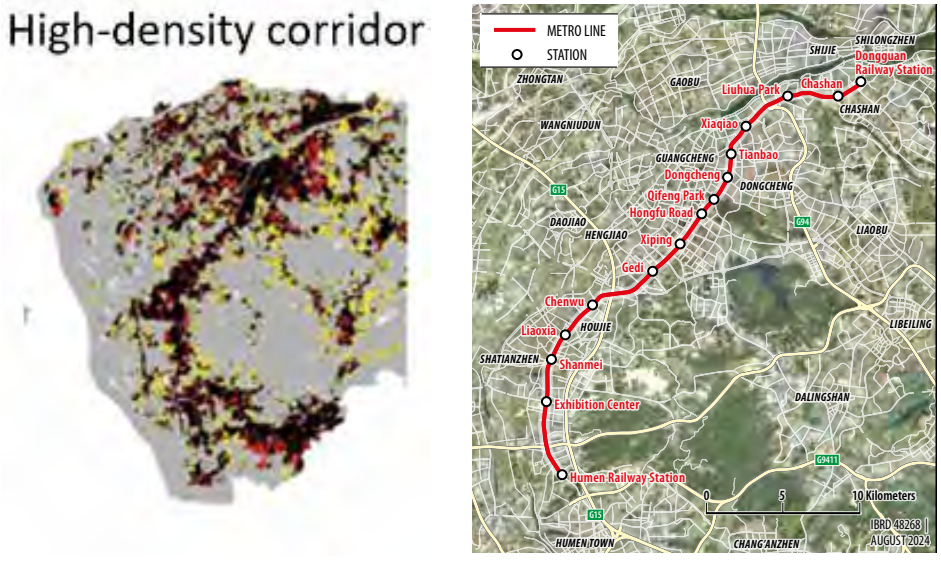
Pancakes to Pyramids also argues that LUR plays a role in the horizontal spread because it limits verticalization—the other limit is personal income because high-rises are more expensive to build than houses. It also calls for flexible LUR that allows higher floor area ratios to allow vertical growth. LUR can, therefore, help by allowing higher densities, as suggested by the framework explained in Chapter 2.

Figure 3.1 Urban Growth in Dongguan, China, 1988-2006



Source: (Liu, et al., 2010).

Figure 3.2 Dongguan's First Metro Line



Source: (Liu, et al., 2010)) and metro map from https://www.metrolinemap.com/metro/dongguan/

3.2 The Urban Road Network in Formal and Informal Areas

The data in the Atlas of Urban Expansion (Shlomo, Blei, Lamson-Hall, Parent, & Handal Gonzalez, 2016) highlights the role of transport in urban expansion. This Atlas analyzed 200 cities, dividing the world into eight regions. It includes detailed data and videos that show the expansion of 30 cities. Table 3.1 presents the changes in world averages when comparing the values before 1990 against the values from 1990 to 2015. On average, cities devoted 1 percent less land to roads, and the roads were, on average, 1.5 meters narrower. The share of arterials 16 meters or more in width dropped by 5 percent points, while the share of roads 4 meters or less wide increased by 9 percent. Walkability also decreased because the share of the urban area within walking distance of arterial roads went from 92 to 82 percent—and the beeline to arterial roads increased by 175 meters. The actual walking distance is longer because the beeline is a straight line that ignores roads—hence, it is easy to calculate.

Table 3.2 shows the regional averages for the same attributes as in Table 3.1. The patterns are similar. Cities are building fewer arterial roads, and the roads are narrower. This outcome is not positive because arterial roads provide the capacity for public transport and private vehicles to access opportunities. In parallel, the share of roads narrower than 4 meters is increasing. Such narrow roads do not allow public transport to operate—only mini-vans and tuk-tuk-like services, plus motorcycles in one direction. Bidirectional travel would be dangerous to pedestrians. These results correlate with the increase in informal urban development worldwide.

In addition, the share of the urban area that was informally developed—outside the LUR framework—increased by 11 percent points. In Sub-Saharan Africa, 46 percent of urban development was informal pre-1990 and 47 percent by 2015. The change was small, but the share of informal urban development is the highest in the world. Latin America, South and Central Asia, East Asia and the Pacific, and Western Asia and North Africa saw increases in informality from 12 to 20 percent points (Table 3.2).

Table 3.1 World Average Changes Between Pre-1990 Against 1990-2015 Values for Critical Attributes Measured by the Atlas of Urban Expansion

Attribute	Change in World Average
Share of Built-up Area Occupied by Roads	-1%
Average Road Width (meters)	-1.5
Share of Roads More Than 16 Meters Wide	-5%
Share of Roads Less Than 4 Meters Wide	9%
Share of Area within Walking Distance of All Arterial Roads	-10%
Average Beeline Distance to All Arterial Roads (meters)	174.84
Share of Residential Areas in Informal Land Subdivisions	11%

Source: Atlas of Urban Expansion database and calculations by authors.

Table 3.2 Regional Averages Pre-1990 and 1990-2015 Values for Critical Attributes Measured by the Atlas of Urban Expansion

Attribute	Value	East Asia and the Pacific	Europe and Japan	Land-Rich Developed Countries	Latin America and the Caribbean	South and Central Asia	Sub-Saharan Africa	Western Asia and North Africa
Share of Built-up Area Occupied by Roads	Value 1990-2015	21%	19%	20%	23%	20%	16%	25%
	(Value before 1990)	22%	22%	22%	24%	19%	17%	25%
Average Road Width (meters)	Value 1990-2015	7.50	6.31	11.25	7.49	6.50	6.40	6.10
	(Value before 1990)	8.73	8.10	11.17	10.18	7.66	8.00	8.79
Share of Roads More Than 16 Meters Wide	Value 1990-2015	10%	4%	15%	5%	5%	5%	3%
	(Value before 1990)	14%	9%	22%	14%	8%	9%	10%
Share of Roads Less Than 4 Meters Wide	Value 1990-2015	37%	31%	15%	16%	31%	30%	32%
	(Value before 1990)	27%	24%	13%	9%	25%	20%	15%
Average Beeline Distance to All Arterial Roads (meters)	Value 1990-2015	542.69	356.60	414.13	324.34	300.22	450.65	520.89
	(Value before 1990)	211.83	261.29	221.01	181.38	234.98	276.63	271.49
Share of Residential Area in Informal Land Subdivisions	Value 1990-2015	22%	25%	1%	36%	45%	20%	47%
	(Value before 1990)	8%	11%	0%	16%	26%	13%	46%

Source: Atlas of Urban Expansion database and calculations by the authors.

Figure 3.3 shows the road network in the formally and informally developed areas of the city of Cali, Colombia. The formal areas on the right of the image follow a grid pattern with arterials and secondary roads. Public transport is possible. The end terminus of the city's bus rapid transit is located close to the border between the formal and informal areas in Figure 3.3. The informal areas, however, have irregular and narrow roads that do not allow public transport, aggravated by the hilly nature of the terrain. Figure 3.4 shows the narrow roads in informal areas on the left panel. The right panel shows formally developed housing. Figure 3.5 illustrates the high density of the informal areas, suitable for public transport—more so, given the income of the population. However, the only way to provide public transport was by building a teléphérique—cable car—that connects this area to the city's Bus Rapid Transit network. Informal urban development has costs. However, it provides affordable housing for its residents.

Finally, as shown in Figure 3.6, arterial roads do not need to be very wide to accommodate public transport. Both examples have wide sidewalks and two lanes per direction. One example has an elevated metro line above, and the other has buses in mixed traffic.

Figure 3.3 Road Patterns in Cali, Colombia, at the Boundary Between Formality and Informality

Source: Authors.

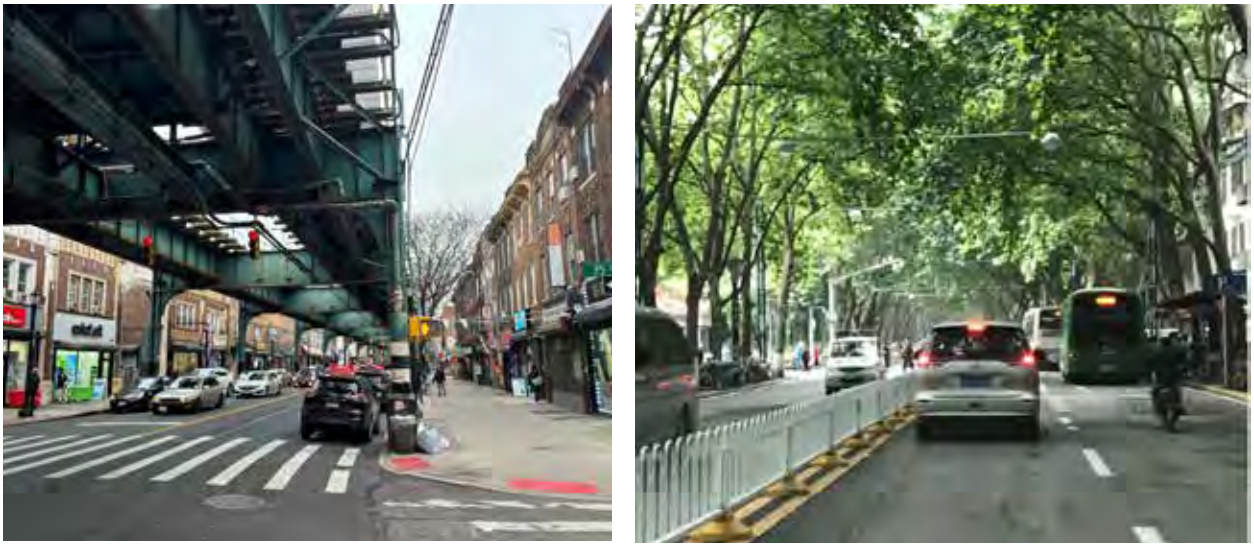
Figure 3.4 Images of Urban Development at the Boundary Between Formally and Informally Developed Areas in Cali, Colombia

Source: Arturo Ardila-Gomez.

Figure 3.5 Images of the Informal Developed Area in Cali and the Teléphérique

Source: Arturo Ardila-Gomez.

Figure 3.6 Examples of arterials roads in Queens in New York City and Wuhan, China



Source: Arturo Ardila-Gomez.

3.3 Urban Development in 3-D: Distant, Dispersed, Disconnected

Urbanization also happens along the pattern known as distant, dispersed, disconnected, otherwise referred to as development in "3-D" (see Figure 16) (Zamorano, 2016) (Kim & Zangerling , 2016). The 3-D urban development pattern is expensive to serve with public transport—walking and biking are difficult or impossible. These developments lack mixed land uses, concentrating houses but lacking jobs and services (i.e., health, education, and others) within the development.

As a result, residents find it expensive to access the city's labor market and basic services. This prevents them from exiting poverty (Hobbs, et al., 2021). The labor market does not work as intended, particularly for people who depend on leaving their houses to generate income. The high cost of transport makes many residents abandon these houses (Zamorano, 2016). Many of these developments had government subsidies, but they were still insufficient to compensate for the high cost of transport. Building these houses consumed resources and they became stranded assets without a viable mobility solution.

"On one hand, the massive building of low-income housing has created "bedroom communities" instead of allowing for the generation of conditions that promote a competitive city. On the other hand, the construction of low-income housing rarely considers other infrastructure and facilities necessary for the urban life of thousands of people. The spaces planned for these purposes are often left vacant and are poorly maintained as a result of lack of investment interest from the public/private sectors" (Centro de Transporte Sustentable de Mexico A.C., 2012). Poor people end up spending a high share of their income because of the need to transfer from these informal vehicles to a bus or metro (Gwilliam, 2002).

Figure 3.7 Examples of Urban Development in 3-D

Source: (right) Gary Todd via Flickr and (left) Chris Parker via Flickr under creative commons license.

3.4 Conclusion

Transport infrastructure attracts urban development because people want to live close to the mobility they provide—mobility that allows access to opportunities. For the urban market to work, agents need to know the location of the future road network. Without this information, developers imagine the roads, resulting in haphazard road patterns. Urban development is increasingly informal. Cities are investing less in arterials, which are critical for public transport. The share of 4m wide roads is increasing. These roads are unsuitable for regular buses. Mini-vans barely fit but in one direction. Reversing these trends will require improvements in municipal public finance so municipalities can afford better road networks (see (Ardila-Gomez & Adriana Ortegon Sanchez, 2016)). In addition, LUR can play a positive role. The next chapter explains the basic LUR, including zoning.

4

Zoning and Land Use Regulations

The definitions of zoning and land use regulations (LUR) help understand how they impact urban development. Alternative zoning approaches in Japan and the USA showcase possible solutions for replicating them in emerging cities. A case for relaxing regulations raises the question of how much is too much.

Chapter 3 described how transport facilities attract urban development around them. Chapter 2 explained how this increase in demand could result in more floor space if the LUR allows developers to construct to meet the demand. In addition, Chapter 2 showed that LUR can constrain the floor space supply. LUR can be beneficial by allowing supply to meet demand. Further, LUR can lead to designs that promote walkability and density, thus increasing the node and place values. LUR can also increase the market value by allowing more built space to meet demand.

4.1 Defining Zoning and LUR

Zoning divides land into zones, each with regulations defining the purposes for which the land can and cannot be used. This is known as 'Euclidean zoning'. The term comes from a US Supreme Court ruling that recognized zoning as a legitimate use of police power to protect public welfare (McDonald & McMillen, 2012). Zoning started in the early 1920s to spatially separate different land uses deemed incompatible, i.e., residential and industrial (Planetizen, 2022). Zoning ordinances define the use permitted and the intensity of use on each parcel (McDonald & McMillen, 2012). Zoning can lock a land use, single-family housing, for example, because they are difficult to change due to vested interests (Levine, 2005).

For example, Curitiba, the capital of the state of Paraná in Brazil, has a master development plan with zones to separate industrial uses from others. In the early 1970s, the mayor of Curitiba, Jaime Lerner, changed land use plans to allocate 10 percent of the city area to the Industrial City of Curitiba (Cidade Industrial de Curitiba, CIC). By 1992, the CIC had 400 industrial firms that directly employed 50,000 and indirectly 200,000. The CIC generated 17 percent of the total revenue from the tax on commerce and industry of the state (Ardila-Gomez, 2004). Industrial jobs are formal and pay higher salaries, which allows these employees to buy quality built-up areas that pay property tax. Formal industrial firms also pay taxes, showing the importance of having a local economic development strategy.

In the US, New York City adopted a zoning ordinance in 1916, and soon, most cities in this country emulated the example after their state government authorized them. Other countries, including low- and middle-income, emulated this example. The first zoning iterations were hierarchical because they started with the residential use and then extended the scope by adding other uses. Housing was, therefore, allowed in all zones except where it was explicitly prohibited (McDonald & McMillen, 2012). Allowing housing in all zones gives more land for housing that is closer to jobs.

However, in the 1950s, as cars became more prevalent, cities abandoned the hierarchical zoning, replacing it with segregated uses by zone. Many residential zones became single-family detached houses. Zoning also included LUR such as setback, backyard, front yard, minimum lot size, floor area ratio, and parking requirements (McDonald & McMillen, 2012). The area allocated for housing diminished, and distances between homes and jobs increased, generating a car-dependent urban development pattern. Mixing land uses became more difficult.

Zoning is developed through LUR, such as:

1. **Floor Area Ratio:** Ratio of built-up area to land used (plot area). FAR sets a maximum value. Anything below is legal. The higher the value, the larger the area of space that can be built per unit of land area. Yet, even with low FARs, cities can still be dense: buildings will be low, units will be small, and public space will be missing. Higher FARs can lead to high rises. For example, the Shanghai World Financial Center (Figure 4.1), with 101 floors, has 377,000 m2 of built-up area on 27,800 m2 of land, for a FAR of 13.5 (Bertaud, 2018). Low FARs increase the relative price of land to the cost of the building. The rich can afford low FARs in general.

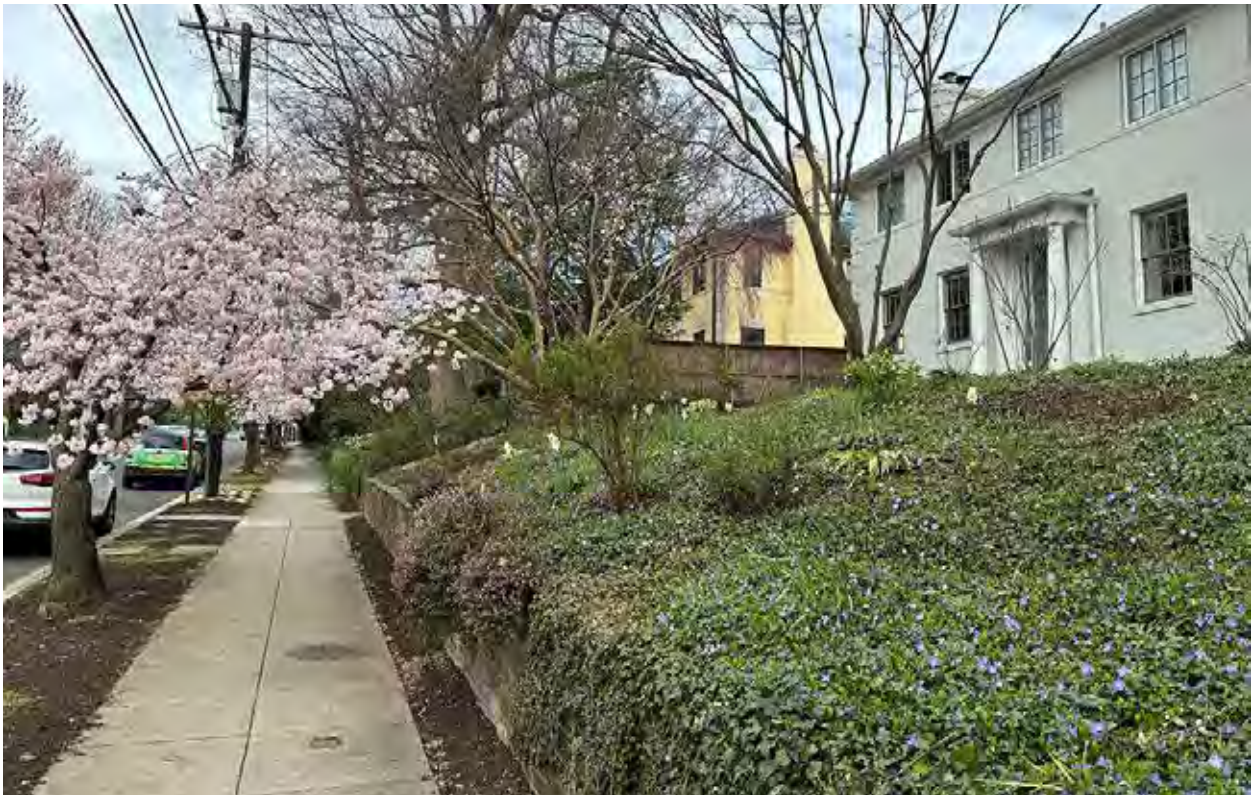
Figure 4.1 Picture of the Shanghai World Financial Center

Source: Arturo Ardila-Gomez.

2. **Minimum Plot Size:** Sets the minimum area a plot must have to be legal to build on. "Minimum plot size requirements, for example, reduce the density of housing and thus the overall supply" (Calder, 2017). Houses in informal areas typically do not meet this requirement because the owners cannot afford as much land as required by the norm. Requirements for large plot sizes lead to lower density, particularly when coupled with low FAR or requirements to build only single-family homes (Figure 4.2). Public transport becomes infeasible in this urban development pattern because of the lower density of travel demand; walkability and cyclability are also severely hampered. Cars offer a better solution for those who can afford them.

3. **Minimum Setback:** Allows the perimeter of the house to start after a certain distance from the street or the sidewalk. The result is a front yard. Analogous regulations might mandate a backyard in addition. For wealthy households, these requirements—like all regulations—are not difficult to afford. However, for the less affluent, these regulations translate into less built-up area per unit of area of land. Houses in informal areas and other low-income areas do not have setbacks. A lower setback requirement increases the density in terms of people per unit area. These populations depend on public transport to access opportunities. Higher setback requirements have the opposite effect, resulting in car dependence (Figure 4.2). Some cities that enforced these high setback requirements now consider allowing the building of a smaller house in the front yard—or the backyard. Walkability increases when setback requirements are low and sidewalks have a reasonable width.

Figure 4.2 Minimum Plot Size and Setbacks in a Car-oriented Area in Washington DC



Source: Arturo Ardila-Gomez.

4. **Plot Coverage Ratio:** Establishes the fraction of the plot area on which space can be built as if looking down from the sky (Tokyo Real Estate, 2022). If the Plot Coverage Ratio is 50 percent, it means that construction can happen in half the area and no construction in the other half.

5. **Minimum Parking Requirement:** Sets a minimum number of parking spaces per area of built-up area per number of units. This requirement assumes the household will eventually own a car (even if it does not have the income) and increases the cost of the built-up area, making it unaffordable for lower-income people. Frequently, parking spaces are empty even in the downtown area, which shows that parking requirements are too high (Shoup, 2017). Further, parking requirements subordinate urban density to the needs of car-based travel (Manville, 2021), generating car dependency. For example, buildings are farther apart because of parking areas. Density falls, and therefore, public transport cannot provide service. Parking requirements also do not solve the lack of a proper parking policy; this begins by recognizing that free parking, particularly on sidewalks and on streets, is not desirable because of its negative externalities (Shoup, 2017) (Figure 4.3).

Figure 4.3 Cars Parked on the Sidewalks in Cali, Colombia (left) and Cairo, Egypt (right)

Source: Arturo Ardila-Gomez.

6. **Single-use Requirement: Prohibits mixing housing with offices and shops, for example.** Market forces also play a role, as explained in Chapter 2, because the high cost of land means only commercial and office users can afford to build on that land. However, ordering single land use aggravates the trend in downtown areas, which end up with only offices and no residences. As a result, at night and on weekends, downtown streets are empty, devoid of life, and can feel dangerous. Yet, some people want to live downtown, which will bring life to this area. The single-use requirement also applies to housing, which can be high-density (Figure 4.4). Residents in these single-use areas must travel long distances to access shops and jobs. Allowing mixed land uses, provided they are not totally incompatible, is one of the key tenets of TOD because of the possibilities for generating walking and public transport trips (Figure 4.5).

Figure 4.4 Housing-only, High-density Development in Bogota, Colombia

Source: Arturo Ardila-Gomez.

Figure 4.5 Mixed Land Use Along a Pedestrian-only Street in Istanbul, Türkiye

Source: Arturo Ardila-Gomez.

a. **Maximum Number of Housing Units Per Block:** This cap specifies the number of housing units per unit area. If FAR is increased to promote TOD but this requirement is not changed, the built-up area does not change (Bertaud, 2018).

b. **Minimum Area for Dwelling Units:** Sets a minimum area a house or apartment must have. Any area below this is illegal. While well intended on social equity grounds, the requirement ignores affordability and market segments. Some individuals, couples, and families could afford a smaller area but are priced out by the requirement. Some move into tenements, living in one room and sharing a kitchen and restroom with others instead of having a small but fully equipped unit—allowing them both a roof and privacy (Bertaud, 2018).

c. **Cumbersome Land Consolidation:** Developers may need to consolidate several plots of land to build a high-rise. However, consolidating plots in the cadastre might take years. If plots are small, developers may incur a high cost to consolidate many plots, particularly if they want to meet an updated minimum plot size regulation (Suzuki, Cervero, & Iuchi, 2013).

d. **Public Space Requirements Not Enforced:** Regulations call for public spaces, but developers do not allocate this space frequently, and governments do not enforce the regulations. Many cities have extremely low public space per inhabitant. Sidewalks and local streets are the basic expression of public space. Yet, private cars park illegally on sidewalks. To prevent this, cities need a parking policy—a key complement to TOD policies. Further, without plans that show streets with sidewalks and proper public financing for the land for such roads, these informal urban developments will allocate minimal space for roads (Ardila-Gomez & Adriana Ortegon Sanchez, 2016). The high density supports public transport, but the precarious street layout means users—who depend on public transport—must walk long distances to access formal transport. In some cases, old sedans and jeeps (informal transport) provide motorized feeder service to connect with main corridors where formal transport exists (Kumar, Zimmerman, & Arroyo-Arroyo, 2021).

This chapter now explores two alternative approaches to Euclidean Zoning.

4.2 Japan's Market-friendly Zoning and Planning

"Two full-time workers earning Tokyo's minimum wage can comfortably afford the average rent for a two-bedroom apartment in six of the city's 23 wards. By contrast, two people working minimum-wage jobs cannot afford the average rent for a two-bedroom apartment in any of the 23 counties in the New York metropolitan area." (Appelbaum, 2023)

Japan's approach to zoning leads to affordable housing. Market forces work better, leading developers to build, even surpassing demand. As a result, Japan has affordable housing—only 3,065 people are homeless (Baseel, 2023). In New York City, in contrast, 100,000 people are homeless—one in 83 inhabitants (The Bowery Mission , 2024). Worldwide, two percent of the population—150 million people—are homeless (Henry, 2021). Homelessness is the extreme exclusion caused by a lack of housing supply. In Japan, zoning and LUR ensure plenty of land for housing, yielding few homeless people due to market-led supply and affordable prices.

Table 4.1 illustrates this point. The zoning allows housing to be built, including houses with small stores and offices, in 11 of 12 zones. Note that the basic housing category allows stores and offices to be part of the houses, thus generating mixed land use from the first echelon. Only the heavy industry zone excludes housing, but other industrial zones allow housing. The zoning devotes seven of the 12 zones to housing, differing in the Floor Area Ratio and plot coverage ratios. For example, Categories I and II, "exclusively low-rise residential zones," have a FAR between 0.5 and 2.0 and plot coverage ratios between 30 and 60 percent. The next five zones are also for housing, with FARs between 1.0 and 5.0 and plot coverage ratios between 30 and 80 percent (Table 4.2). Therefore, Japan's zoning provides ample land for housing and allows intensive use of each plot—if the plot's owner desires, considering market forces.

Table 4.1 Zoning in Japan

Control of Building Use by Land Use Zones								can be built			usually cannot be built		
Examples of buildings	Category I exclusively low-rise residential zone	Category II exclusively low-rise residential zone	Category I mid/high-rise residential zone	Category II mid/high-rise residential zone	Category I residential zone	Category II residential zone	Quasi-residential zone	Neighborhood commercial zone	Commercial zone	Quasi-industrial zone	Industrial zone	Exclusively industrial zone	Areas with no land-use zone designation (Urbanization Control Areas are excluded)
Houses, Houses with other small scale function (stone, office, etc.)												D	
Kindergartens, Schools (Elementary, Junior High, Senior High)											■	■	
Shrines, Temples, Churches, Clinics													
Hospitals, Universities	■	■									■	■	
Stores (mainly selling dairy commodities)/ Restaurants with floor space of 150m² max. on the first or second floor (excluding¤)	■											D	
Stores/Restaurants with floor space of 500m² max. on the first or second floor (excluding¤)	■	■										D	
Stores/Restaurants not specified above (excluding¤)	■	■	■	A	B							■	
Offices, etc. not specified above	■	■	■	A	B								
Hotels, Inns	■	■	■	■	B						■	■	
Karaoke boxes (excluding¤)	■	■	■	■	■								
Theaters, Movie theaters (excluding¤)	■	■	■	■	■	■	C				■	■	
¤ Theaters, Movie theaters, Stores, Restaurants, Amusement facilities and so on, with more than 10,000m² of floor area	■	■	■	■	■	■	■				■	■	■
Bathhouses with private rooms	■	■	■	■	■	■	■	■		■	■	■	■
Independent garage with floor space of 300m² max. on the first or second floor	■	■											
Warehouse of warehousing company, Independent garage of other types than specified above	■	■	■	■	■	■							
Auto repair shop	■	■	■	■	E	E	F	G	G				
Factory with some possibility of danger or environmental degradation	■	■	■	■	■	■	■	■	■				
Factory with some possibility of danger or environmental degradation	■	■	■	■	■	■	■	■	■	■			

Note:
A: Must note be built on the third floor or higher. Must not exceed a floor area of 1,500m².
B: Must not exceed a floor area of 3,000m².
C: Audience seating floor area must not exceed 200m².
D: Stores and restaurants must not be built.
E: Floor area must not exceed 50m².
F: Floor area must not exceed 150m².
G: Floor area must not exceed 300m².

Source: (Ministry of Land, Infrastructure, Transport, and Tourism of Japan, 2024).

Table 4.2 FAR and Plot Coverage Ratio by Zone in Japan

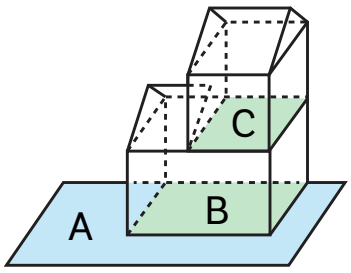
Floor-area Ratio and Building Coverage Ratio Regulations in Land Use Zones																
Category of Land Use Zone	**Maximum floor-area ratios (%)**												**Maximum building coverage ratios (%)**			
Category I exclusively low-rise residential zone	50	60	80	100	150	200							30	40	50	60
Category II exclusively low-rise residential zone	50	60	80	100	150	200							30	40	50	60
Category I mid/ high-rise oriented residential zone	100	150	200	300	400	500							30	40	50	60
Category II mid/ high-rise oriented residential zone	100	150	200	300	400	500							30	40	50	60
Category I residential zone	100	150	200	300	400	500							50	60	80	
Category II residential zone	100	150	200	300	400	500							50	60	80	
Quasi-residential zone	100	150	200	300	400	500							50	60	80	
Neighborhood commercial zone	100	150	200	300	400	500							60	80		
Commercial zone	200	300	400	500	600	700	800	900	1000	1100	1200	1300	80			
Quasi-industrial zone	100	150	200	300	400	500							50	60	80	
Industrial zone	100	150	200	300	400								50	60		
Exclusively Industrial zone	100	150	200	300	400								30	40	50	60

Floor-Area Ratio (FAR)

$$\text{FAR (\%)} = \frac{\text{total floor area (B+C)}}{\text{site area (A)}} \times 100$$

Building Coverage Ratio (BCR)

$$\text{BCR (\%)} = \frac{\text{building area (B)}}{\text{site area (A)}} \times 100$$



Source: (Ministry of Land, Infrastructure, Transport, and Tourism of Japan, 2024).

The zoning allows building kindergartens and schools in 10 of 12 zones—only excluded in two industrial zones. It allows shrines, temples, and clinics in all 12 zones, as well as hospitals and universities in all but two zones. Shops, stores, and restaurants can happen, according to Table 4.1, in all housing zones—remember, the basic housing category allows shops and offices as part of the house. The Japanese zoning also requires planners and authorities to allocate space for industrial uses, allowing industries to be in three of the 12 zones and housing to be in two of these industrial zones. The zoning allows mixed land uses almost everywhere.

National Law mandates Japan's zoning framework. Municipalities must abide by this inclusive zoning approach. Municipalities crafted their urban plans with this zoning and mandated FAR and plot coverage ratio (Ministry of Land, Infrastructure, Transport, and Tourism of Japan, 2024). Japan's zoning allows market forces to set prices free of the caps set by Euclidian zoning, resulting in an ample housing supply, usually above demand levels in Tokyo (Appelbaum, 2023); (From, 2022), (Dispatch, 2023). (Gao, Asami, & Katsumata, 2006) found that "land prices for plots with an effective FAR of between 60 percent and 100 percent were significantly lower than those for plots with an effective FAR of between 110 percent and 160 percent".

Tokyo is also a transit metropolis (Cervero, 1998) because the city's rail and metro systems carry 8.7 million passengers daily (Lin, 2014). The zoning and LUR are transit-friendly due to the ample supply of affordable housing. The zoning mixes uses from the outset. The Euclidian Zoning's fear of mixing industry and housing does not appear in Japanese zoning. Originally, Euclidean zoning was hierarchical, allowing housing in all zones, but later segregated land uses. The Japanese zoning system could be called hierarchical, but above all, it is market-friendly and provides local governments with a clear planning framework (Hobbs, et al., 2021).

Box 4.1 The Arlington TOD Case Study

A world-famous TOD case, Arlington Country (VA, USA), illustrates the benefits of allowing mixed land uses, higher FAR, higher plot coverage areas, and changing parking requirements. Arlington had low-density zoning that promoted a car-oriented development. The county planned to concentrate future urban development on high-density, mixed-use transit corridors. The county authorities lobbied to change the proposed at-grade Orange Metro line from the median of a highway to an underused commercial corridor—and be underground. The plan allowed higher density and mixed land use on a 400 m radius around the five metro stations of the Orange Line in Arlington (Brosnan, 2010) and (Smart Growth Online, 2016). The plan adopted regulations that promote walking, such as wide sidewalks, zero or short setbacks, and formal off-street parking inside buildings—usually underground.

The results are impressive. "In 1970, the Rosslyn-Ballston Corridor had 22,000 jobs. By 2009, that number had increased to 98,500. Similarly, the amount of office space increased from 5.5 to 21.7 million square feet [508,000 to 2.0 million square meters], and the number of housing units grew from 7,000 to 28,643. Metro ridership has also increased over the years, and many of Arlington's arterial streets experienced a decrease in automobile traffic despite continued growth" (Smart Growth Online, 2016). Figure 4.6 shows the higher density around metro stations, with decreasing density towards low-density housing. Figure 4.7 shows the ample sidewalks, low setback requirements, and high FAR close to a metro station in Arlington.

Figure 4.6 also shows areas zoned for low-density, single-family housing. These areas are car-oriented, and this zoning locks in a car-oriented development that neighbors a world-class transit-oriented corridor. Arlington authorities are trying to densify these low-density areas but they face major opposition (Armus, 2024), which illustrates Levine's (2005) point that once regulations are enacted they stay for life. Hence why this book argues below for a different approach.

Box 4.1 The Arlington TOD Case Study (cont.)

Figure 4.6 Picture of Arlington, VA

Source: Brosnan, 2010.

Figure 4.7 Wide Sidewalks and Narrow Setbacks in Arlington County by a Metro Station

Source: Arturo Ardila-Gomez.

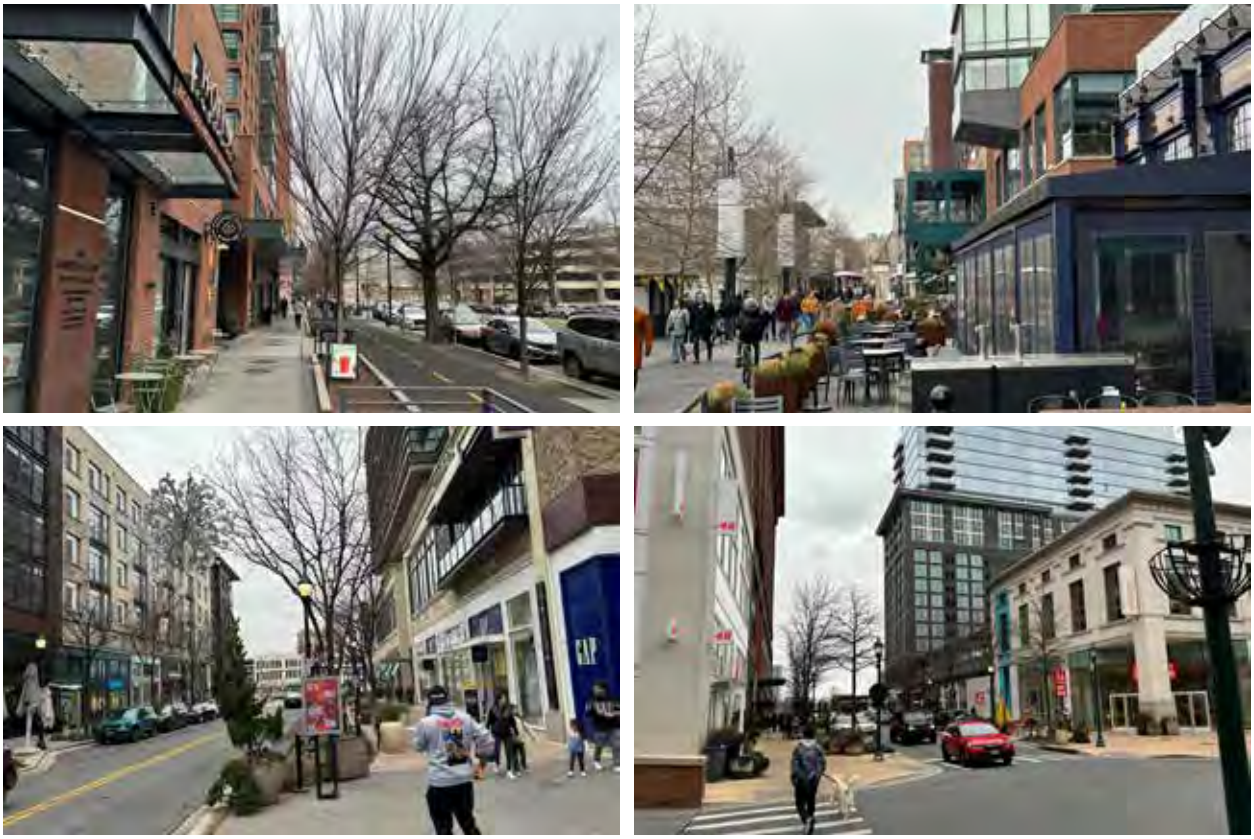
4.3 US-inspired Form-Based Codes

Form-based codes (FBC) emerged as new attempts to counter the adverse effects of Euclidean zoning, including sprawl. FBC regulates the relationship between building façades, the sidewalk, and the street (Planetizen, 2022). It pursues pedestrian-oriented development, promoting mixed-use, street-level design guidelines and interaction between the built environment and pedestrians (Reimann & Chriqui, 2019). In the USA, FBC achieves results in new developments that become pockets of walkability. This walkability improves the chances of people riding a bus. However, the surrounding developments are car-oriented, limiting the usefulness of public transport.

FBC improvements align with the literature on walkability—and with the way cities looked before the advent of the car. The pedestrian environment and adjacent land use are determinants of pedestrian and public transport demand. (Sallis, Bull, Burdett, & Frank, 2016) and (Vergel-Tovar & Rodriguez, 2018) found that the level of public transport ridership is associated with mixed land use and a good pedestrian environment that promotes walkability. Vergel-Tovar and Rodriguez (2018: 183) state that these factors promote bus rapid transit use, "mixing land uses, pedestrian infrastructure, and the presence of public facilities and institutional uses around the stations such as hospitals, libraries, markets, plazas, and churches". On the other hand, "Generous on- and off-street parking (mostly free, although this was not systematically collected), industrial uses, a poor pedestrian environment with long blocks, and relatively limited compactness conspire against increased BRT ridership."

The FBC approach indicates ways the LUR could promote walkability and public transport. For example, sidewalks are necessary. Broad setback requirements will increase walking distance and reduce the willingness to walk to access public transport. FBC, therefore, recommends wide sidewalks and minimal or no setbacks so that the "eyes on the street" concept applies (Jacobs, 1961). Frequent doors and windows, including restaurants and shops, are at the street level. The upper floors host residences and offices. The streetscape matters for walkability—plus mixing land uses (Gehl, 2010) and (Gehl, 2011). Figure 4.8 shows pictures of developments that follow FBC in the Washington area.

Figure 4.8 Examples of Urban Development that Follow FBC



Source: Arturo Ardila-Gomez.

In sum, FBC allows urban development to resemble how cities looked like before they became car-oriented. The streets are narrow, the sidewalks are generous, and the setbacks are low. When the setbacks exist, they could generate outdoor restaurant seating areas or extend the walking area.

4.4 Conclusion

Zoning and LUR can support public transport by mixing land uses, allowing higher densities and lower setbacks, which promote walking as long as sidewalks exist and are not occupied by illegally parked cars. The TOD literature recommends relaxing land use regulations to allow higher density and mixed land uses around transit stations—which can be done before the transit line is built, as argued in this book. The mixed land uses and the reasonable floor area ratios allowed by zoning in Japan are best practices. Form-Based Codes, inspired by the USA, indicate ways in which the LUR could promote walkability and public transport—higher density, mixed land use, low setback, and good sidewalks.

The next chapter explains the stylized model used in this book to quantify the impact of LUR on the likelihood of using public transport.

5

The Sandbox Model: Effects of Modifying LUR

An innovative sandbox model unlocks hidden connections between land-use regulations and commuter habits. It is also a powerful tool for urban visionaries. By manipulating land-use regulations, planners can reveal subtle yet profound ways to reshape thousands of commuters' daily journeys.

5.1 Developing a Sandbox Model

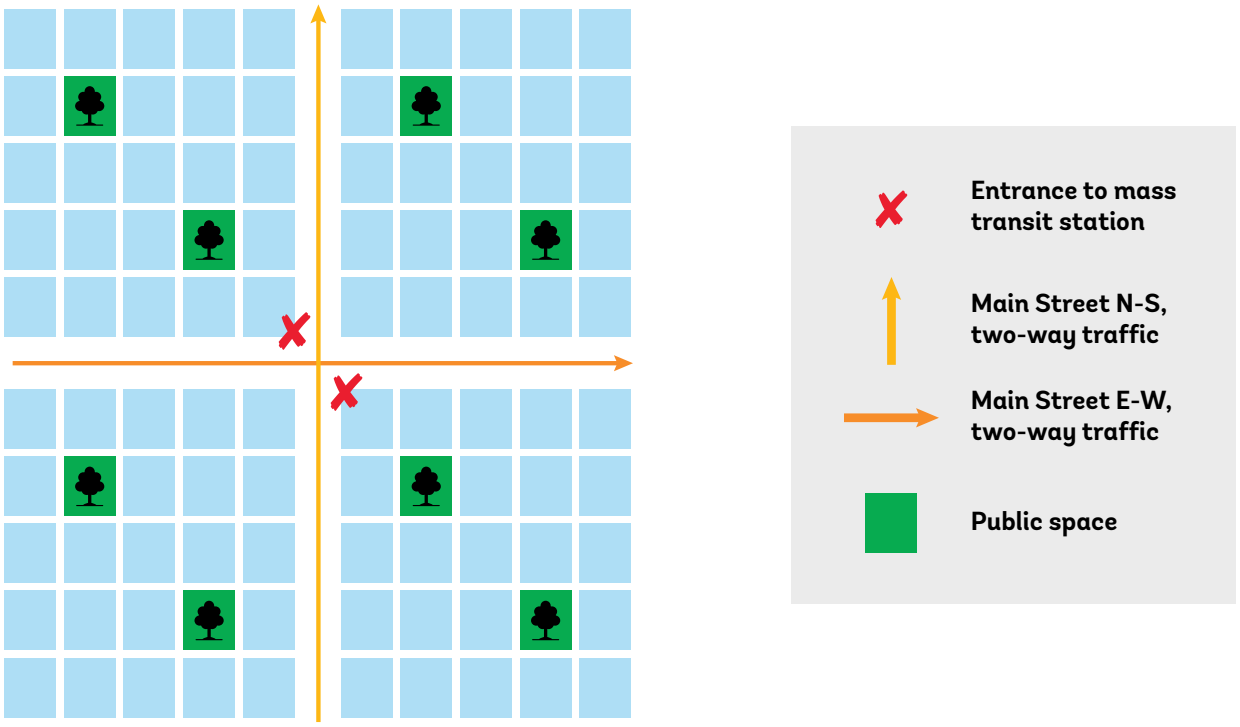
The authors developed a sandbox model to test the effects of changes to land use regulations on public transport use. The model estimates the housing supply allowed by the regulatory mix and calculates the willingness to walk to a public transport station or stop. To estimate the housing supply, the model assumes developers will build the maximum allowed by the regulations. This assumption is strong, but remaining constant between scenarios allows for comparisons. Using the model, the authors tested the impact of the following LUR: Floor Area Ratio (FAR), setback or build-to-line, plot coverage ratio, and on-the- and off-the-street minimum parking mandates.

The model uses a stylized residential neighborhood comprising 10X10 blocks, each measuring 100 m in width and length (Figure 5.1). Two main avenues can change in width to reflect the number of lanes and on-street parking requirements. The avenues have two-way traffic. These main avenues are arterial roads that cities need because they allow public transport and mixed traffic. Chapter 3 explained how cities in developing countries are building fewer arterial roads, which has negative implications for the mobility of the city. These arterial roads, moreover, can host mass transit in the future, such as bus rapid transit or a metro line. Any mass transit needs space. In the model, one avenue runs north-south and the other east-west. Local streets are analogous. The avenues and local streets are complete because they have a sidewalk and carriageway. Sidewalks are critical for walkability.

The green space allocation follows World Health Organization (WHO) guidelines, recommending a maximum 300-meter distance to public green space (European Environment Agency, 2022). Each 5X5 quadrant has 92 percent residential and 8 percent green areas. The public space areas take two entire blocks, which generate zero walking trips to the public transport station in the model. Only blocks with residents generate trips to the bus stops—the model does not need to consider trips from the bus stop to the public space or residential areas. This allocation of green space could also be used for schools. In cities like Washington, DC, public and even private school playgrounds double as parks when the school day is over—after 4 pm. The same space provides multiple services depending on the hour of the day.

The model assumes two entrances to bus stops diagonally across from one another. These points could also be entrances to mass transit stations. This book is agnostic regarding public transport modes. It assumes that any public transport service merits better land use regulations that promote mixed-use and higher density. This will build demand for public transport to the point of requiring mass transit—hence the need for arterial roads with reasonable width. There is no need to wait for the mass transit line to intervene.

Figure 5.1 10 by 10 Block Neighborhood Layout With Two Avenues, Local Streets, Public Space, and Two Accesses to Public Transport



Source: Authors.

The model uses a sigmoid function from Nourian, et al. (2018) to quantify the probability of walking to take public transport. These authors validated this approach empirically.

$$P = \frac{1}{1 + e^{\lambda\left(x - \frac{R}{2}\right)}}$$

Where:

P is the probability of walking by the residents of a block (i, j) to reach the public transport station.

x is the travel distance from the block (i, j) to the station; the farther, the less likely it is to use public transport. The model uses actual walking distances.

R is the catchment area radius. It represents a threshold above which the perceived convenience or feasibility of traveling while walking is assumedly zero. This model used the corresponding radius to a 15-minute threshold time. It uses an average walking speed of 3.7 km per hour. R is, therefore, equivalent to 0.925 km, which matches the TOD literature.

$\lambda = \frac{2}{R} \ln\left(\frac{1}{\epsilon} - 1\right)$ This condition ensures that the perceived convenience or feasibility of walking becomes nearly negligible (<∈) when the walking distance is larger than R.

The smaller ∈ is, the higher the willingness of individuals to walk. ∈ is inversely related to the overall walkability of the route to the public transport station—the condition of the sidewalks and the feeling of safety. This reflects that the willingness to walk to public transport stations decreases exponentially, not linearly, as distance increases (Figure 5.2).

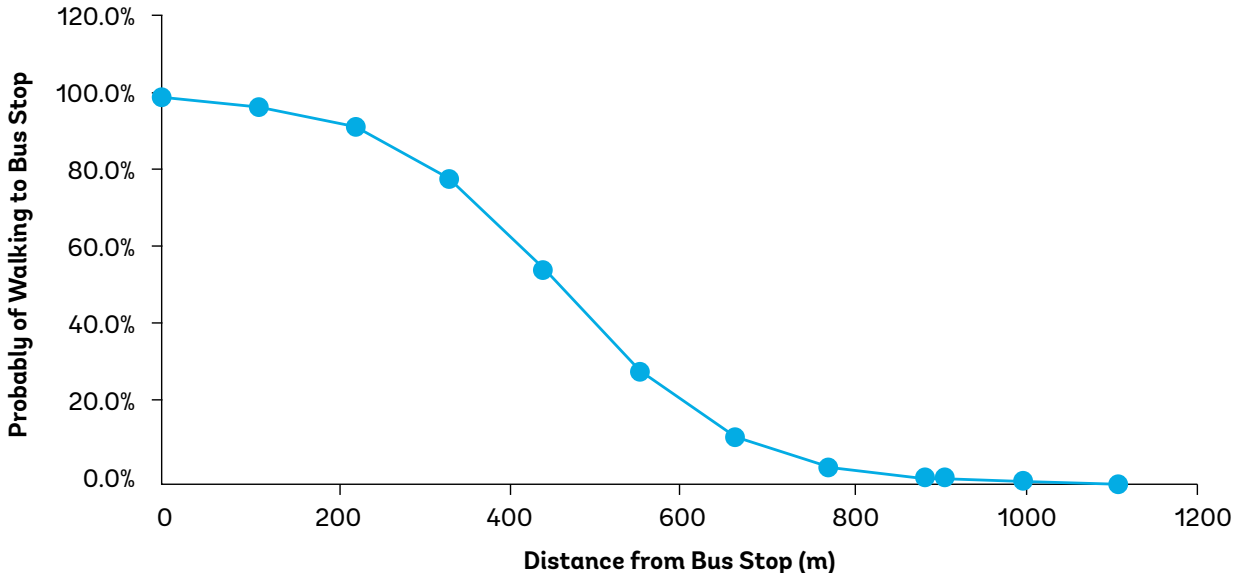
For these sandbox experiments, the authors used an ∈ of 0.01, indicating a high willingness to walk, as assumed in the TOD literature and the 15-minute city. Specifically, the TOD literature recommends concentrating activities on a 1-km radius around transit stations. This model assumes the average human will walk at 3.7 km per hour. In 15 minutes, this average person will walk 925 meters, which is close to the TOD recommendation. The model uses actual walking distances, not the beeline distance. However, Figure 5.2 shows that the probability of walking this distance is low.

The literature validates this approach. (Iacono, Krizek, & El-Geneidy, 2008) estimate decay functions for walking, biking, and public transport use as a function of distance for Minneapolis and St. Paul in the US. They found that most walking trips are concentrated in the first kilometer. (Daniels & Mulley, 2013) found that for the Australian case, the "overall average walking distance to public transport is 573 meters, with 25 percent of trips less than 235 meters and 75 percent of walking trips less than 824 meters".

In the Norwegian case, (Tennøy, Knapskog, & Wolday, 2022) found that, "Average walking distances found in studies relevant for this paper range from 170 to 549 m to local public transport stops and 805–882 m to railway stations." In the case of Bogota, (Guzman, Peña, & Carrasco, 2020) found that in 2015, 45 percent of walking trips were shorter than one kilometer, but 55 percent were longer, reaching even 12 km. "Bogotá's land-use patterns involve long commuting trips, forcing low-income households (low-SES) to make frequent complex multimodal trips, usually including long travel

distances, causing unequal accessibility levels." They found a positive relationship between walking distance and land use segregation, which hurt the low-income population mainly by forcing them to walk longer distances. Finally, (van Soest, Tight, & Rogers, 2019) reviewed the literature and found that "walk to and from PT is dependent on the particular location and circumstances, ranging from an average distance of 170 m to buses in Calgary, Canada to an average of 1392 m to terminal BRT stations in Jinan, China".

Figure 5.2 Probability of Walking to a Bus Stop as a Function of the Distance to the Bus Stop



Source: Authors.

The model then multiplies the estimated number of residents in each block by their probability or willingness to walk the distance between their block and the PT station. This calculation yields the potential public transportation riders in each block. By summing up these values across all the blocks in the neighborhood, the total potential ridership in the 10X10 neighborhood is obtained. The model assumes two people per household that will commute outside the house.

The model takes advantage of the symmetry in the 10X10 block neighborhood because the 5X5 quadrants behave similarly. Table 5 presents the probabilities of walking to the PT stations for the 5x5 quadrant on the bottom right of Figure 18. The matrix represents the percentage of residents living within the block in row i and column j from the PT station and who are willing to walk the distance from their block to the PT station located in the top left corner. Block (1,1) is the closest to the transit station entrance. Block (5,5) is 908 m away from the transit entrance. Notice the drop in the willingness to walk to the public transport. For example, residents in (1,1) have a 99.0 percent probability of walking to that point, while residents in (5,5) have only 1.5 percent. This change is because the residents in (5,5) walk 900 meters more than the residents in (1,1). The model assumes actual walking distances and not beeline distances.

Table 5.1 Percentage of Residents in Each Block Willing to Walk to the Public Transport Station

j \ i	1	2	3	4	5
1	99.0%	97.1%	91.7%	78.6%	55.1%
2	97.1%	91.7%	78.6%	55.1%	29.0%
3	91.1%	78.6%	55.1%	29.0%	12.0%
4	78.6%	55.1%	29.0%	12.0%	4.4%
5	55.1%	29.0%	12.0%	4.4%	1.5%

Source: Authors.

5.2 Conclusion

The sandbox model used in this book is for people who have no option but to walk to public transport stations or stops. The model uses a sigmoid function validated by the literature. People are willing to walk to a certain point, which matches the idea in the TOD literature on relaxing LURs only in the area where people are willing to walk to the transit station. Nonetheless, this book questions this approach in the subsequent chapter.

The sandbox model is indicative, allowing the authors to estimate the impacts of LURs on potential public transport use. For example, the sign and slopes of the model's predictions are more important than the actual values. The model also allows for comparing different scenarios. However, the model is indicative, not predictive, because it does not predict actual behavior.

6

How Land Use Regulations Impact Transit Use

The sandbox model is used in multiple scenarios, beginning from a car-oriented baseline. This is followed by an examination of the impact on public transport ridership when one regulation is relaxed at a time.The study is supported by figures that illustrate the relationship between each factor/regulation.

6.1 Baseline Scenario: Car Oriented

The model starts with a car-oriented pattern, with wide avenues and local streets, small sidewalks, low FAR, significant setbacks, low plot coverage ratio, and minimum on- and off-street parking requirements (Table 6.1 and Figure 20). This scenario predicts that 4,398 people will use public transport. The population is 9,016 people in the 10X10 area. This population density is high, reflecting the high density in urban areas in developing countries. The model is indicative, and this value is a baseline.

Table 6.1 Baseline Scenario: Car-Oriented

I. Household characteristics		
1. People per Household		2
II. Human Factors		
1. Average Walking Speed (km/h)		3.7
2. Catchment Area Radius (in travel time distance-min)		15
III. 5x5 block Layout		
1. Land Use Zoning	1.1. Residential Area (%)	92
	1.2. Green Area (%)	8
	1.3. Commercial Area (%)	0
2. Public Transport		See Figure 5.1
3. Road Design	3.1. Number of Lanes on Main Road (except on-street parking lanes)	4
	3.2. Number of Lanes on Local Roads (except on-street parking lanes)	2
	3.3. Lane Width for Main Road (m)	3.5
	3.4. Land Width for Local Road (m)	3.35
IV. Land Use Regulations for (2,3) block		
1. Land Use Zoning	Residential Area (%)	100
2. Housing Density	2.1. FAR	1.5*
	2.2. Plot Coverage Ratio	0.4*
	2.3. Minimum Area per Dwelling Unit (m2)	100
3. Parking	3.1. Off-street Parking Minimums per Dwelling Unit	1*
	3.2. On-street Parking Lanes (width of 2.3 m)	2*
4. Sidewalk Width	4.1. Setback (m)	4.5*
	4.2. Pedestrian zone width (m)	1.5
	4.3. Street furniture zone width (m)	0

* Variables to change their range to see the impact of land use regulations on the public transport ridership
Source: Authors.

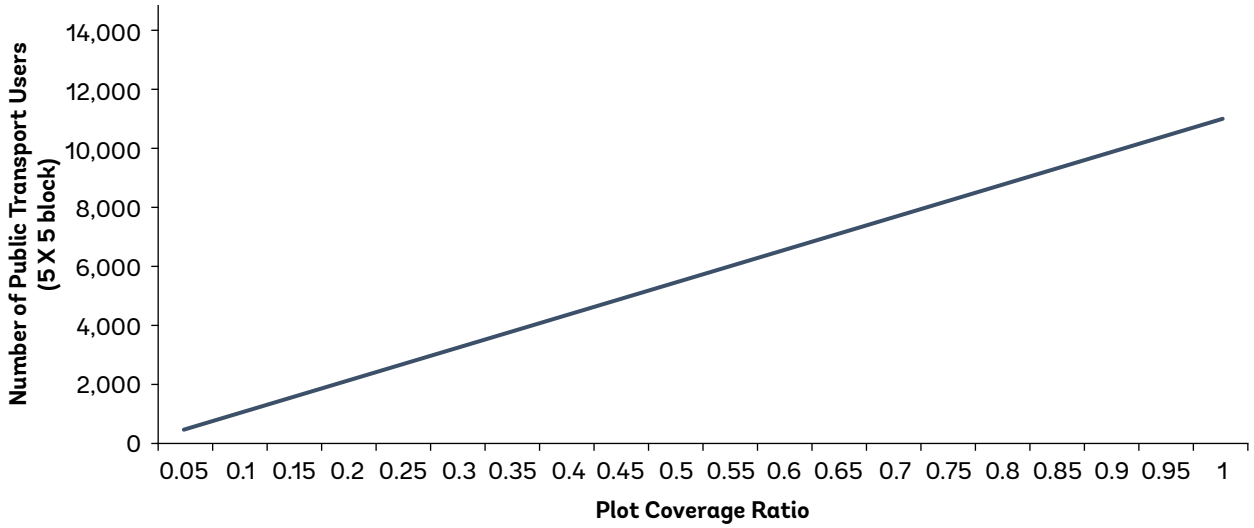
Figure 6.1 Images for the Car-oriented Scenario

Source: Arturo Ardila-Gomez.

6.2 Change in Plot Coverage Ratio

The plot coverage ratio determines the percentage of a land parcel the buildings can cover (Duarte, Stepner, Roberts, Dickson, & Rosenhall, 2010). It is among the most influential regulations and represents Euclidean zoning schemes to control housing density. The model shows that as the plot coverage ratio increases, the public transport ridership increases—a positive and linear association (Figure 6.2). A higher plot coverage ratio allows more dwelling units and residents, resulting in higher population density. The baseline had a plot coverage ratio of 0.4. If the value increases to 0.65 to reflect a public transport-oriented area, the public transport ridership increases to 7,112 users—a 62 percent increase. The population has increased to 14,536.

Figure 6.2 Plot Coverage Ratio and Public Transport Ridership

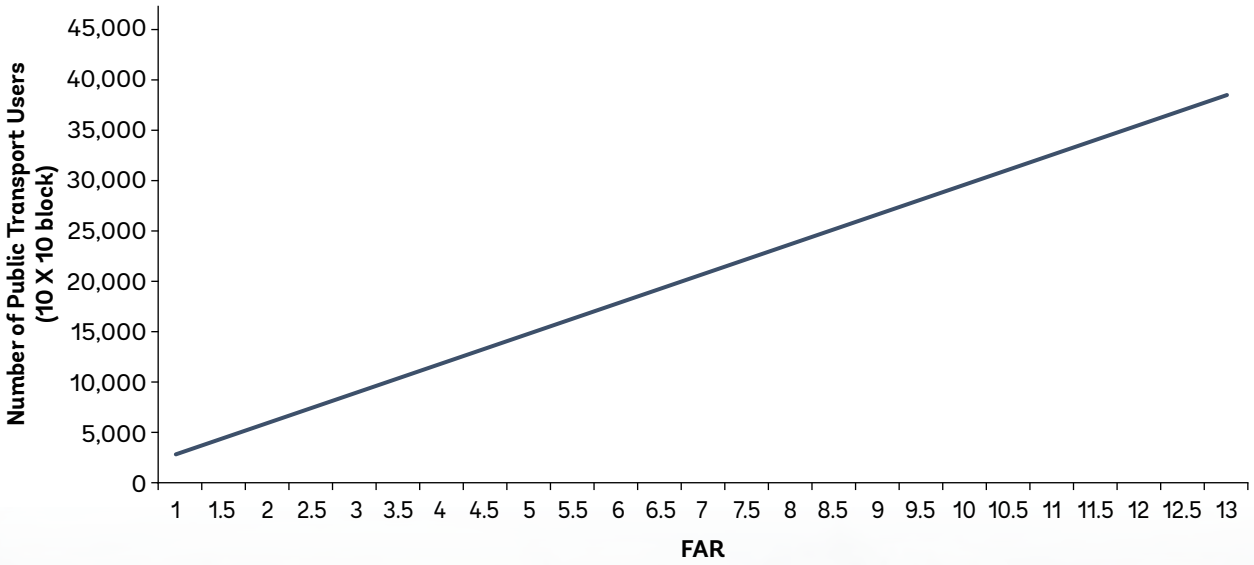


Source: Authors.

6.3 Change in Floor Area Ratio (FAR)

The FAR is the ratio of the total building floor area to the plot area. Higher FAR increases the available floor area. The model predicts that as the FAR increases, public transport ridership increases (Figure 6.3). The FAR in the baseline was 1.5, and the plot coverage was 0.4. A FAR of 4.0 results in 11,764 public transport users—a 167 percent increase with respect to the baseline. The population has increased to 23,920 residents. These results explain why the TOD literature uses FAR as the prime regulation—but ignoring the others can backfire, as explained.

Figure 6.3 FAR and Public Transport Ridership



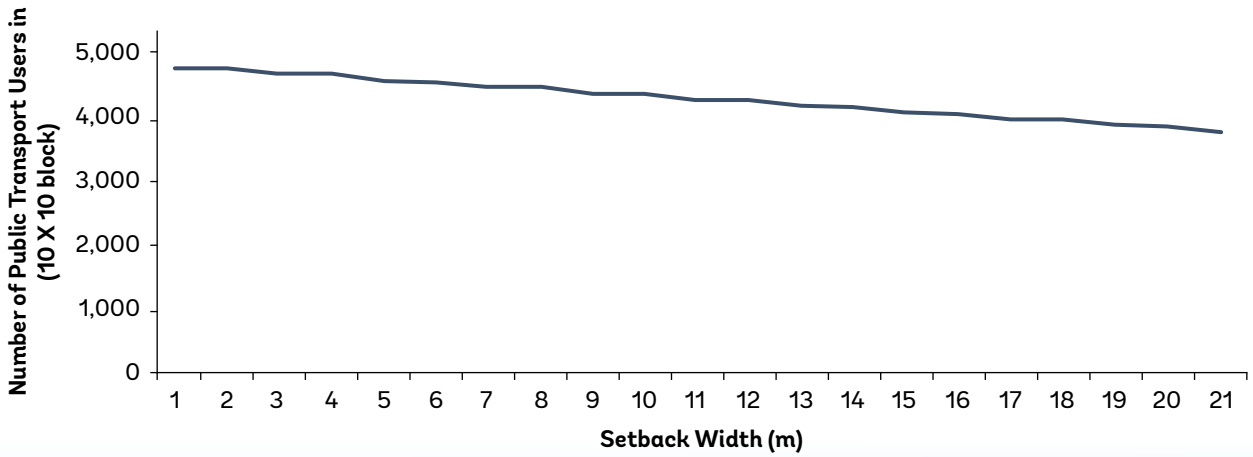
Source: Authors.

6.4 Change in Setback (Build-to-line)

Setback regulations mandate a minimum distance between buildings or a building and a property line (Duarte, Stepner, Roberts, Dickson, & Rosenhall, 2010). There are various setbacks, including front, rear, side, and parking. The frontage zone requires a space between the building façade and the property line or the sidewalk. One objective is to generate space between buildings so that windows on the side of the building are a minimum distance apart.

The model shows that setback regulations negatively affect potential public transport ridership (Figure 6.4). Setback requirements reduce the land available for dwelling units. They also increase walking distances because people must walk longer to get to the sidewalk, and from there to the public transport station. Notice that a plaza in front of a high-rise has a similar effect. The recommended maximum setback is only 0.5 m (Santos, Caccia, Samios, & Ferreira, 2019). When a 0.5 m setback width is assigned to all properties, the model predicts 4,804 public transport users—a 9 percent increase with respect to the car-oriented baseline. The number of residents increased to 9,752—an 8.2 percent increase. These results show why some cities with large setback requirements now allow building additional houses in the front yards and backyards.

Figure 6.4 Setback Width and Public Transport Users

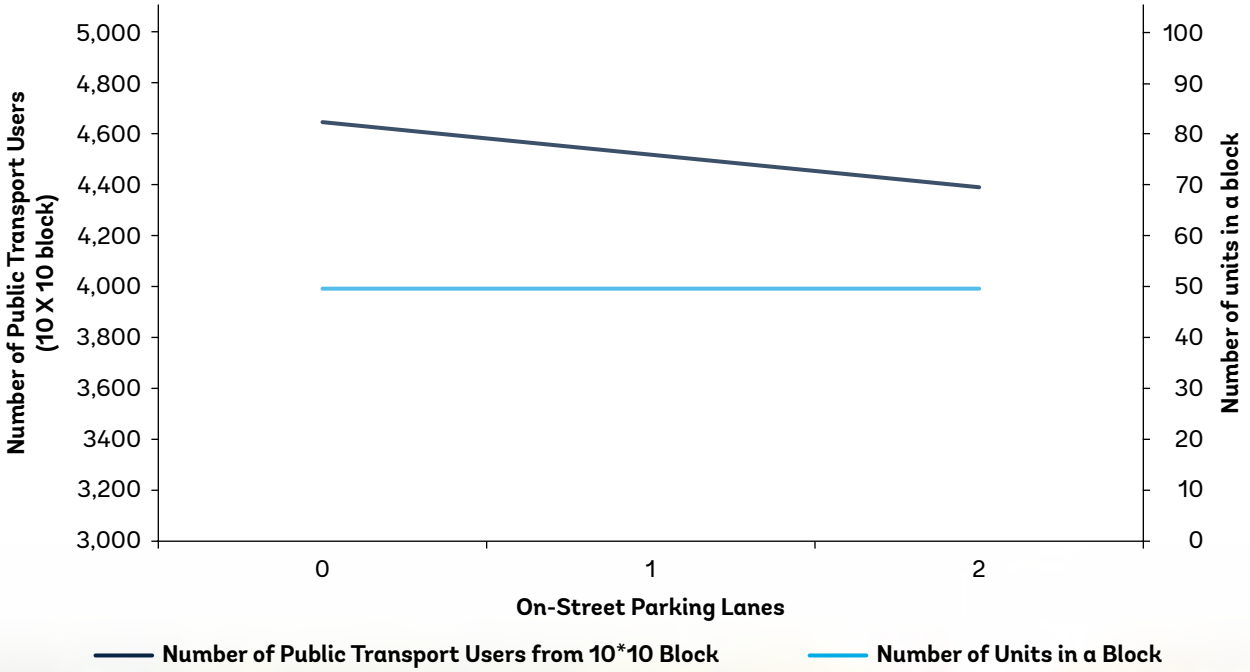


Source: Authors.

6.5 Change in On-the-Street Parking Mandates

On-the-street parking mandates widen roads because they allocate space for parking instead of circulation. The requirement can be zero, one lane, or two lanes, one on each side of the road. In the car-oriented development with a two-lane parking requirement on all roads, the model thus assumes that 29.1 percent of the total land is allocated for roads. When the requirement is one lane, this fraction allocated to roads is 27 percent, and when the requirement is zero lanes, it is 24.8 percent. Public transport ridership increases by 6 percent when the on-the-street requirement is zero lanes compared to two lanes. The population does not change because the on-the-street parking requirement changes road widths, not the area of the blocks (Figure 6.5). Additionally, by reducing land supply, on-the-street parking requirements can increase the cost of housing.

Figure 6.5 The Number of On-street Parking Lanes and Public Transport Users

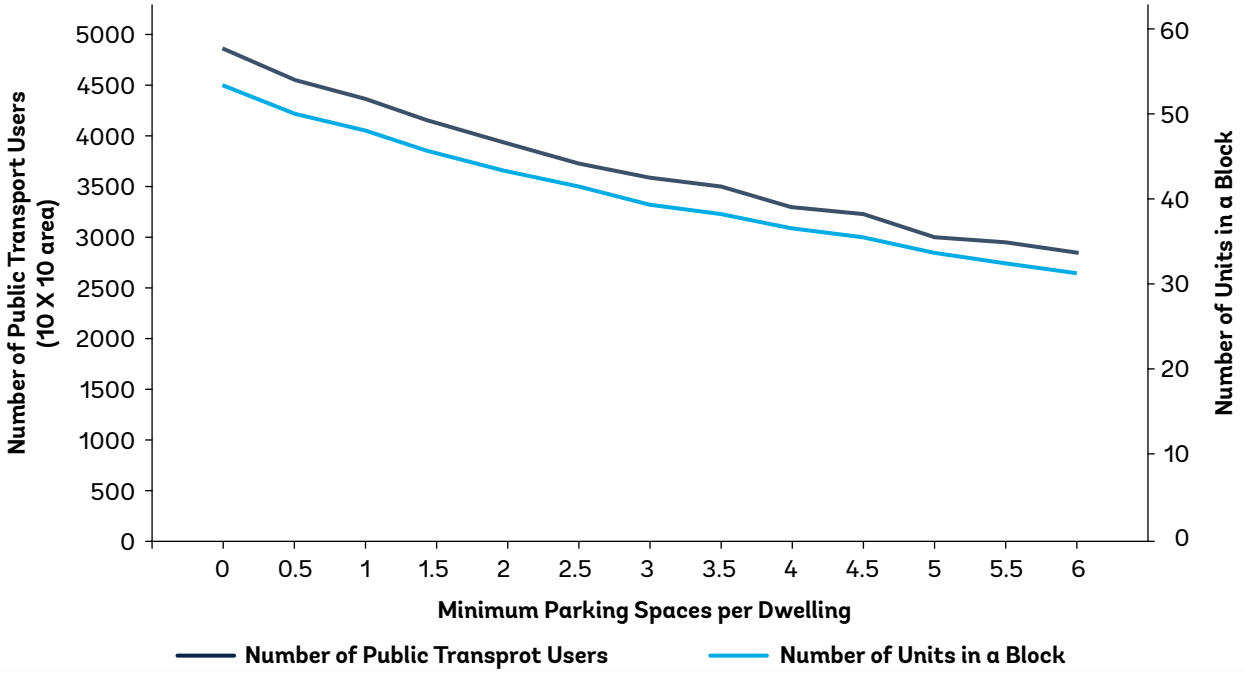


Source: Authors.

6.6 Change in Off-the-Street Parking Requirements

Parking requirements mandate the minimum number of parking spaces a dwelling unit must have. Some cities require off-the-street parking in addition to on-the-street parking. The model captures the interaction between this requirement and other LURs. The minimum parking requirement reduces the floor area built (Figure 6.6). Off-street parking mandates show a negative association with public transport ridership. The car-oriented baseline scenario had a one-parking-spot-per-dwelling requirement. Lowering the requirement to zero increases public transport ridership by 10 percent and increases the population to 9,936. A requirement of four parking spaces reduces ridership by 25 percent— and the population drops to 6,808 residents.

Figure 6.6 Parking Minimums and Public Transport Users



Source: Authors.

6.7 Modeling Long and Wide Blocks: Super Blocks

Finally, the model can change the block length and width to 250 m from 100 m. These blocks can be called superblocks due to their massive size. To show the results, the model uses the probability table shown originally in Table 5.1 for the 100X100 m blocks. This table shows the probability of walking to the station or bus stop in the 5X5 block quadrant. Table 6.2 shows the probabilities when the block is 250X250 m. The table highlights the probabilities below 50 percent. Notice the large number of blocks in Table 6.2 that have zero probability of people walking to the station. These blocks will become car-dependent. This result validates the Place Value that calls for frequent intersections, such as every 100 m.

An example of the superblock is a large urban compound because the arterials where public transport can operate are far apart. These arterials are also wider, generating a barrier effect (Calthorpe, 2022). People have to walk longer distances, provided the compound has good internal sidewalks. If walls surround the compound, walkability is negatively affected because walls create a barrier that does not meet the eyes on the street principle. People do not like walking by a wall (see Chapter 9). If designers met the minimum parking requirement by putting parking places between the sidewalk or the wall and the building, walking distances would be longer (see Chapter 7). The compound could have high rises and high density, but the longer distances discourage walking to public transport—aggravated by a wall. The development becomes car-oriented despite the density—even if it has a metro station close by. This urban development pattern is known as high-density sprawl (Calthorpe, 2022).

Table 6.2 Percentage of Residents in Each Block Willing to Walk to the Public Transport Station of the 250x250 m Superblocks

j \ i	1	2	3	4	5
1	99.0%	87.9%	34.8%	3.8%	0.3%
2	87.9%	34.8%	3.8%	0.3%	0.0%
3	34.8%	3.8%	0.3%	0.0%	0.0%
4	3.8%	0.3%	0.0%	0.0%	0.0%
5	0.3%	0.0%	0.0%	0.0%	0.0%

Source: Authors.

6.8 Conclusion

The stylized sandbox model shows how land use regulations affect public transport ridership in the 10X10 neighborhood, which has two main streets, local streets, and 8 percent green or park space. The model stylizes the potential impacts on ridership resulting from different LURs. The model is indicative, not intended to predict.

The model shows that public transport ridership increases as the plot coverage ratio and the FAR increase. Increasing the FAR is critical, validating the emphasis the TOD literature places on this regulation. The model also shows an inverse relationship with the setback requirement. Large setback requirements generate a car-oriented pattern because they lower density and increase the distance people must walk to access the sidewalk and then walk to the transit stop.

The model shows how on-the-street parking requirements occupy land that could be used for housing. Reducing these requirements will increase the housing supply and reduce prices, improving affordability. Off-the-street parking requirements—all other things constant—reduce space for people because of the need to allocate space for cars. The nascent trend to reduce and even eliminate parking requirements is reasonable and will improve housing affordability. However, reducing and eliminating parking requirements should happen in the context of a sound parking policy that includes better pricing and incentivizes the private sector to invest in formal parking (Ardila-Gomez, Bianchi Alves, & Moody, 2021). Chapter 10 expands on these points.

Finally, frequent intersections increase walkability, while superblocks reduce it—generating even car-oriented islands. Large compounds generate the superblock. Walls and parking between the sidewalk and the buildings aggravate the situation. Large, high-density compounds surrounded by walls and parking lots result in a car-oriented development, even if a metro station is nearby—high-density sprawl.

7

How Multiple LUR Changes in Parallel Impact Transit Use

As multiple regulations shift together in the sandbox model, they create a kaleidoscope of potential futures. Each scenario unfolds like a choose-your-own-adventure for city planners, revealing unexpected synergies and surprising outcomes. Navigate through this complex web of cause and effect to witness the intricate interplay between various factors.

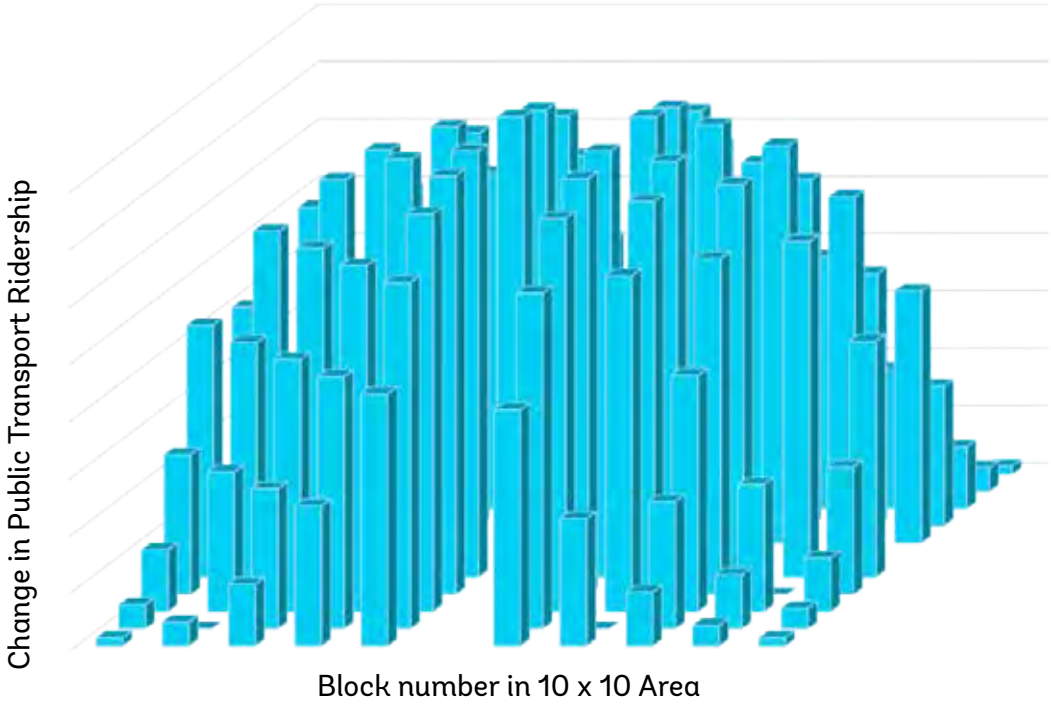
7.1 Transit-Friendly Scenario

Now compare the car-oriented baseline scenario against one that seems transit-friendly—inspired by the TOD literature. The setback is only 0.5 m. The FAR is 4.0, and the plot coverage ratio is 0.60. Parking requirements are zero, which means the market will decide how many spaces to provide—maybe only for visitors because public transport is good, to increase affordability, or both.

The bars in Figure 7.1 show the *increase* in ridership due to the pro-public transport regulatory mix compared to the car-oriented scenario. Ridership in the car-oriented baseline was 4,398 users for the 10X10 area, and the population was 9,016 people. Total ridership increases to 23,008 in the pro-public transport scenario—a 420 percent increase. The population increases from 9,016 to 40,208—resulting in a density of 400 people per Ha.

This simple simulation shows the value of the approach to understand how regulations and their mix impact the number of people willing to walk to a public transport stop or the entrance to a mass transit system. Indeed, Figure 7.1 reflects one LUR mix. There are many others because LURs interact with one another. Generally, a higher plot coverage ratio and FAR increase public transport ridership because population density increases. Lower setback and parking requirements also increase ridership. The model did not include other regulations, such as maximum building height or maximum dwelling units per area. The inference is that capping the building height can erase the gains from a higher plot coverage ratio and FAR, which is the same for capping the dwelling units.

Figure 7.1 Change in Public Transport Ridership Between Pro-public Transport and Car-oriented LUR



Source: Authors.

Furthermore, the larger differences in transit users closer to the station, represented by the longer bars, could be interpreted as a call to have transit-friendly LUR close to the entrance to the mass transit. However, the model has the same transit-friendly LUR in all areas, not just around entrances to mass transit or bus stops. Therefore, transit-friendly LUR should be allowed in all blocks. Transit-friendly LUR will allow market forces to work—specifically, developers target market segments. For example, a building with a small apartment—25 m2—will cater to young people willing to walk longer distances. This building could benefit from a high FAR and high plot area ratio. The resulting high-rise could be on the farthest away block. If this pattern continues, demand for public transport will increase on the boundary of the 10X10 used in the model. New public transport could start because it is feasible owing to higher ridership (Figures 7.3 and 7.6).

7.2 Modeling an Informal Settlement

Informally-developed areas have high densities (Kit, Ludeke, & Reckien, 2013). Formal housing has lower densities and still supports public transport. With respect to the previous scenario, the plot coverage ratio is increased to 0.85 to reflect the intensive use of land in these areas. Total Ridership increases to 31,954 in the informal settlement scenario—a 527 percent increase with respect to the car-oriented baseline. The population increases from 9,016 to 61,824—resulting in a density of 670 people per Ha—seen only in informal areas.

The high densities in informal areas show crowded conditions with little floor areas per person, contrary to lower densities with higher floor areas per person in formal areas. For example, Kinshasa has an average density of 40,167 people per square kilometer, and Hong Kong has 44,992. If density is measured instead in terms of built space—floor area—then Kinshasa has a density of 19,618, and Hong Kong has a density of 7,163 (Lall S. , Lebrand, Park, Sturm, & Venables, 2021). The quality of the built floor space matters.

7.3 Barcelona's Superille—Super-Island

Barcelona started implementing in 2002 the superille—super-island—plan. The English literature calls them super-blocks, but this book adopts a literal translation from Catalan. The superille plan creates islands of pedestrian- and bicycle-oriented neighborhoods, served by a grid of bus routes integrated with the metro. The bus routes operate on roads 400 m apart on arterial roads that are also used by cars. There are north-south and east-west routes. The objective is for people to walk a maximum of 200 m—exceptionally 300 m—to access a bus that can take them to the metro ((Bausells, 2016), (Collins, 2023) and (Nieuwenhuijsen, et al., 2024)). Figure 7.2 shows the map of bus routes in Barcelona. The LUR also promote public transport use in Barcelona. The city is dense, with areas reaching 32,000 inhabitants per kilometer square—320 per hectare (ITDP , 2024).

To understand the effective design of this route plan, revisit Table 5.1 with the probabilities used by the model. The first two columns and rows have the highest probabilities for the blocks 100 and 200 m away from the public transport stops. If there are bus routes every 400 m, there are stops on each corner of the superille. The probability table looks like these first two columns and rows, as shown in Table 7.1. Figure 7.3 shows the resulting demand pattern—akin to a deep-dish pizza because

the ridership estimates are high for all blocks. Ridership increases by 36 percent with respect to the transit-oriented scenario due to the density and convenience of the public transport service. The comparison uses 4x4 blocks to be consistent.

Figure 7.2 Map of Bus Routes and Entrances to Metro Lines in Barcelona (Section)

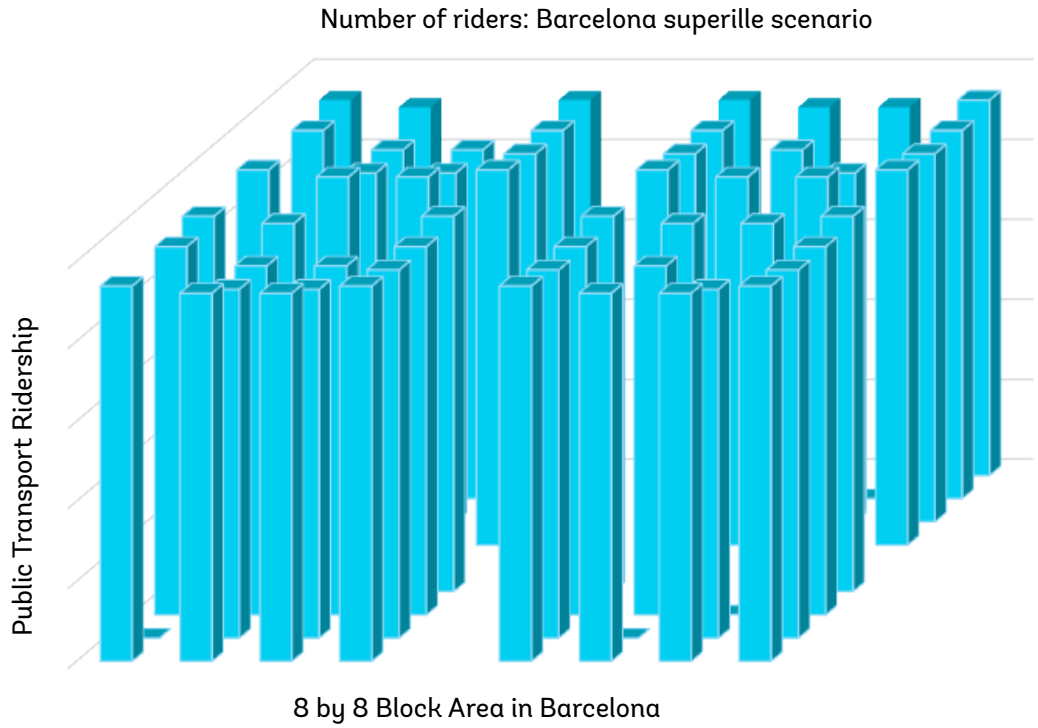
Source: https://www.tmb.cat/documents/20182/96078/Pl%C3%A0nol+xarxa+bus.pdf/9b5bfa95-6117-4117-9843-fb3e3fde5447?t=1673959629000.

Table 7.1 Probabilities of Walking to the Bus Stop or Mass Transit Entrance

j \ i	1	2	3	4
1	99.0%	97.0%	97.0%	99.0%
2	97.0%	91.2%	91.2%	97.0%
3	97.0%	91.2%	91.2%	97.0%
4	99.0%	97.0%	97.0%	99.0%

Source: Authors.

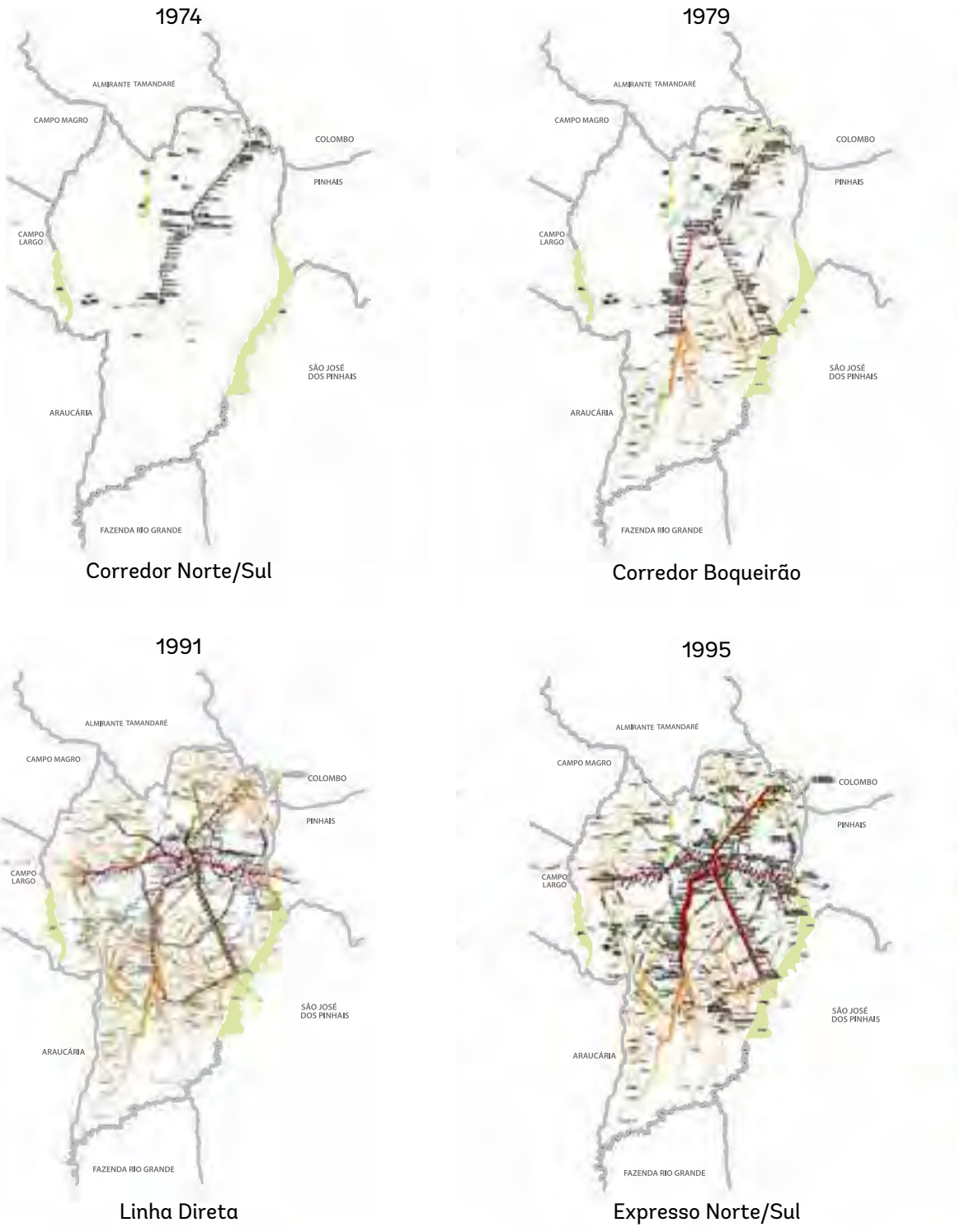
Figure 7.3 Model Forecast for the Barcelona Superille (Super-island Concept)



Source: Authors.

The city of Curitiba (Brazil) is also internationally recognized because of its TOD approach. Curitiba innovated by implementing busways that gave exclusive lanes for buses in the early 1970s. The selected corridors had high density, which the plan allowed to increase due to market pressure—it was convenient to live close to the busways. As demand grew, planners developed the bus rapid transit (BRT) concept by building stations from which passengers enter the buses at grade. Not having to climb steps, passengers take one-eighth of the time to enter the bus. BRT emulates metros. Curitiba also has feeder buses. The result is a dense network of bus routes, feeders in mixed traffic, and trunk buses in exclusive busways with stations. There are integration terminals, and fares are integrated, allowing people to pay once and transfer as needed. People walk short distances to get to a bus, leading to high ridership figures—about two million per day. (Ardila-Gomez, 2004). Figure 7.4 shows the evolution of Curitiba's Integrated Transit Network (Rede Integrada de Transporte).

Figure 7.4 Evolution of Curitiba's Integrated Transit Network—Trunk and Feeder



Source: (Borges & da Silva, 2021) using data from www.urbs.curitiba.pr.gov.br.

7.4 Plans for High FAR

The model allows planners to test proposals with high FARs. In Chapter 4, the definition of FAR showed a 101-story building in Shanghai with a FAR of 13.5. What happens when FARs approach or surpass that level? Table 7.2 shows the results, comparing them against the car-based scenario. The only changes are the FAR and the plot coverage ratio. The on- and off-street parking requirements and the setback remain the same in the car-oriented scenario. The results suggest these FAR values will result in high densities above informal areas. If they materialize, mass transit will be the only way to provide mobility. Cars will clog the streets.

However, FAR is a maximum value. Developers can choose a lower one. Moreover, tall buildings embed diseconomies of scale because every additional floor means a stronger structure for all the floors below. These diseconomies explain why informal areas develop with houses up to three stories high. High-rises are for wealthier people who can afford the higher prices. High-rises for wealthier people are good because they use less land than if people lived in houses. These savings free up land for other users and lower the price of land. Therefore, for these high FARs to materialize, economic growth is critical because it raises income per capita. (Lall S., Lebrand, Park, Sturm, & Venables, 2021). Yet, the density would be so high that mass transit is a must.

Table 7.2 also shows a regulatory tradeoff seen in some plans that allow a higher FAR but mandate a lower plot coverage ratio. The High FAR scenarios 2 and 4 in Table 7.2 show that the population, ridership, and density remain the same because when the FAR is double, the plot coverage ratio is halved. However, scenario four will lead to thin towers surrounded by plazas that could reduce walkability, as explained in section 7.5. The same will happen for scenario 3—and likely for the other scenario, given the high FAR values.

This result would be benign. There is, however, the interaction of the FAR and plot coverage areas with other regulations, such as minimum plot size. Assume the regulations allow development on plots with areas larger than 5,000 square meters. Further, assume that the existing plots are small, about 20 in the 5,000 square meters and that consolidating land parcels in the cadastre takes years. The result would be zero buildings of any height developed. Urban development would be frozen because developers cannot reach the 5,000 square meter minimum easily. While the FARs are huge, other regulations lead to zero development. The demand for these high-rises would be unsatisfied. Urban development would happen in other areas of the city where regulations are more flexible, expanding the urban footprint.

Table 7.2 High FAR Scenarios

Scenario	Floor Area Ratio	Plot Coverage Ratio	Population	Estimated Ridership	Population Density
Car-based	1.5	0.4	9,016	4,398	90
High FAR 1	7.0	0.8	84,272	41,734	598
High FAR 2	14.0	0.5	105,248	52,132	746
High FAR 3	20.0	0.38	114,264	56,600	810
High FAR 4	28.0	0.25	105,248	52,132	746

Source: Authors.

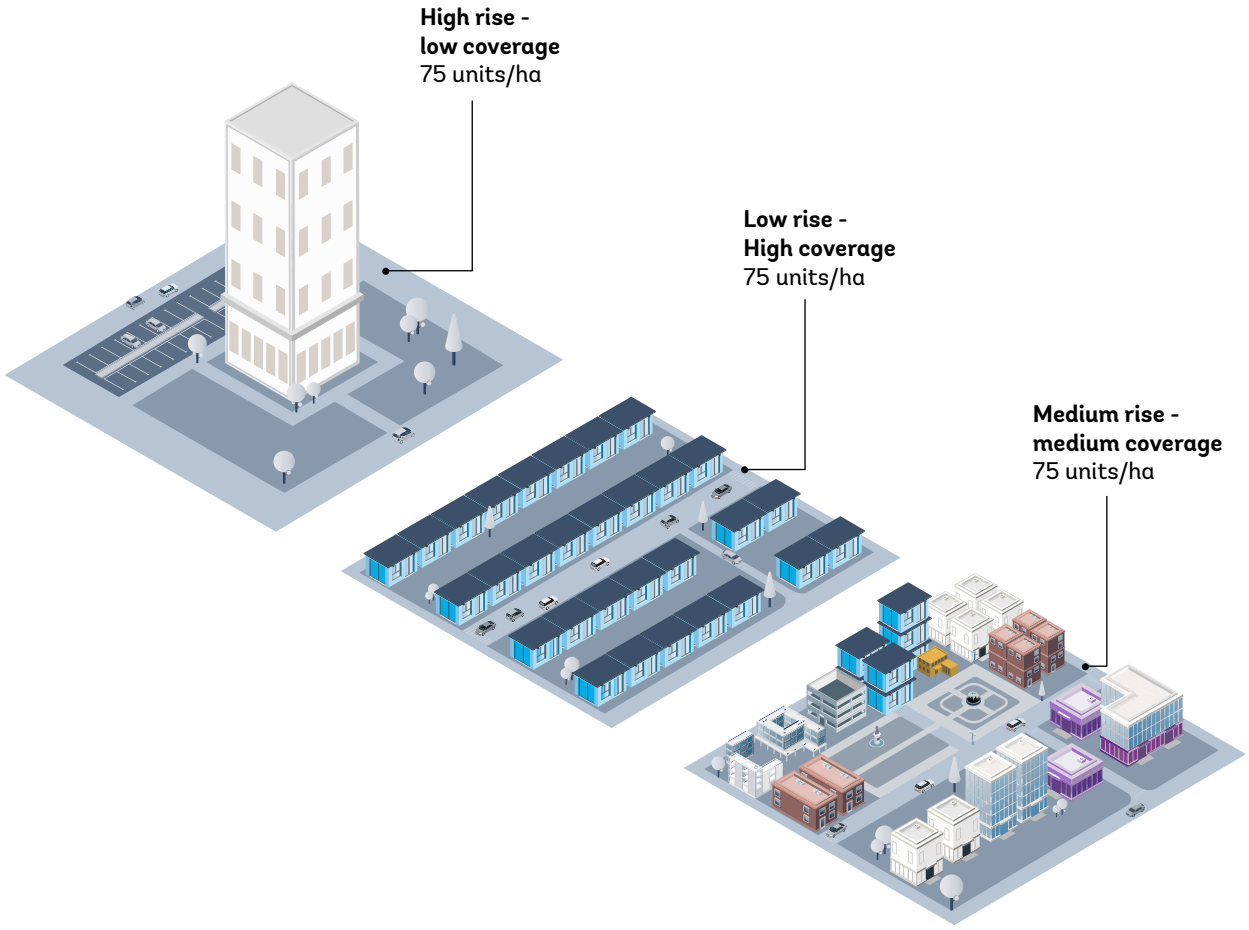
7.5 An Example of FAR, Plot Coverage, Setback, and Parking Requirements

The interaction between LUR can result in different urbanization patterns with the same density (Figure 7.5). The high-rise on the top left of the figure has a high FAR, low plot-coverage ratio, and a high off-the-street parking requirement. Assume that meeting the parking requirement does not count toward the plot coverage ratio—only the high-rise counts. The sidewalk that faces the parking reduces the walkability and attractiveness (see Chapter 10). The big plazas in front of the building also reduce walkability because, like the parking plot, the distance between the building and the sidewalk is too long, violating the eyes on the street principle. This principle is explained in detail in Chapter 9. Finally, the high-rise building is the least affordable because of diseconomies of scale—each floor added implies reinforcing the entire structure. Another drawback is the lack of mixed land use—maybe the zoning allows stores on the first floor. However, the stores would rely only on clients from the high-rise because outside clients must walk long distances to get to the only entrance.

The next pattern is the low-rise, high-coverage pattern that has the same FAR and a higher plot coverage ratio. There is zero setback between houses, which is common in townhouses in the US. The setback requirement is in the front of the house. The pattern meets the eyes of the street idea toward the sidewalks and the alleys. This example shows that setbacks can help, depending on the context. The alleys allow small plots that make this pattern affordable. Many public housing projects emulate this approach. Some alleys have on-the-street parking. The other alleys could become pedestrian-only, turning into parks and playgrounds. The drawback of this pattern is the lack of mixed land use unless the zoning is like in Japan, allowing shops and offices in all houses if they choose to have them.

Finally, the medium rise-medium coverage development in Figure 7.5 has the same FAR, a plot-coverage ratio between the two other examples, and different setback requirements. The zoning allows mixed land uses. The pattern increases walkability on all sides of the block because of the many doors meeting the eyes on the street—see and be seen—principle. The shops will have clients from the block itself and neighboring areas, making them economically feasible. This development is also more affordable than the high-rise but less than the previous pattern. Notice the mid-block service road that allows smaller lots, as in the high-coverage pattern.

Figure 7.5 Three Different Configurations Result in the Same Density but Different Walkability



Key

Target a mix of activities include a variety of house types

- Community facilities
- Houses
- Shops and workspaces
- Apartments
- Maisonettes

Source: (Rogers, 2015).

7.6 Consequences of Limiting the Supply of Floor Space

The model in this book estimated the impact of five regulations, from FAR to minimum parking policy requirements, and their interaction. There are many LURs beyond these, such as minimum plot size and minimum unit—house or apartment—size, maximum height, maximum number of units per block, etc. When LUR limits the supply of floor space, there are consequences. Figure 2.6 depicts a rigid regulation that is unresponsive to prices. No matter the price, the supply of built space remains constant. Any increase in demand leads to an increase in the prices of the built floor space area. The wealthy can pay, but the less well-off are priced out (Bertaud & Brueckner, 2005); (Bertaud, 2018), (Glaeser, 2011) ; (Gray N. , 2022).

(Tsivanidis N. , 2019) shows that Bogota (Colombia) authorities did not adjust the zoning and the FAR to satisfy the increased demand by people who wanted to move closer to the high-capacity Bus Rapid Transit (BRT). This BRT increased access opportunities. This author found that "the welfare gains would have been around 40 percent higher had the government implemented a more accommodative zoning policy".

In Bogota, in addition, the BRT system operated at high congestion levels due to pronounced pendular movements from residential to employment areas. Serving this peak required a large fleet to provide service during the morning peak, overwhelmingly heading to the central business district (CBD). The off-peak hours required a much smaller fleet. Boardings at stations in the morning peak were higher in high-density residential areas and in the afternoon in areas with high employment density. However, boardings were lower when housing and jobs were mixed in the same zone (Guzman & Gomez, 2021). If zoning and land regulations had allowed mixed land uses, then many people would work close to their houses, reducing travel demand. Work areas beyond a central business district also allowed reverse flows from the CBD to the residential areas, balancing the load and improving the financial equation for the transit system. Bogota's updated urban master development plan allows mixed land uses almost everywhere, correcting this regulatory distortion (POT, 2021).

In effect, separating land use is one of the main factors that cause urban sprawl and car-oriented development (Hall, 2006). This literature recognizes the results of zoning and related LUR (e.g., minimum plot size), specifically for the residential areas, triggering urban sprawl and car-oriented development (De Vos, 2015); (Priemus, Nijkamp, & Banister, 2001). Distances are too long to walk, locking in car use. Politicians and planners propose urban expressways to serve the large volume of cars. Meanwhile, low-income households are priced out and contribute to income segregation (Christafore & Leguizamon, 2019) and informal urban development (Davis, 2004); (World Bank, 2020).

There are other economic consequences when zoning and LUR limit the supply of floor space. For example, (Hsieh & Moretti, 2019) analyzed the impacts of zoning and land use regulations. They found that by capping supply and increasing housing prices, zoning and LUR slowed down economic growth in the US. "We conclude that local land use regulations that restrict housing supply in dynamic labor markets have important externalities on the rest of the country. Incumbent homeowners in high-productivity cities have a private incentive to restrict the housing supply. By doing so, these voters de facto limit the number of US workers who have access to the most productive American cities. In general equilibrium, this lowers income and welfare of all US workers."

(Lall S., Lebrand, Park, Sturm, & Venables, 2021) echo this view, saying, "Regulations, such as floor-area restrictions (FARs), can be economically counterproductive by limiting density (residential and commercial) and by lengthening commutes. Zoning restrictions can be damaging if they lock in patterns of land use that become inefficient as a city develops." For example, single-family detached housing generates long commutes that demand massive infrastructure to tend to rush hour.

Zoning and LUR can have negative consequences when they limit the supply of built space. A better approach is to adopt mixed land uses, as in Japan, from the outset. Mixed land uses increase the placemaking value because some people can walk to run errands or even work. Mixed land makes the area more attractive for others to visit.

7.7 Conclusion

While adopting a regulatory mix inspired by the TOD literature, the model reflected a supportive public transport scenario. The changes with respect to the car-oriented scenario were significant—the ridership estimate increased by 420 percent. The model also reflected informal settlements with high densities. These areas have precarious roads that do not allow public transport service, as explained.

The model was able to reflect the Barcelona Super-Illes. Barcelona is an example in the literature because its density and layout support public transport and walking. (Bertaud, 2003) compares Barcelona against Atlanta in the United States:

> "Atlanta and Barcelona have about the same population; both cities have recently emerged as regional economic powerhouses; both cities recently hosted the Olympic Games. However, the spatial structures of the two cities are extremely different: the average built-up density of the Barcelona metropolitan area (171 p/ha) is 28 times larger than Atlanta's (6 p/ha). The difference in density implies that in Atlanta, the area covered by the transport network has to be 28 times larger than in Barcelona while carrying about the same number of people.
>
> The metro network in Barcelona is 99 kilometers long, while 60 percent of the population lives less than 600 meters from a metro station. Atlanta's metro network is 74 km, not so different from Barcelona – but only 4 percent of the population lives within 800 meters of a metro station. It would not be a surprise if, in Atlanta, only 4.5 percent of trips are made by transit vs. 30 percent in metropolitan Barcelona, where the high density also allows an impressive 8 percent of all trips to be walking trips.
>
> Suppose that the city of Atlanta wants to provide its population with the same metro accessibility that exists in Barcelona, i.e., 60 percent of the population within 600 m from a metro station. Atlanta would have to build an additional 3,400 kilometers of metro tracks and about 2,800 new metro stations. Such an enormous new capital investment would allow the Atlanta Metro to potentially transport the same number of people that Barcelona does, with only 99 kilometers of tracks and 136 stations. In short, the effect of density on the viability of transit is not trivial."

Therefore, the model developed in this book, using TOD parameters for the LUR and the walkability assumptions, predicted a dense, walkable, and transit-oriented city such as Barcelona (Figure 7.6 and 7.7). The model proved, moreover, that the TOD suggestions for FAR and plot area coverage are reasonable and will allow an emerging city to grow with higher density. For example, in 1990,

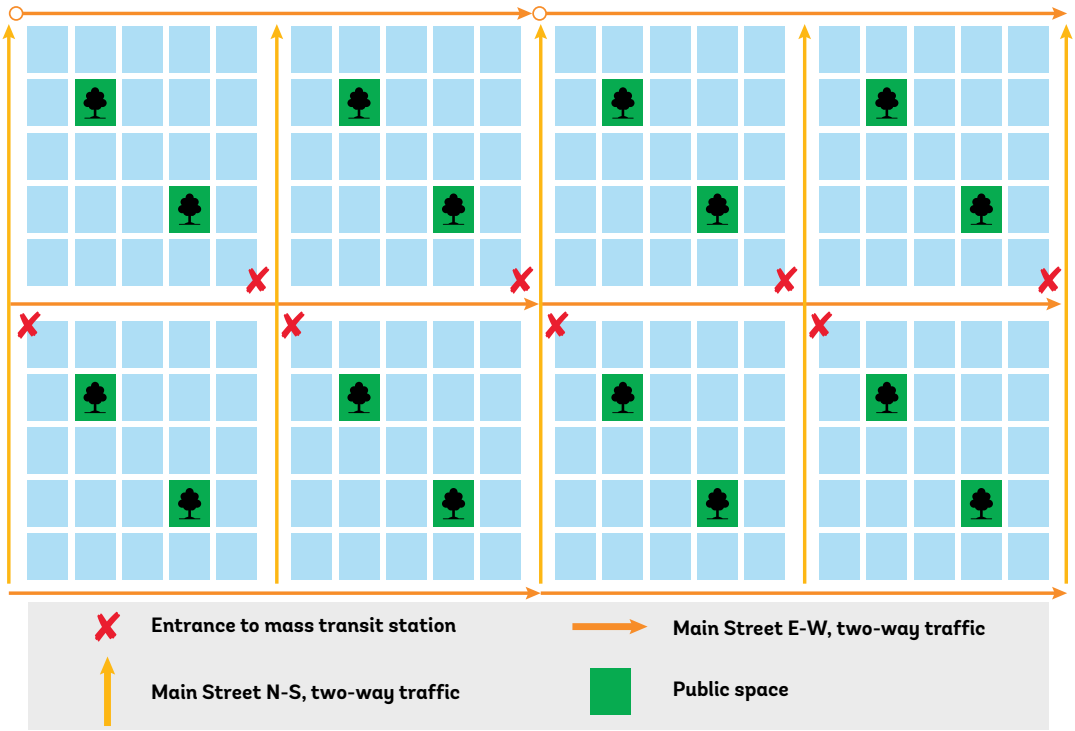
Barcelona occupied an area of 162 km² for 2.8 million inhabitants—compared with Atlanta, which occupied 4,280 km² for 2.5 million people.

Barcelona also has a street network like the one used in this book. The model assumed 100-meter blocks and roads with sidewalks to reflect minimal walkability conditions (Figure 7.6). Barcelona planned its future road network in 1860, when walking was the primary way to access opportunities and public transport was horse-drawn carriages—the first horse-drawn tramway opened in 1872 (Sabate, 2020).

The model also analyzed high FAR, which resulted in high densities. However, the intersection of LUR can disincentivize developers from building these tall buildings because of the minimum plot requirements that could be difficult to meet. The ultimate result is no development in the area where this regulatory mix applies.

The chapter also analyzed three examples of regulatory mixes that result in the same density. Density is critical for public transport to be feasible and convenient. However, a high-rise building surrounded by parking becomes a car-oriented development because the parking discourages walking by breaking that "eyes on the street" principle. The effect is worse if a fence surrounds the high-rise, as shown in Chapter 6). The TOD parameters used in this chapter will result in adequate density and pedestrian-friendly urban development, particularly when mixed with recommendations from the Form-Based Codes, such as mixed land use, short setbacks, frequent doors and windows at the street level, and wide sidewalks.

Figure 7.6 Public Transport is More Feasible if there are Transit-friendly LUR in All Blocks



Source: Authors.

Figure 7.7 Image of Barcelona

Source: Freepik https://www.freepik.com/free-photo/aerial-view-eixample-district-barcelona-spain_1583870.htm#query=barcelona%20aerial%20view&position=0&from_view=keyword&track=ais&uuid=2f1f059a-48c3-4fe9-ae42-072173906566"Image by bearfotos on Freepik.

8

Modeling Growth Scenarios in Search of a Compact City

In the race against urban sprawl, can a city transform its destiny? The sandbox model takes on this challenge, charting the course of a burgeoning metropolis from a modest 500,000 residents to a bustling 5 million. Delve into the combinations that can shrink a city's footprint while expanding its potential. Explore how a car-dependent community can evolve into a model of efficiency where public transport and walkability take center stage.

8.1 Four Scenarios

The baseline is a 500,000-person, car-oriented city, as shown in the baseline model Chapter 6, which results in a density, including road area, of 63.9 people per hectare. The city's footprint is 7,825 hectares (= 500,000/63.9). The city does not have a downtown or business district. The sandbox model is for a housing suburb. This modeling approach does not invalidate the model because fewer items are varied at a time. Adding a business district would introduce changes that complicate the analysis.

The first scenario is the do-nothing one, where the LUR and density remain constant over time. This scenario captures vested interests and Not-In-My-Backyard (NIMBY) behavior that prevents LUR from changing. These interests see upzoning—increasing FAR, plot coverage ratio—as something that could be negative because they benefit from limiting the housing supply.

The second scenario assumes that the suburb benefits from a metropolitan mass transit line. The city adopts TOD policies. (Ollivier G., Ghate, Bankim, & Mehta, 2021) are used to define this scenario as increasing the FAR from 1.5 to 3.0, the setback is 0.5m, and the plot coverage ratio to 0.6 from 0.4. The parking policy is market-led. The scenario assumes 0.25 parking spaces per housing unit in the TOD area and 1.0 in the car-oriented area. The on-street parking is one lane devoted to parking on all roads in the TOD area and 2.0 in the car-oriented area. Following TOD principles, the FAR is higher on the mass transit corridor and lower outside it. After five blocks in each direction perpendicular to the transit line, the LUR changes into the car-oriented scenario. Figure 6.6 illustrates the scenario based on the Arlington example. The car-oriented area does not change its LUR compared with the base scenario. This assumption is realistic because there are cases, such as Arlington, that reflect it due to the vested interests and NIMBY (see Box 4.1).

The Barcelona super-island model inspires the third scenario. Each super-island has 4X4 blocks instead of 5X5, which is used in the sandbox model. The block length and area are the same as in the original model. Having an arterial road every 400 m instead of 500 m increases the total area devoted to roads.

The fourth scenario follows the Barcelona approach but with the 5X5 super-island. This scenario is more affordable because less land is allocated to roads.

These last two scenarios assume one mass transit line as in the TOD scenario to minimize the number of changes and facilitate comparisons. The transit line extends in length as the city's population increases in these three scenarios. These scenarios use the same FAR and LUR for the area of influence of the mass transit line as in the TOD scenario. However, the TOD scenario has NIMBYs that do not allow further change in the LUR beyond the transit corridor, generating low-density areas around. The two Barcelona-inspired scenarios relax this approach by assuming that the LUR allow higher densities in the expansion area. Market forces can operate better, reflecting demand. For a total population lower than 3 million, the density outside the transit corridor will increase to half the value in the transit corridor. Once the city surpasses 3 million people, the model assumes the LUR allow density to increase to 75 percent of the value in the TOD corridor. Assuming a single mass transit line simplifies the analysis. However, because density is also higher in the area outside the TOD corridor, planners could justify a second mass transit line that would allow even higher densities. A corollary is that adopting TOD principles from the outset for the entire area would generate a virtuous cycle, as explained below.

8.2 The Modeling Approaches

The sandbox model can estimate the number of residents—keeping the two-person household constant—and the density for a 10X10 segment—8X8 for the Barcelona scenario. The entire city is a square built of 10X10 or 8X8 sections—and a fraction in the margin. Using the population for a 10X10 segment, the module calculates the length of the square that fits the city. This provides the initial length for the mass transit line.

The TOD scenario doubles the FAR and increases other parameters, resulting in higher density on the mass transit corridor. The model calculates this population and subtracts it from the total for the horizon year. This residual value is the population that will live in housing under the same LUR as in the car-based scenario. The two Barcelona-inspired scenarios follow a similar approach, except that the population outside the area of influence of the mass transit corridor will live in higher density than in the car-oriented and TOD scenarios.

The Barcelona-inspired scenarios have public transport stops every 400 and 500 m. The car-based and the TOD scenarios have stopped every 1.0 kilometers, which is the assumption in the sandbox model. This changes the probability tables that determine if people are willing to walk to the stop (see Tables 7.1 and 8.1). This approach models a hierarchically integrated transit system (HITS) with a mass transit line, such as the trunk and feeder buses that reach stations and offer service in between, as in Barcelona. This modeling is necessary to answer this book's leading question—What transport and land-use policies allow a city without transit to grow into a transit-oriented city that relies on public transport and walking? A HITS is part of the answer. This approach penalizes the TOD scenario because TOD literature is aligned with the idea of a HITS. The results will show the significance of achieving physical and fare integration, making transferring seamless.

8.3 The Results: Toward a Compact City

The car-oriented scenario results in sprawled urban development with a constant density as the population grows. The results for the TOD scenario, or the second one, show the value of this policy because the city-wide density increases—the table does not show the density value on the TOD corridor, but it is higher. When the city reaches 5 million inhabitants in the year 50, the TOD policy would have saved 11 percent of the land (Table 7.2) with respect to the car-based scenario.

The first Barcelona scenario (400 m, 4X4) saves an additional 58 percent of the land required to house the population compared to the TOD scenario. This result shows the value of liberalizing zoning and LUR throughout the city and not just on the TOD corridor. The assumption all along has been that developers will use the maximum FAR. Chapter 2 highlights that developers will likely supply a higher density by the public transport line and lower as they move away. Still, developers could identify market segments that are willing to walk more and would build for them if the regulations allow them, which validates the modeling assumptions.

The second Barcelona scenario (500 m, 5X5) shows additional land savings of 6 percent compared to the previous one. The savings come from the lower area devoted to roads. Arterials are expensive, and Chapter 3 outlines how cities are building fewer of them, which is a problem because distances to these few arterials increase. The last section of this chapter analyzes the implications of the

lack of arterials. Arterials every 500 m, coupled with a HITS, result in the compact city for all the 10-year periods modeled. City-wide inclusive zoning and LUR increase the supply of built-up areas, preventing sprawl and increasing affordability.

The modeling also validates the literature that states that denser cities need shorter mass transit networks ((Bertaud, 2003) and (ITDP , 2024)). The TOD scenario started in Table 8.1 for a one-million-person population with a 10.5-km long mass transit line; the Barcelona 500-meter system needed only 7.5 km. For the five-million-person population, the TOD scenario needed a 26 km long line, while the Barcelona 500m needed only 16.5 km. The model assumed only one mass transit line. However, the higher density would justify other lines, generating a virtuous cycle that would be allowed by adopting TOD-friendly regulations before the mass transit line is built. This approach will build the density and demand that justify mass transit—and buses in mixed traffic earlier on. Figure 8.1 illustrates the point by plotting the km of mass transit and the city area for each scenario.

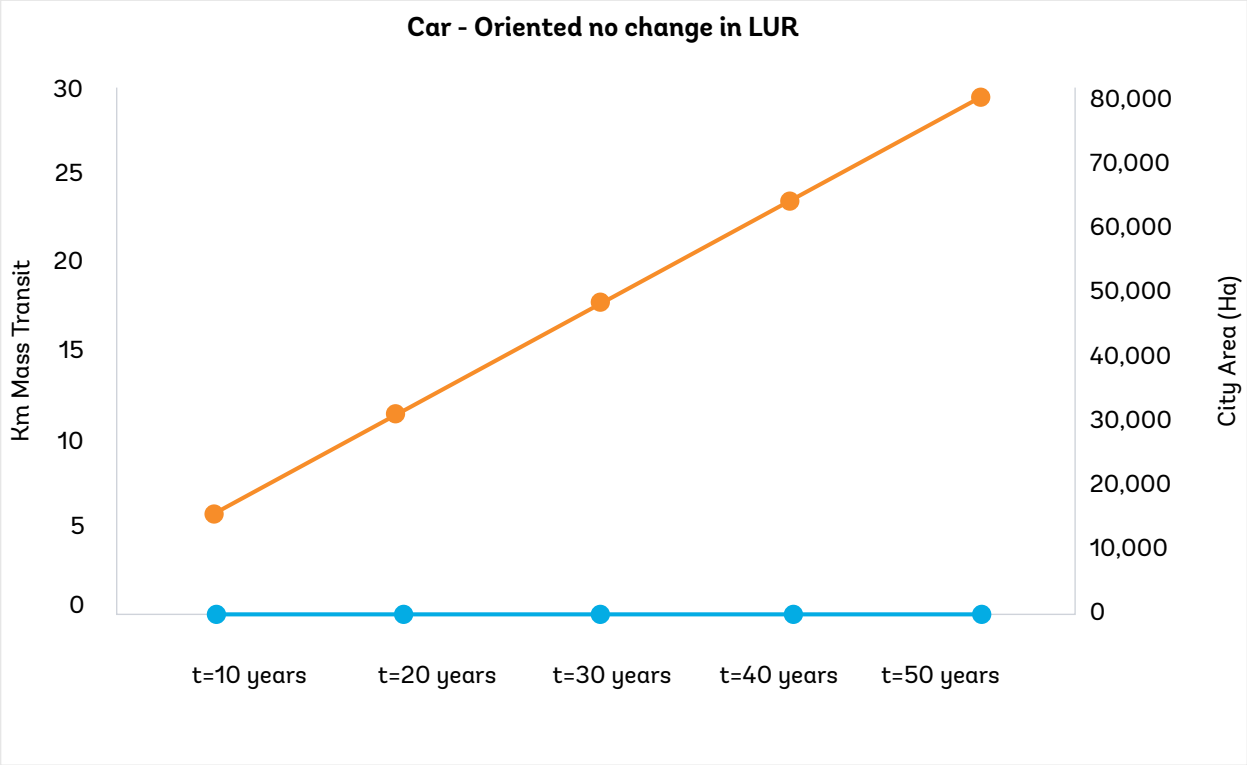
Finally, a caveat on the results in Table 8.1. The Sandbox model used in this book has indicative value, not predictive value, but it nonetheless allows comparisons. Still, the model estimates that a compact city that allows TOD-type LUR throughout would occupy a third of the space of a car-oriented city—66 percent less area. This value underestimates the savings from adopting TOD-type LUR in the entire city because the model baseline scenario reflects the high urban densities in developing countries. If the model used Atlanta's density—6 people per hectare– as the, the gains would be higher. As stated above, in 1990, Atlanta occupied an area of 4,280 km^2 for 2.5 million people, while Barcelona occupied 162 km^2 for 2.8 million inhabitants. Barcelona's area is four percent of Atlanta's. This fact reinforces the finding that compact cities need transit-supportive LUR throughout, more so in cities in the developing world, to preserve and enrich the density advantage they have.

Table 8.1 Results for the Four Scenarios

Item	Car-Oriented no change in LUR	TOD-one line, high FAR on corridor, low outside	Barcelona arterial every 400m	Barcelona arterial every 500m
Time		t = 10 years		
City Population		1,000,000		
Km of mass transit	0.0	10.5	8.0	7.5
Average city density	63.9	85.4	148.7	161.2
City Area (Ha) including roads	15,649	11,713	6,724	6,202
Time		t = 20 years		
City Population		2,000,000		
Km of mass transit	0.0	15.5	11.5	11.0
Average city density	63.9	85.4	148.7	161.2
City Area (Ha) including roads	31,299	25,488	13,816	12,896
Time		t = 30 years		
City Population		3,000,000		
Km of mass transit	0.0	19.5	12.0	11.5
Average city density	63.9	85.4	148.7	161.2
City Area (Ha) including roads	46,948	39,638	14,429	13,780
Time		t = 40 years		
City Population		4,000,000		
Km of mass transit	0.0	23.0	13.5	13.5
Average city density	63.9	85.4	148.7	161.2
City Area (Ha) including roads	62,598	53,976	19,307	18,449
Time		t = 50 years		
City Population		5,000,000		
Km of mass transit	0.0	26.0	17.0	16.5
Average city density	63.9	71.5	168.7	178.8
City Area (Ha) including roads	78,247	69,906	29,641	27,970
Land saving with respect to previous scenario (%)		- 11%	-58%	-6%
Land saving with respect to the car-oriented scenario (5)		- 11%	-62%	-64%

Source: Authors.

Figure 8.1 Km of Mass Transit and City Area for the Four Scenarios



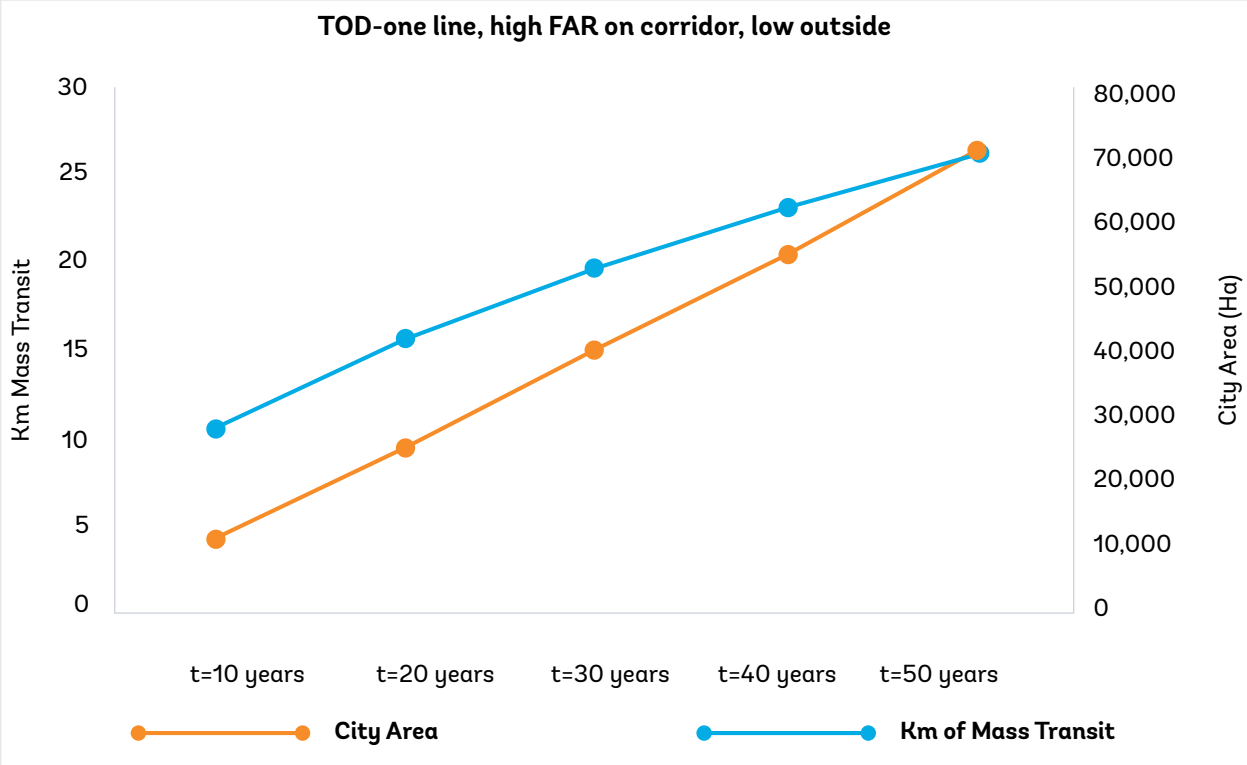
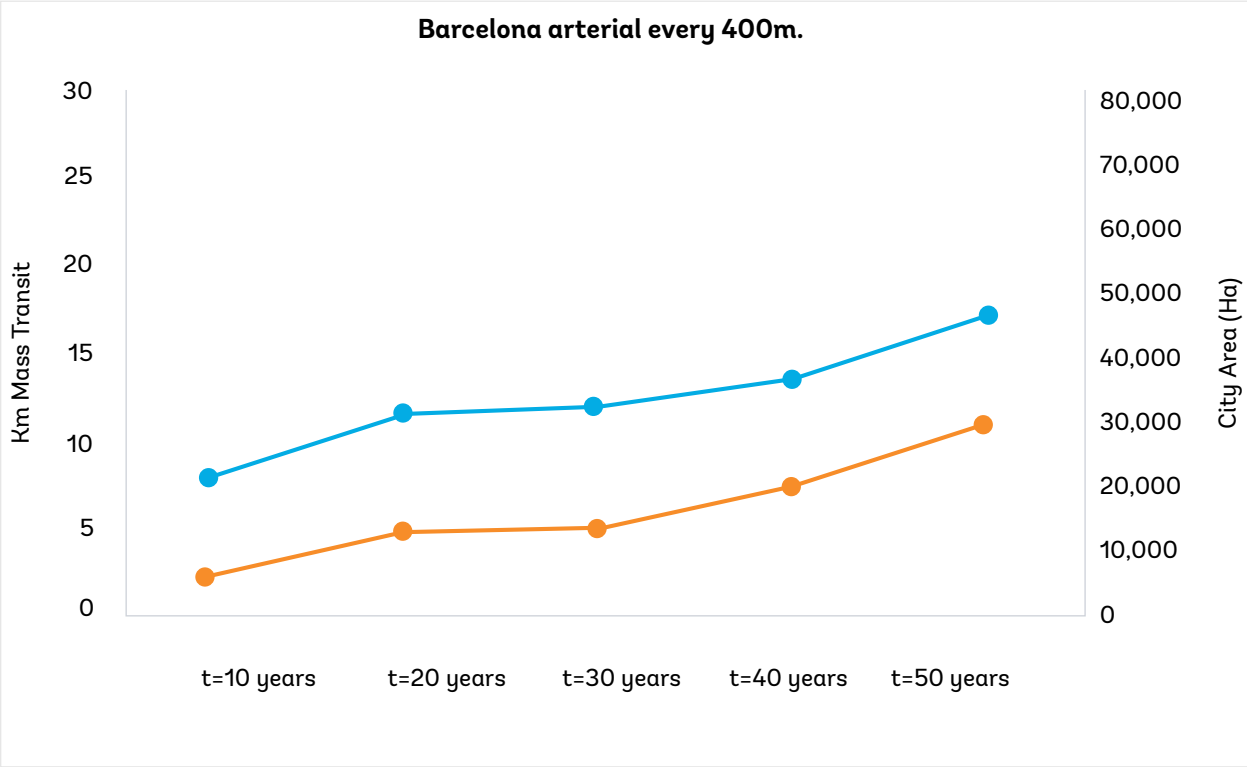
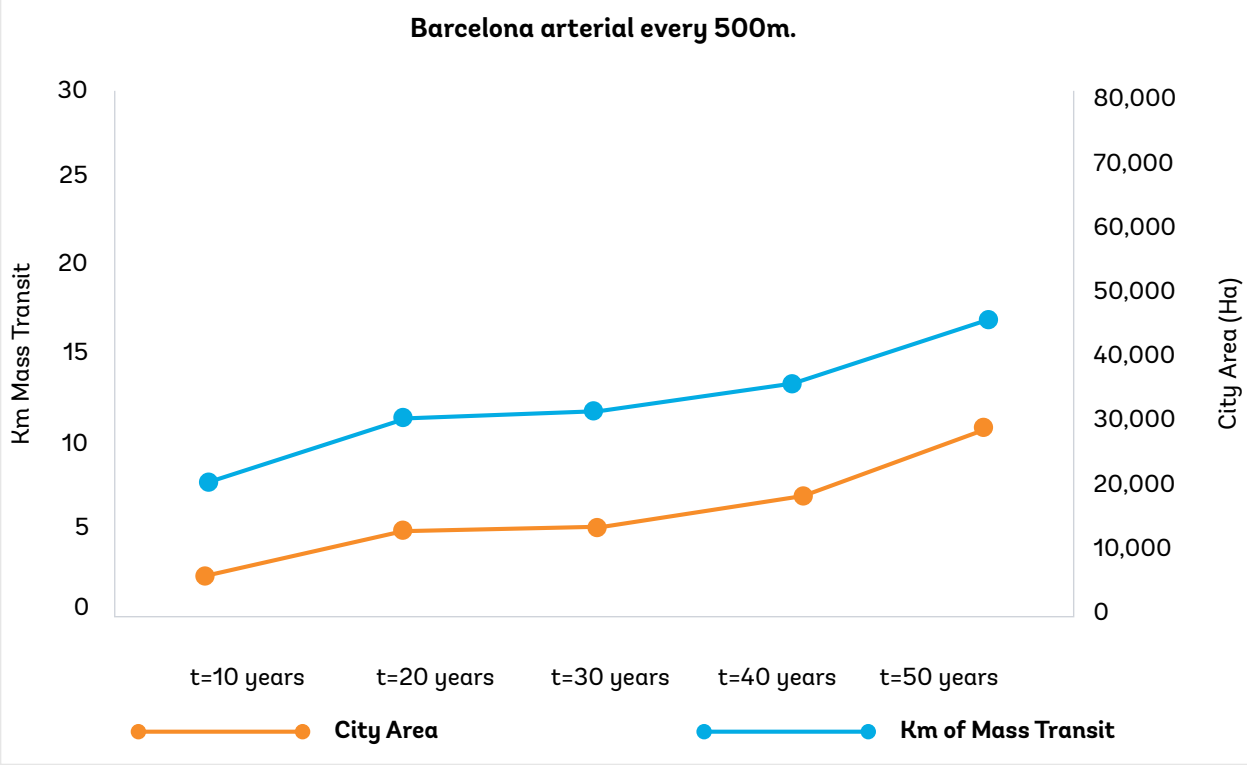


Figure 8.1 Km of Mass Transit and City Area for the Four Scenarios (cont.)





Source: Authors' calculations.

8.4 Implications for Informal Areas

The previous section showed the optimal was the Barcelona scenario with arterials every 500m. Chapter 3 identified that developing country cities are building fewer arterials. This section uses the model to analyze the implications of cities building fewer arterial roads, leading to longer walking distances and fewer corridors for public transport. This section uses the probability matrix that is part of the algorithm in the sandbox model. The sigmoid function used by the sandbox model (Chapter 4) plummets the probability after 500 m—which is the value some TOD sources use as the cutoff for increasing FAR around stations (Arlington County). Therefore, the probability of people willing to walk is below 50 percent for all the shaded cells—and in some cases, the probability is zero (Table 8.2).

The consequences of not building sufficient arterials—generating wide distances between them—impact the high- and low-income populations differently. The areas shaded in Table 8.2 will become car-dependent if high-income people move there, which will result in long walking distances for the low-income population. Figure 8.2 shows the layout of wealthy areas in Washington, DC, which are over 600 m away from an arterial road. Notice the lack of sidewalks, the huge setbacks, and the need to use a car for everything because there is no mixed land use. The figure also shows a map with the street layout in this area. Notice the lack of an orthogonal pattern, which is easier for cars but difficult for pedestrians and buses. The plots are large, and the plot coverage ratio is low.

On the other hand, Figure 8.3 shows the road pattern in informal areas in Nakuru and Bogota that are distant from arterial avenues. The formal areas have arterial roads, but the informal areas lack this pattern. The low-income people who live there will have to walk long distances to access public transport, which will mobilize them to opportunities.

Table 8.2 Probability of Walking to a Public Transport Stop on the Block (1,1)

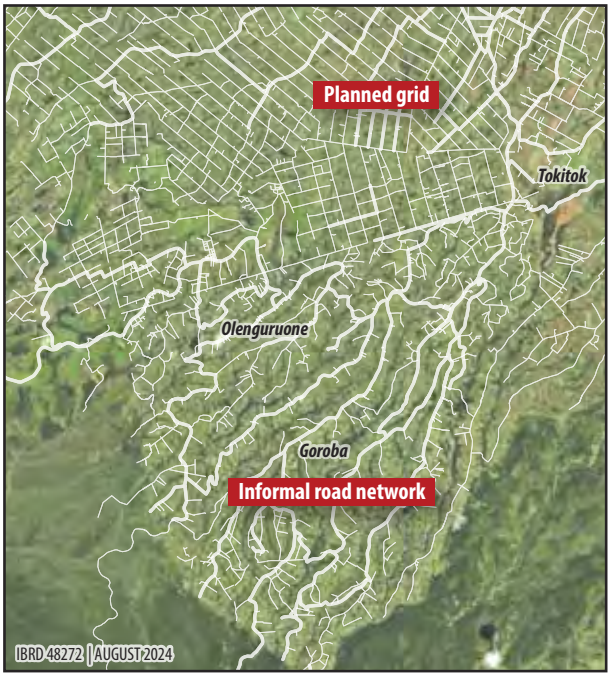
j \ i	1	2	3	4	5	6	7	8
1	99.0%	97.0%	91.6%	78.4%	54.6%	28.5%	11.7%	4.2%
2	97.0%	91.6%	78.4%	54.6%	28.5%	11.7%	4.2%	1.4%
3	91.6%	78.4%	54.6%	28.5%	11.7%	4.2%	1.4%	0.5%
4	78.4%	54.6%	28.5%	11.7%	4.2%	1.4%	0.5%	0.2%
5	54.6%	28.5%	11.7%	4.2%	1.4%	0.5%	0.2%	0.1%
6	28.5%	11.7%	4.2%	1.4%	0.5%	0.2%	0.1%	0.0%
7	11.7%	4.2%	1.4%	0.5%	0.2%	0.1%	0.0%	0.0%
8	4.2%	1.4%	0.5%	0.2%	0.1%	0.0%	0.0%	0.0%

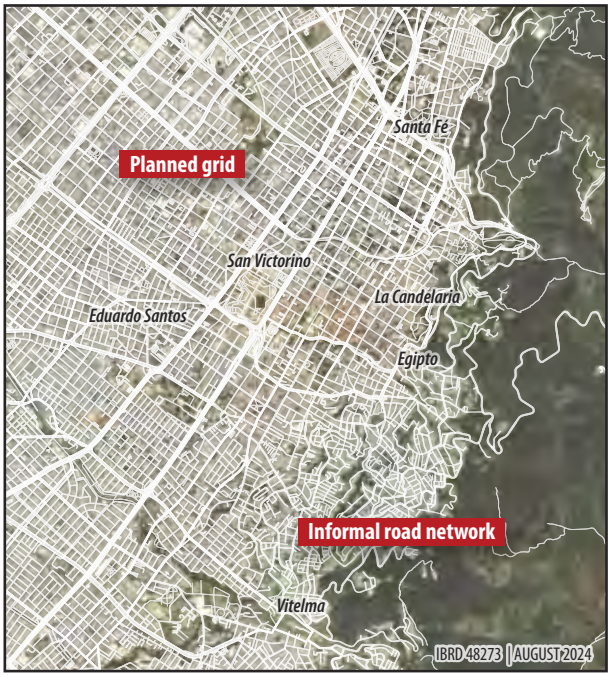
Source: Authors.

Figure 8.2 High-income Neighborhoods, Houses Located 600 M or More Away From the Arterial Road

Source: (Right) Arturo Ardila-Gomez; (left) https://anvaka.github.io/city-roads/.

Figure 8.3 Road Patterns in Nakuru (Left) and Bogota (Right) Informal Areas





The maps are not drawn at the same scale.

Source: Authors.

8.5 Conclusion

Compact cities are more likely to occur when cities adopt TOD-friendly regulations for expansion areas—high FAR and plot coverage ratio, low setback, and a parking policy—that allow the supply of floor space to match the demand. The compact city scenario—Barcelona 500 m, 5X5—occupies a third of the area of the car-oriented scenario and needs shorter mass transit lines than the TOD scenario. The Barcelona 500m scenario includes higher zoning and land use and, therefore, allows market forces to work better. More supply of built-up areas means lower prices and affordability. The scenario also includes a HITS, where feeder buses take passengers to the mass transit stations, minimizing walking distance. This assumption is part of the design of mass-transit systems (Pulido, Darido, Munoz-Raskin, & Moody, 2018). High density throughout the expansion area will make public transport feasible on many corridors, some of which will justify mass transit such as bus rapid transit, light rail, or even rail rapid transit as the city expands.

This book enriches the TOD literature by showing evidence that increasing FAR only in the mass transit corridor leads to economic losses, particularly for lower-income residents. Allowing higher FAR outside the corridor will increase the supply of built space. More people living in buildings relatively far from the mass transit station will generate demand for bus services that, in the future, could need another mass transit line—a virtuous cycle.

The lack of arterial roads identified in Chapter 3 is a trend that cities must reverse. This chapter found that arterials every 500 m are suitable for a walkable, transit-oriented city. Arterials are needed for public transport to provide better service because they can carry many vehicles. A parking policy is needed to prevent cars parked on the street from delaying buses.

Finally, notice that the recommendation on arterial roads every 500 m is from the point of view of pedestrians and public transport users. If the recommendation was from the point of view of car users, then the distance between the arterials could be higher.

9

Gender and Land Use Regulations: Eyes on the Street or See and Be Seen

Explore the significant gender differences in mobility and their impact on public transport usage in both developed and developing countries. The analysis of the intersection of land use regulation and gender-responsive urban planning highlights the need for integrated solutions to enhance women's mobility and access to public spaces. This approach aims to ensure equal enjoyment of urban services for both women and men—and for the elderly, children, and those with physical disabilities.

9.1 The Importance of Considering Gender

There is growing evidence of gender differences in mobility in developed and developing countries (Alam, Kurshitashvili, Dominguez Gonzalez, Gonzalez Carvajal, & Baruah, 2022). Gender has been recognized as a determinant of mobility choices, and even if some societies are evolving towards a bigger contribution of men to household activities, statistically, care responsibilities still fall on women's shoulders (Sanchez de Madariaga & Novella Abril, 2021). This strong persistence of women in care activities defines their decisions around how, where, when, and for how long to travel.

In addition, because of gender gaps in earnings, access to quality jobs, and time poverty, women have been disproportionally affected by barriers related to the availability, affordability, and acceptability of public transport. Together with pervasive gender social norms, women have also been particularly influenced by safety and security issues in their decision to travel when accessing and utilizing public transport (Dominguez Gonzalez, Machado, Bianchi Alves, & Portabales, 2020). Globally, solutions have been brought to address some of the external and normative barriers. However, they end up being piecemeal solutions and, in some cases, reactive, without meaningfully incorporating a gender perspective into the transport planning process.

While the urban sector has stressed the need to incorporate a gender perspective for more than three decades, there are not many examples in which this has translated *de facto* into urban development systematically and practically (Sanchez de Madariaga & Novella Abril, 2021). For instance, even if there is some literature about issues related to women and the built environment, there is limited evidence or examples on how zoning and land use regulation can contribute to equal use and enjoyment of public space (Ritzdorf, 1994). The same is the case of limited good practices to enhance women's perception of safety through a built environment and land use regulation, given the difficulties of measuring their impact in the absence of fine-grained data on safety for different neighborhoods and streets within the same city (Hawken, et al., 2019).

This chapter argues that there is a strong relationship between women's mobility and accessibility and usage without limitation of public space and land use regulation. To deconstruct this relationship, this chapter will start by summarizing gender differences in mobility and looking at the extent to which land use regulation can contribute to addressing the main differentiated challenges that women face in their mobility and accessibility. It opens the door to bringing gender-responsive urban and transport policies to sustain the equal enjoyment of the city and the services it offers between women and men to the same conversation. By the same token, inclusivity should also extend to the elderly, children, and those with physical disabilities.

9.2 Gender Differences in Mobility

Mobility patterns are different for women and men. Women's travel patterns are more complex and heterogeneous than men's (Meloni, Bez, & Spissu, 2009). The strong persistence of the mobility of care is a determining factor for women's mobility: women need to make trips that are shorter in both time and distance, be more willing to combine trips, make more household-serving trips (Crane, 2007), and travel with children and with more packages than men do, and normally at off-peak hours (Inter-American Development Bank, 2013). This may have negative impacts on women's income; shorter-distance trips to save time and money may result in limited job opportunities, with implications for women's empowerment (Mehndiratta & Peralta, 2014).

In addition, women are disproportionally affected by mobility barriers related to the availability, affordability, acceptability, and accessibility of transport (Dominguez Gonzalez, Machado, Bianchi Alves, & Portabales, 2020). Women's lower financial capacity due to the existence of a wage gap when compared to men affects their choice of transport based on what they can pay (Deike, 2002). Women are also disproportionally affected by the limited availability of transport and accessibility to jobs and services, given their time constraints derived from their multiple responsibilities at home and outside (Dominguez Gonzalez, Machado, Bianchi Alves, & Portabales, 2020). Since women walk more and depend more on public transport (Alam, Kurshitashvili, Dominguez Gonzalez, Gonzalez Carvajal, & Baruah, 2022), poor pedestrian pathways, and inconvenient access to transport facilities impact their daily journeys more. Transport arrangements that are unsuited to women's needs, for instance, in terms of routes, schedules, and frequencies, are excessively time-consuming, especially for those who must balance domestic responsibilities with paid work (Noack, 2010).

Among the barriers that women face in their mobility, personal safety requires special attention given the preventive approach that land use regulation and built environment can convey.
As discussed in the literature, women, in particular, face safety concerns when accessing public spaces that can even result in them altering their routes or cutting out areas that they perceive as unsafe (Navarrete-Hernandez, Vetro, & Concha, 2021). Women's perception of safety should not be limited to the transport service but extended to the surrounding spaces that provide access. The Sustainable Development Goals include safety as one of the main components of SDG11, the urban goal. Target 11.7 establishes that by 2030, countries shall provide universal access to safe, inclusive, and accessible green public spaces, particularly for women and children, older persons, and persons with disabilities ((SDSN), 2015). In this sense, the design and the planning of the urban space have been promoted to address issues of perceived safety, but little has been implemented in practice.

9.3 Thinking About a Gender Perspective in Land Use Regulation

The literature on urban planning has stressed the importance of designing women's usage of public space as they differ from men (Navarrete-Hernandez, Vetro, & Concha, 2021). However, this call for prioritizing women has not translated into urban reality and has been difficult to consolidate due to limited evaluation tools and empirical examples of what works.

For example, there is little evidence of the impact of common strategies used to increase women's perception of safety, such as improving street lighting or installing closed-circuit television (CCTV) (Navarrete-Hernandez, Vetro, & Concha, 2021). Here are some entry points to incorporate a gender perspective on land use regulation, some of which are starting to be supported by the evidence.

9.3.1 Zoning

Traditional or Euclidian zoning principles based on the separation of different uses of land did not enable a support system for the double or triple burden faced by women when combining household and remunerated activities. For instance, some residential land policies exclude the combination of home and work and the location of childcare, shopping, or services in residential neighborhoods. There are even occasions when the regulations dictate family definitions to the nuclear family, thus excluding those who are unrelated by blood or marriage from living together (Ritzdorf, 1994).

9.3.2 Closeness of Services

The availability and closeness of services are particularly relevant for those associated with care activities, which women normally carry out (Sanchez de Madariaga & Novella Abril, 2021). As mentioned, the mobility of care includes all travel resulting from home and caring responsibilities (i.e., escorting others, shopping, household maintenance, and organization, etc.) (Sanchez de Madariaga I. , 2013). Mixed land use contributes to improving the accessibility of those in charge of household and remunerated chores by making more proximate different activities through flexible zoning (Sanchez de Madariaga & Novella Abril, 2021). Bringing schools, daycares, shops, and bathrooms closer to home will contribute to women's autonomy and well-being by addressing their constraints in terms of time and being able to have a better balance between care and professional responsibilities (Sanchez de Madariaga & Novella Abril, 2021).

9.3.3 Recreational Public Spaces

In terms of public spaces that sustain recreational activities for women and their families, think about the impact of zoning on the usage of public spaces such as parks. There is limited evidence on the impact of zoning on the usage of public parks. A study from Kabul conducted an analysis based on qualitative research and observation to assess how land use regulation impacts women's usage of public parks. It concludes that parks surrounded by residential zones received more users compared to those surrounded by commercial and mixed-use zones (Mushkani & Ono, 2021). However, it also recognizes that the analysis doesn't consider other elements that might influence the usage of public space, such as a park's physical space quality (amenities and facilities), the surrounding buildings (educational institutions and religious buildings), the ethnicity of the residents of the surrounding area (for example, certain parks where users belong to one particular ethnic group),

the socioeconomic status of the residents of the surrounding area (the majority were considered to be medium to low income), and cultural attitudes (Mushkani & Ono, 2021). Other urban planners in the field have noted these elements as a cornerstone for making parks more welcoming for users, particularly women.

9.4 The Need to Talk More About Women's Accessibility and Not Just Mobility

Mobility is the ability to move from one place to another to access opportunities. Mobility should be free of constraints, particularly those that constrain women in terms of affordability, availability, and acceptability of transport. Improving mobility is a laudable idea to achieve gender equality. Moreover, land use patterns can further impact women negatively. Shorter distances and travel times for women are particularly relevant given their time poverty.

However, women's travel has unmet *spatial* needs, with different destinations than men and at different times of day. This stems from employment and household activities. For example:

- "Pink collar" professions are more dispersed throughout residential areas (schools, domestic work, local health services)
- Women in the informal economy and street vending need access to wholesale markets and peri-urban farming/light industry
- Women traveling earlier in the day for domestic work
- Women are traveling off-peak for childcare

Such patterns vary by city but are often different from men's, who are more likely to work in formal jobs, which are concentrated in the CBD or other pronounced employment clusters. Transport networks tend to follow these land use patterns, connecting residential areas to CBDs rather than providing intra-neighborhood connections and effective off-peak services. Underserved mobility needs are, therefore, difficult to capture. As this travel is unsupported, travelers may walk or rely on expensive taxi services.

There are different ways to calculate accessibility. However, it has been difficult to incorporate a gender perspective, as accessibility is mainly measured from the supply side. Some potential entry points to explore:

1. Collect household disaggregated data on trip origin, destination, and purpose, asking all adults to answer separately.
2. Incorporate linked trips in the assessment and integrate the friction and reduced preference for transfers, even when technically possible.
3. Collect data on childcare facilities and schools and children's safety and access to schools to interact with employment and travel data for parents.

4. Identify through a safety audit the streets that lack a violence prevention environmental design and transport stations or bus stops that lack one. Penalize them in the model.

5. Use different walking speeds for women and men as the literature shows that women walk at slower speeds, which reduces the distance that they can reach, and, in general, they walk more than men.

6. Use travel diaries and GPS tracking to capture actual mobility outside of the available transport network and surveys.

7. Consider "latent demand" and counterfactuals in household travel surveys, asking about missed and postponed travel and desired but rarely or never accessed destinations.

8. Use quasi- and fully experimental methods to establish potential "desire paths" for travel, such as taxi vouchers and temporary bus services, and consider the employment and time-use impacts by gender.

9.4.1 Impediments for Walking

One of the recommendations to enhance how women experience public space is to include elements that support their mobility patterns of traveling with children, elders, and packages. Equipping sidewalks with abundant benches, trash cans, inclusive signage, and trees has been stressed by practitioners working on gender and urban design (Sanchez de Madariaga & Novella Abril, 2021). Some technical criteria have been recommended for the placement of these items. For example, it has been suggested that a good city should locate suitable places to sit at regular intervals of 100 meters (Gehl, 2011). However, it should not be lost out of sight that these elements are designed in a way that there is no obstruction of walkability and visibility.

The 12 quality criteria concerning the pedestrian landscape developed by Jan Ghel welcome sidewalk amenities and greenery to provide aesthetic experiences and pleasant impressions. Still, it also incorporates as a criterion the importance of having room for walking and no obstacles (Gehl, 2010). Other authors have even recommended specific measures to facilitate free passage, for example, having sidewalks with well-sized widths so that the free passage is always equal to or greater than 140 cm, considering urban furniture, signage, trees, and other types of elements (Sanchez de Madariaga & Novella Abril, 2021).

In recent decades, these recommendations for no obstruction have been migrating to actual regulations. An example of this is the Spanish regulation OM VIV 561/2010 from February 1st, which develops the technical document on basic conditions of accessibility and non-discrimination for access and use of urbanized public spaces (updated by order TMA 851 /2021). This regulation introduced the accessible pedestrian route as a guiding element of pedestrian mobility in cities.

Paving conditions of sidewalks have also been considered as key for improving the walkability experience, which is particularly important for rolling pedestrian traffic, including people walking with strollers and on wheelchairs. Surfaces shall be even and non-slip. Cobblestones and broken natural slate stones contribute to the street's aesthetics but do not address the requirements of certain population groups, such as women with strollers, elders, or people with disabilities (Gehl, 2010).

9.4.2 Perception of Safety and "Eyes on the Streets"

Jane Jacobs coined the concept of "eyes on the streets" in her book *The Death and Life of Great American Cities* (Jacobs, 1961). She defines those eyes as belonging to the natural proprietors of the streets and that buildings on the street should be designed in a way that guarantees the safety of residents and strangers passing by (Jacobs, 1961). The "eyes on the street" shall be present in the morning and the night. For Jacobs, effective surveillance requires a relevant number of stores and businesses sprinkled along the sidewalk, which are open in the evening and at night, giving an excuse for people to be present at different times of the day, enhancing the perception of safety (Jacobs, 1961). Regarding land use regulations, this concept formally impacts zoning and floor area ratio, in addition to specifications on street space and its design and organization.

In this sense, ground floors should be open for business by making the compatibility of uses in residential buildings more flexible to include shops, offices, and other services at street level (Sanchez de Madariaga & Novella Abril, 2021). In addition, other studies have provided evidence that removing solid walls will significantly increase the perception of safety, particularly for women (Navarrete-Hernandez, Vetro, & Concha, 2021).

The concept of "eyes on the street" has been translated into practice by civil society organizations conducting safety audits of public spaces through different methodologies, including technological approaches. The NGO SafetiPin rates public spaces using a set of key safety parameters through a rubric-based method of assessment. The rubric includes the following parameters: light during the night; openness of public space; visibility of the space through windows and doors; the presence of people; the presence of security professionals; quality of walking path; proximity to public transport; balance of gender usage of public space; and feeling/perception of safety (Hawken, et al., 2019). This organization has used indicators of visibility through windows and doors and light during the night as proxy measures of "eyes in the street".

A recent study conducting statistical analysis using data from Safetipin in the city of Bogota identified that street lighting, openness, visibility, and public transport increased the perception of safety in public spaces, and visibility had the highest impact on this perception (Hawken, et al., 2019). They conclude that one is 500 times less likely to feel safe if there are 'no eyes' on the street than if it is highly visible. As per the measurement of public transport, one is 31 times less likely to feel safe if the public transport is distant than if it is close, improving to 5 times if it is nearby. When it comes to street lighting, one is 29 times less likely to feel safe in a poorly lit place than where it is brightly lit, improving to 4 times if it has 'enough' lighting (Hawken, et al., 2019). Initiatives using technology and open-source data, such as Safetipin, can contribute to closing the gap in information needed to plan cities to increase the perception of safety practically.

Another land use regulation that has an impact on women's perception of safety through its implications on the "eyes on the street" is Floor Area Ratio (FAR). A reasonably wide sidewalk and low setback that brings the face close to the sidewalk with frequent doors and windows promotes the principle of "eyes on the street." Some literature highlights that neighborhoods with low and medium floor area ratios bring a higher sense of community (Du Y., Jiang, Huang, & Yang, 2023), and, very likely, safety. On the contrary, poorly planned high-density, high-rise buildings result in a less welcoming environment (Gehl, 2010), an absence of eyes on the street from the upper floors, and a higher sense of anonymity, which reduces community belonging and the perception of safety. Public spaces that will attract people are those with reasonable density, good-quality city space, adequate population density, and acceptable walking and biking areas. These are better options than erecting tall buildings that create high-density and poor public space (Gehl, 2010).

9.5 Conclusion

This chapter showed the relevance of land use regulations and urban planning to make cities gender inclusive—not gender-blind. It highlighted relevant entry points through gender-responsive regulations and environmental design to improve zoning, walkability, and safety perception. The evidence could be limited, but the need to enhance women's enjoyment of the public space and travel experience is clear. More data and evidence need to be produced on the impact of land use regulations on women's mobility and accessibility. Cited elements such as FAR and zoning need to feature more frequently in the discussion on women's usage of public space, including transport systems and access to economic opportunities and services.

10

Parking Policy, Land Use Regulations, and Pricing

Picture a city where parking spaces are not just empty rectangles, but catalysts for economic vitality and sustainable transit. Peel back the asphalt to reveal how smart parking strategies can transform cityscapes, steering away from concrete jungles towards vibrant, walkable communities.

10.1 The Objectives of a Parking Policy

The main objective of a parking policy is to generate economic activity. People who shop or eat in restaurants typically park for one or two hours. Women drivers do more linked trips, as seen in the previous chapter, which means they park for short periods, sometimes less than one hour. The parking policy should generate rotation among cars parked, disincentivizing long-term parking, which takes place during the morning and evening peak hours (Shoup, 2017).

A related objective is to promote public transport use, particularly during peak hours. This objective has a physical implication because a sound parking policy should promote walking. Another objective is to save scarce resources, such as lanes on an urban road or space in residential units, to make housing more affordable. This objective is related to housing affordability.

Finally, by promoting economic activity and saving scarce resources, a parking policy will manage parking in the area or city, provide adequate supply, and promote public transport. The private sector will respond by building proper parking plots and charging to make a profit. If the city allows parking on some streets, it should extract revenue from the road space devoted to parking and built with public funds (Ardila-Gomez, Bianchi Alves, & Moody, 2021) and (Ardila-Gomez & Adriana Ortegon Sanchez, 2016).

10.2 Pricing for Parking to Promote Economic Activity

A parking fee structure that promotes economic activity must generate rotation. In commercial areas, parking should be for customers, not for commuters. This means charging less per hour for the first and second hours and increasing the charge per hour after that. For example, "$X for the first hour, $1.5X for the second hour, for a total of $2.5X for two hours. Each additional hour the car is parked should cost more per hour. A commuter, therefore, pays $10X" (Ardila-Gomez, Bianchi Alves, & Moody, 2021).

This efficient pricing policy will incentivize shopping while disincentivizing commuting by car. Unfortunately, most cities allow an inefficient parking fee structure that charges, for example, $Y for the first hour and $2Y for two hours of parking and above. Therefore, a person who eats at a restaurant will pay $2Y—the same as the person who parked for 8 hours. In this logic, Y is greater than X because the current fee structure overcharges for short stays that subsidize the long stays that do not pay their way. The current approach misses the rotation factor and the benefit to shops and restaurants from more customers.

No matter the parking fee structure, the critical policy aspect is to charge for parking because car use is highly subsidized (Ardila-Gomez & Adriana Ortegon Sanchez, 2016). Charging for parking is the first step in leveling the playing field between public transport and private cars. Parking for free on the street and even on sidewalks is a huge subsidy for car users. Cars parked on sidewalks endanger pedestrians and people in wheelchairs. Sidewalks are for pedestrians, not for illegally parked cars that pay zero.

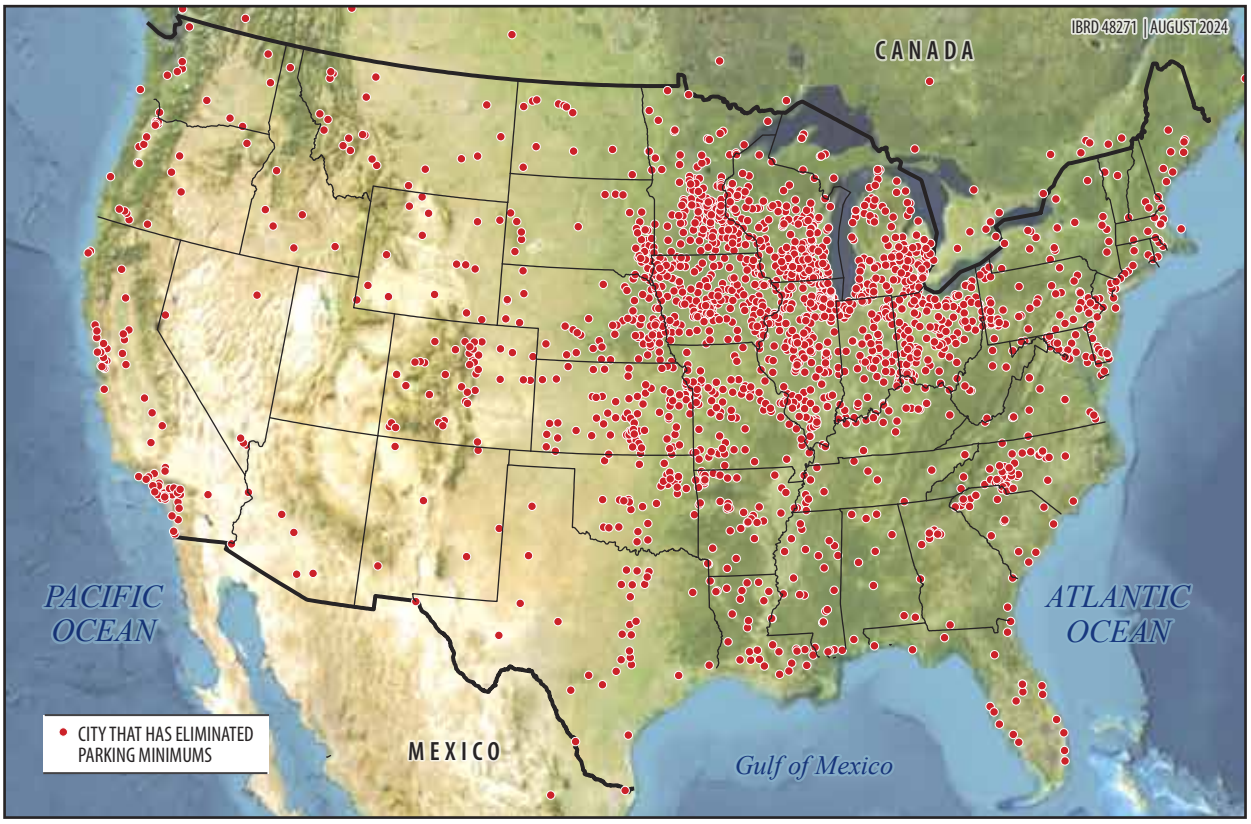
Technology facilitates parking charges. Authorities, through a third party, can develop applications for smartphones that track the vehicle's location, the time it began to park, and the time it should leave. These applications and parking meters connected to the internet can use dynamic pricing. In dynamic pricing, the goal is always to have parking spots available. This means the price increases to reflect the scarcity of parking space. Some drivers will not be willing to pay, leaving the scene. Others will pay (Shoup, 2017).

10.3 Parking Requirement: Minimum, Maximum, Or Let Market Forces Decide?

Minimum parking requirements have no scientific basis. Some cities require three spots per shop; others require the area of the shop multiplied by a factor. The result is the area the developer must devote to parking. In the end, there is more area devoted to parking than area built for human activity ((Shoup, 2017) and (Grabar, 2023)). In the United States, there are 2 billion parking spaces for 200 million cars (Quinn-Smith, 2020), which occupy up to 14 percent of the urban areas in some cities (Margolies, 2023).

To improve the situation, many cities in the United States have eliminated parking minimums, which allowed market forces to decide how much parking to supply (Figure 37). (Hess & Rehler, 2021) evaluated the decision of the city of Buffalo (NY, USA) to eliminate parking minimums citywide. Their main findings are as follows: "First, 47 percent of major developments included fewer parking spaces than previously permissible, suggesting earlier minimum parking requirements may have been excessive. Second, mixed-use developments introduced 53 percent fewer parking spaces than would have been required by earlier minimum requirements, as developers readily took advantage of the newfound possibility to include less off-street parking. Aggregate parking spaces among single-use projects exceeded the earlier minimum requirements, suggesting developers of such projects were less motivated to deviate from accepted."

Figure 10.1 Sample of Cities in the USA that Have Eliminated Parking Minimums



Source: https://parkingreform.org/resources/mandates-map/.

If car-oriented cities in the USA and Canada—plus Mexico DF—can eliminate parking minimums and see positive results, cities in low- and middle-income countries can test the idea. Cities copied parking minimum standards. Now, cities can copy the idea of eliminating parking minimums, allowing market forces to define the supply of parking space. Real estate developers have target clients in mind. They know if this segment will need parking, and how much, or not at all. For example, in Bogotá, after the Transmilenio BRT entered operation in an area of downtown where the land use regulations tolerate high FAR, two 25-story buildings were built without parking (Ardila-Gomez, 2008). "The developers targeted a market segment that wanted to use public transport and would not buy a car. This example also shows why, in areas close to good public transport, developers can choose to build more affordable housing" (Ardila-Gomez, Bianchi Alves, & Moody, 2021).

10.4 Interaction between parking and land use

Public transport users must walk to the station or bus stop. People prefer to walk on wide sidewalks surrounded by human activity. Hence, there is a need for zero or low setbacks. The parking policy should encourage parking to be behind buildings or underground, not at the front of the building. The policy should also encourage proper access from the street to the parking plot (Ollivier G., Ghate, Bankim, & Mehta, 2021).

Figure 10.2 shows good practices because the sidewalks are wide, the façades are close to the sidewalk, and the parking entrance protects pedestrians. The buildings have windows that face the sidewalk, respecting the eyes on the street or see and be seen principle. The interaction between the parking and the sidewalk is good.

Figure 10.2 Good Parking—sidewalk Interaction

Source: Arturo Ardila-Gomez.

Figure 10.3 shows counterexamples because the parking is in front of the building. Pedestrians walking on the sidewalk feel unsafe because the façades are distant and disconnected from the sidewalk. These designs violate the eye on the street principle. Figure 10.4 shows another violation of this principle by the walls that fence the parking garages. In the picture on the left, the wall is over one story high. The picture on the right has a façade suitable for a prison, not an urban parking lot.

Parking design can easily emulate the surrounding buildings to improve the streetscape and the pedestrian experience. Figure 10.5 shows examples of places where the design situates shops and restaurants in front of the parking building. In one case, the parking garage is four stories above ground, and the other is several levels underground.

Figure 10.3 Poor Parking—Sidewalk Interaction

Source: Authors.

Figure 10.4 The Wall Effect Destroys Walkability

Source: Arturo Ardila-Gomez.

Figure 10.5 Shops and Restaurants in Front of Parking Buildings

Source: Arturo Ardila-Gomez.

10.5 Conclusion

Leveling the playing field between public transport and private cars is important to incentivize public transport use and disincentivize car use. This chapter provides the tenets of a modern parking policy. The main objective is to promote economic activity, followed by leveling the playing field with public transport and generating an adequate parking supply. The parking fee structure is critical for achieving these objectives. The chapter also discussed the interaction between the parking entrance or garage and the sidewalk. Parking spaces placed between the sidewalk and the building's façade destroy walkability because they limit the eye on the street principle. Parking garages can have a good design that respects the principles of the eyes on the street or see and be seen. Good parking design starts by placing it behind the building or underground it, to allow restaurants and shops at the street level. In short, a good parking policy promotes economic activity, generates parking supply, frees up sidewalks for pedestrians, and incentivizes commuting by public transport.

11

Planning for Future Transit-Oriented Development

A deep-dive into strategies that increase the potential for emerging cities to incorporate Transit-Oriented Development. A toolbox of cutting-edge techniques turn abstract urban planning concepts into tangible, measurable realities.

11.1 TOD for Emerging Cities and Cities that Want Transit

What transport and land-use policies allow a city without transit to grow into a transit-oriented city supported by public transport and walking? This book's entry point was a 500,000-person emerging city. Emerging cities house 75 percent of the urban population. Their population will grow into the millions, particularly in Africa and Asia, where the urban population is expected to increase by over two billion people by 2050. Developing country cities are already dense, so the recommendations must preserve and enhance this advantage.

Emerging cities have public transport but no mass transit yet. This entry point required the analysis to be agnostic regarding public transport modes. The assumption is that public transport will respond to increased demand.

The book analyzed and modeled land use regulations considering the theoretical framework presented in Chapter 2. On the economic side, markets ultimately determine city form. However, Land Use Regulations (LUR) play a role because they can promote urban development that supports public transport—or that locks in car dependency. LUR can limit the supply of floor space, leading to sprawl. LUR that allows supply to meet demand results in an adequate supply of built floor space, making it affordable by increasing density. Dense cities are suitable for public transport.

The analysis in this book is also from the point of view of a pedestrian, following TOD literature that correctly states that riders walk to the bus stop and metro station. This literature also says people should access most destinations by walking—analogous to the 15-minute city—hence the need for mixed land use, good sidewalks, frequent road intersections, and low setbacks. The model measures willingness to walk as a function of distance. Twenty percent of the people are willing to walk up to 300m, and another 30 percent will walk up to 500m. After this threshold, the willingness to walk plummets.

The 3V (Ollivier, et al. 2021) complemented the theoretical framework by indicating the elements of node, placemaking, and market potential values, showing how land use regulations (LUR) can enhance each. For instance, increasing FAR and plot coverage boosts node value by raising density.

Emerging cities that wish to grow transit-oriented, supported by public transport and walking, should craft a Transit-Oriented Development (TOD) strategy that maximizes the three values—node, placemaking, and market. This strategy will integrate transport and land use aspects (Table 11.1).

LUR that require wide sidewalks, short setbacks, and mixed land use improve placemaking value and creates transit-supportive spaces. Form-based codes provide additional guidance by focusing on the interaction between façades, sidewalks, and streets. LURs that enable developers to meet the demand for floor space maximize the market potential value.

The TOD should include the future road network and information on the location of parks, public schools, hospitals, and community centers. The information on the future location of public goods is critical because markets need this information to work. Developers want to build by a road, not on the site of a future road. The latter scenario means authorities will have to demolish the building.

The planned road network should plan a grid with secondary roads every 100m and arterial avenues every 500m to maximize walkability and the willingness to use public transport. Arterials are critical because they allow buses to operate and can be upgraded to mass transit if demand increases.

Table 11.1 How LUR Maximize the Node, Place, and Market Values and their Benefits

3 Values and their definition	LUR that maximizes the values	Benefits
Node value: passenger traffic volume, intermodality	• High FAR • High Plot Coverage Ratio • Wide sidewalks • Low setback • Parking policy • No minimum plot or unit size • No maximum height	• Higher density • Higher demand for public transport • Mass transit eventually • Walkable and vibrant urban development • Shade from trees • Enhanced economic activity
Place or placemaking value: schools, plazas/open spaces representing the urban fabric around the station.	• Allow mixed land uses • Plan that shows public goods layout: - road network with arterial and secondary roads with frequent intersections. - Parks, schools, hospitals, libraries • Wide sidewalks • Low setback • Parking policy	• Markets have the information to function efficiently • Street level floor with restaurants and shops, especially on arterials • Walkable and vibrant urban development • Day-care centers close to housing areas • Enhanced economic activity • Polycentric city
Market potential value: *demand for* residential and employment.	• Mixed land uses • High FAR • High Plot Coverage Ratio • Wide sidewalks • Low setback • Parking policy • No minimum plot or unit size • No maximum height	• Demand supply for floor space match • Developers target market segments • More formal and affordable urban development • Less or no area developed informally • Higher density that justifies public transport, eventually mass transit • Enhanced economic activity

Source: Authors.

Moreover, the road network plan should consider modern approaches to extract higher capacity from an urban road—the multimodal approach shown in Figure 11.1 (Global Designing Cities Initiative, 2016). Thinking about the different users of an urban road results in higher throughput. Moving people is what matters, not moving cars. Multimodal streets (MMS) also contemplate universal access and include gender considerations.

Therefore, a road grid that uses MMS is the seed that should result in a virtuous cycle. An MMS improves the travel experience for all users, including public transport vehicles. The MMS should have ample sidewalks with even and non-slip surfaces, trees for shade, benches for pedestrians to rest, and inclusive signage to favor women, men, children, the elderly, and disabled people.

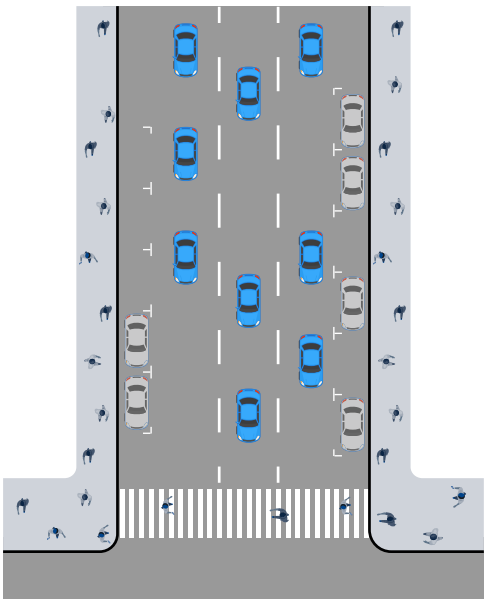
The lower travel costs will attract people who want to live closer to the improved urban road. The TOD plan will contemplate LUR that accommodates this increased demand for built space around this multimodal arterial—to maximize the market value in the 3V Framework. The proposed approach will allow developers to identify demand by segment and provide floor space accordingly. Analysis shows that the LUR that allows more built space should extend beyond the vicinity of the arterials because people are willing to walk, particularly if the density of MMS is high—about every 500 m. A compact city is more likely if the TOD plan has transit-friendly LUR throughout so that arterials—multi-modal corridors—support public transport.

As demand increases, the city can upgrade the MMS to technology with higher capacity, such as a bus rapid transit, light rail, or metro, on corridors that justify the upgrade. Curitiba followed this strategy. This city's master urban development plan allowed higher FAR and plot coverage ratios while reducing setbacks along arterials with good sidewalks. Density increased. Curitiba then implemented busways that assigned exclusive lanes to buses. The densification continued due to a new round of improved regulations. By 1990, Curitiba had invented rapid bus transit on these same corridors. Bogota has a similar story, adopting busways in 1990 and then BRT in 2000. Bogota—a dense city that is getting denser—is now building its first metro line on the first corridor that adopted busways and then BRT. Compact cities occupy lower areas and require shorter mass transit networks.

Figure 11.1 also shows improved parking management. A parking policy is needed to level the playing field between private car use and public transport. Private car use is subsidized. A critical subsidy is free parking. It is free to the user, not to society, because cars use road capacity or park on sidewalks. A parking policy generates economic activity, promotes public transport use, and generates a supply of parking. The updated Zoning and LUR should let market forces decide how much parking to supply.

Figure 11.1 Multimodal Street Example that Improves Space Allocation and Throughput

Car-Oriented Street



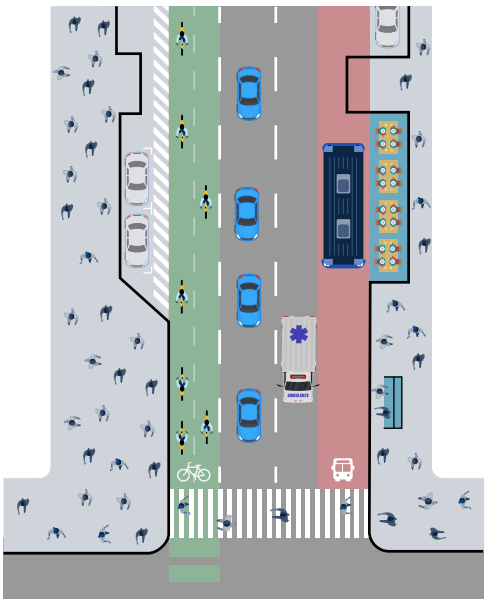
The capacity of car-oriented streets and multimodal streets. These two diagrams Illustrate the potential capacity of the same street space when designed in two different ways. In the first example, the majority of the space is allocated to personal motor vehicles, either moving or parked. Sidewalks accommodate utility poles, street light poles and street furniture narrowing the clear path to less than 3m, which reduces its capacity.

Hourly Capacity of a Car-Oriented Street

	4,500/h	x2	9,000 people/h
	1,100/h	x3	3,300 people/h
	0	x2	0 people/h

Total capacity: 12,300 people/h

Multimodal Street



In the multimodal street, the capacity of the street is increased by a more balanced allocation of space between the modes. This redistribution of space allows for a variety of non-mobility activities such as seating and resting areas, bus stops, as well as trees, planting and other green Infrastructure strategies. The Illustrations show the capacity for a 3m wide lane (or equivalent width) by different mode at peak conditions with normal operations.

Hourly Capacity of a Multimodal Street

	8,000/h	x2	16,000 people/h
	7,000/h	x1	7,000 people/h
	6,000/h	x1	6,000 people/h
	1,000/h	x1	1,100 people/h
	0	x1	0 people/h

Total capacity: 30,100 people/h[29]

Source: (Global Designing Cities Initiative, 2016).

Figure 11.2 Multimodal Street in Reality in Bogota, Colombia

Source: Arturo Ardila-Gomez.

Figure 11.3 Multimodal Street in Reality in Paris, France

Source: Arturo Ardila-Gomez.

11.2 Recommendations for Improving TOD Practice

This book has five recommendations for improving TOD Practice. The recommendations are in the context of the Transit-Oriented Development Strategy developed following the 3-Value approach, as recommended above.

11.2.1 Accessibility

Planners should carry out an accessibility analysis using the software tool developed as part of the parent ASA for this book, Low-Carbon Mobility and Efficient Urban Form (P178294).

The "Isochrone Accessibility" indicator—also known as "Cumulative Opportunities Accessibility"—is a widely used measure of the efficiency of land use-transport systems. It captures the total number of opportunities—often jobs—that can be reached within a given travel time threshold.

To evaluate isochrone accessibility, the user uploads data on the street network from the OpenStreetMap format, a polygon shapefile of opportunities (e.g., a grid with the number of jobs in each grid cell), and optionally a GTFS file specifying the transit operations. Then, the user chooses which modes (walk, bike, transit, car) to make available and the travel time threshold, which is typically 30 or 60 minutes. Suppose a GTFS file was uploaded, and transit was made available. In that case, the user should also set the time and day for the analysis to ensure that the transit schedule is accurately represented in the results.

Although relatively simple, the isochrone accessibility indicator can be adapted to create a variety of useful analyses to show the impact of transport investments and efficient urban form. For example, the impact of a new mass transit line can be shown as a difference in accessibility between two scenarios, one with transit available and one without. Alternatively, in a context where private motorized vehicles are primarily available to men, women in households have considerably poorer accessibility. This gap in access to opportunities can be shown as the difference in accessibility with the car mode toggled on and off.

11.2.2 Beneficiaries

Planners should measure the number of beneficiaries from transport projects. The parent ASA also developed the software tool to measure this indicator.

The "Project Beneficiaries" indicator captures the number of people who live near new transport infrastructure projects and are likely to benefit directly from their use. It was developed as an indicator for the World Bank Corporate Scorecard that aligns with the existing rural accessibility index and is universally applicable—even in data-poor environments.

To evaluate project beneficiaries, the user uploads the alignment of their transport project as a zipped shapefile. The tool then calculates the number of project beneficiaries as defined by the Corporate Scorecard indicator. Namely, the number of people residing within the catchment area of the project. The radii of the catchment areas are defined as follows:

- Non-motorized transport infrastructure: 0.5 km
- Mass transit corridor: 1.0 km
- Transit terminal or large station: 2.0 km
- Rural or interurban road: 2.0 km

11.2.3 Affordability

Planners should track housing affordability through the ratio between median income and median housing price (Bertaud, 2018). The city's property tax system includes a cadastre that registers properties' characteristics, including the price or value. Planners can extract the median housing price from the cadastre. Ideally, they should track several income groups in different locations. Household surveys can indicate the median income. This indicator will show the need to change LUR to allow developers to build more housing to make it affordable again.

11.2.4 Urban Economics Model

Planners should use an urban economics model. Chapter 2 presented the basic idea that underlies current models that can model small, medium, and large polycentric cities. The economic model will show real estate prices. If the model shows that real estate prices increase, planners should propose improvements to the existing LUR. Plans are better when they have information on prices because high prices show scarcity and low ones show abundance. The parent analytical work also developed the software tool to measure this indicator.

Numerous efforts have been made to quantify and operationalize the interplay between the transportation and land use systems discussed in this book. Starting with Lowry's (1964) *Model of the Metropolis*, which was more than half a century ago, these efforts have become increasingly sophisticated—taking advantage of advances in data availability, computation power, and theory. For comprehensive reviews and historical snapshots of these models, see, for example, Acheampong & Silva (2015), Hunt et al. (2005), Engelberg et al. (2021), Moeckel et al. (2018); Waddell (2011); and Wegener (2004).

Recent interest in these topics from urban and trade economists has contributed economic rigor to the field through so-called quantitative spatial equilibrium models. Their equilibrium approach provides a theoretically compelling structure for modeling interactions between mobility, land, and labor markets. The following example applications showcase the capabilities of these models:

- Tsivanidis (2018) examined the impacts of Bogota's TransMilenio BRT. Not only does he analyze transport impacts, but through the spatial equilibrium framework, he quantifies impacts on land value capture policies through the land market and distributional outcomes for high and low-skill workers through the labor market

- Kleineberg (2022) examined the interaction between two new BRT lines in Amman and the city's zoning restrictions. Specifically, they show that the land use regulations limited the supply of floor space, in turn preventing the city's residents from fully benefiting from the infrastructure investment

- Zarate (2022) examined the impacts of a new subway line in Mexico City. In particular, he analyzes how the improved job access facilitated by transit infrastructure investments affects workers transitioning between the formal and informal economies

- Liotta et al. (2022) examined a fuel tax in the context of Cape Town. A fuel tax has complex distributional impacts. Using the NEDUM-2D model, they quantify how different income groups are affected, depending on their transport mode of commuting and residential location in relation to major employment centers

These studies simultaneously highlight the complexity of land use-transport interactions and underscore the usefulness of land use-transport models, specifically quantitative spatial equilibrium models. Transportation infrastructure is the backbone of cities, facilitating production, trade, learning, and much more. Hence, it is crucial to quantify the wider impacts when evaluating transport projects.

11.2.5 City-wide TOD to get to the Compact City

The model showed that a compact city is possible if plans adopt city-wide LUR that promote transit, such as high FAR and plot coverage and low setback. Adopting these LUR only around a mass transit corridor or station leads to a larger urbanized area and zones that become car-oriented. The TOD literature, therefore, should recommend relaxing LUR beyond the mass transit corridor and its stations. Market forces will concentrate urban development around the transit line because of the time savings the line generates. Yet some developers will see opportunities for densifying areas outside the 500 or 1000 m around the corridor. The result is that another mass transit corridor can be implemented in the future on a nearby corridor because it has enough demand. No area in the city should have low-density LUR because it results in a car-oriented urban development. A transit-oriented future is more likely if the entire city adopts transit-supportive LUR because, over time, densification will happen, justifying public transport and, eventually, mass transit.

11.3 A Virtuous Cycle Toward a Transit-Oriented City.

Emerging cities—and cities that want to generate transit corridors—can generate a virtuous cycle toward a transit-oriented city that results in a walkable, livable, vibrant, transit-oriented, inclusive, compact, and low-carbon city.

This strategy will inform the market about where roads, parks, schools, hospitals, and all public goods will be located and integrate transport and land use considerations. The road network should have arterials every 500 m and secondary roads—some of which can be pedestrianized.

The TOD strategy should adopt LURs that maximize the node, place, and market value (Table 11.1). These LURs enable a high floor area ratio (3.0 to 4.0), high plot coverage ratio (0.6 to 0.85), low setbacks (0.5m), especially facing arterial streets, and a parking policy that promotes enhanced economic activity.

LUR that limit the supply of floor space lead to economic and welfare losses, for example, by pricing out the lower income groups and by occupying more space than a compact city. The right LUR can lock in a transit-oriented future. Adopting these regulations only around arterials or transit corridors will lead to sprawl because they lock in the areas with restrictive LUR into a car-dependent future when a transit-oriented one is possible.

Mixed land uses should be allowed in all areas, like the Japanese zoning system, except for heavy industry. Market forces will materialize the mixed land uses on the arterials first because they will have public transport and more pedestrians. A polycentric city could emerge.

The arterial and secondary roads should follow Multi-Modal Street (MMS) design principles (Figure 11.1) to maximize the travel experience for all users, from pedestrians to public transport users to cars and trucks. MMS benefit all users because they should have ample sidewalks with even and non-slip surfaces, trees for shade, benches for pedestrians to rest, and inclusive signage to favor women, men, children, older people, and disabled people.

Due to mixed land use, sidewalks, and low setbacks, people can walk to many destinations and use public transport services within walking distance when they wish to access other opportunities. Public transport providers can increase their services. Mass transit can materialize on high-demand corridors that pass the cost-benefit analysis, plus environmental and social criteria.

The 15-minute city is possible for many aspects of life, such as education for children, shopping, leisure, and recreation, by allowing mixed land uses. However, public transport is needed for the labor market to work. Some people will find jobs within the 15-walking area; most will need public transport to access the jobs they want. The resulting urban development locks in a transit-oriented pattern (Figure 11.4).

Finally, the sidewalks along the road network with will future-proof the expansion area for emerging cities. This research used an average walking speed of 3.7 km per hour. As people age, they walk slower. The sidewalks, coupled with mixed land uses, will allow older people to walk to most services they need.

People who walk —and who use public transport—have lower weight and better health than car users. Emerging cities can grow healthily by adopting LUR that maximize the node, place, and market values that allow people to walk to many destinations and use public transport to access opportunities beyond their neighborhoods—the virtuous cycle.

Figure 11.4 Metro Entrances in Downtown Washington DC

Source: Arturo Ardila-Gomez.

Appendix

Detailed Description of Land Use Regulations

A detailed description of the critical land-use regulations. The objective is to help transport practitioners understand these regulations and their impacts so they can discuss them with their counterparts to improve the connection between transport and land use planning.

Floor Area Ratio (FAR)

Floor Area Ratio (FAR)	
What is it?	The floor area ratio (FAR) is the ratio of the sum of a building's floor area to a plot area. For example, on a site with 10,000 net square km of land area, a floor area ratio of 1.5 will allow a maximum of 15,000 gross square km of building floor area to be built. The primary purpose of FAR is to control the volume of buildings on the land in consideration of their use (American Planning Association, 1958). Two factors determining the FARs are bulk and use. Bulk indicates the "volume, shape, and spacing of building on the land", and use indicates "activities permitted on the land within buildings", such as residential, commercial, and industrial activities. FARs vary depending on the uses. For example, FARs for residential zones are between 0.5-10.0 (New York, Chicago); FARs for commercial zones are between 0.8-15.0 (New York) and between 1.2-16.0 (Chicago); and FARs for industrial zones are between 2.0-15.0 (New York) and 1.2-7.0 (Chicago). Developing countries have comparatively lower FAR regulations. According to the Kigali Master Plan 2050 (Kigali City Council, 2020), its FAR(s) for residential zones are between 0.5-1.8, commercial zones are between 1.4-2.4, and industrial zones are 1.2. **Figure A.1 Different Urban Landscape by FARs and Height Regulations**  Gangnam Area in Seoul, Korea  Washington DC, USA Source: Ok Stella Namkung.

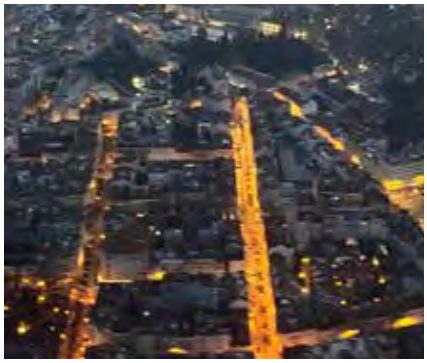
Floor Area Ratio (FAR)	
What is the impact on public transport use?	FAR is positively associated with public transport ridership. According to the study authors' sandbox model, which examines the association between land use regulations and public transport ridership, FAR is the strongest instrument to increase urban development density and public transport ridership. When FAR is increased to 4.0 from the baseline situation of 1.5, public transportation ridership increases 1.67 times.
What is the impact on walking?	Previous studies argued that walking is positively associated with residential density (Huang, Moudon, Zhou, & Saelens, 2019) (Rodríguez, Evenson, Roux, & Brines, 2009). The abovementioned studies also indicate that higher FAR induces more residents to walk to the public transit. However, when the same residential densities are assumed to be the same for the different residential sites, walking becomes a matter of interactions between pedestrians and built-up environments. Suppose the FAR allows high-rise buildings with broad roads and sidewalks, large off-street parking lots, and open spaces. In that case, residents might not prefer to walk due to perceived insecurity about walking and comparatively farther walking distance to local amenities and public transit. This could lead to car-oriented travel patterns. On the contrary, residential areas with middle- and low-rise buildings could encourage residents to walk with psychological safety and walking comfort to access local activities and public transit.
What is the gender-related impact?	Some literature highlights that neighborhoods with low and medium FARs bring a higher sense of community and very likely safety. On the contrary, poorly planned high density with high-rise buildings result in a less welcoming environment, absence of eyes on the street from the upper floors, and a higher sense of anonymity, of anonymity which reduces community belonging and perception of safety. Public spaces that will attract people are those with reasonable density, good-quality city space with adequate population density, and acceptable walking and biking areas, which are better options than erecting tall buildings that create high-density and poor public space (Gehl, 2011).
What is the impact on affordability?	• An increase in FAR has a positive association with housing affordability, as large-scale dwelling unit provision stabilizes market housing prices • An increase in FAR would increase transportation affordability by supporting more residents to save commuting expenses with good access to public transit

Floor Area Ratio (FAR)	
What is the impact on economic efficiency?	• FAR is one of the key elements to adjust the density of a district. By granting higher FAR with mixed land use, the city government can expect 1) higher land value capture and 2) a vitalized local economy (Suzuki, Murakami, Hong, & Tamayose, 2015) • However, the following transaction costs could occur by capping the supply of buildable area: - Urban Sprawl: FAR and height regulations might limit the provision of total area of floor space, which ultimately leads to urban sprawl (Bertaud, 2018) - Gentrification and informal urbanization
What is the road safety impact?	It is argued that fewer traffic crashes break out at the intersections in high-rise residential buildings. Not only does building height matter, but also shorter right-of-way, closer setbacks, and more design amenities (Jones & Jha, 2010).

Plot Coverage Ratio

Lot Coverage Ratio	
Similar terminology	Building-To-Land Ratio, Building Coverage
What is it?	The plot coverage ratio determines the percentage of a land parcel the buildings can cover (Duarte, Stepner, Roberts, Dickson, & Rosenhall, 2010). Pairing with the FAR and maximum height limits, the plot coverage ratio is among the most influential regulations and represents Euclidean zoning schemes to control housing density.

Figure A.2 Different Urban Landscapes by Plot Coverage Ratios



Apartment-Oriented Residential Districts in Lisbon, Portugal

Single Detached House-Oriented Residential Districts in Washington DC, USA)

Source: Ok Stella Namkung.

Lot Coverage Ratio	
What is the impact on public transport use?	The study authors' sandbox model shows that as the plot coverage ratio increases, the public transport ridership increases—a positive and linear association. A higher plot coverage ratio allows more dwelling units and residents, resulting in higher population density.
What is the impact on walking?	As the model outcome shows, a higher plot coverage ratio increases public transport ridership, which indicates walking demands increase, too. This modeling outcome coincides with the findings of the previous studies that residential density is positively associated with walking demands.
What is the gender-related impact?	High plot Area Ratio related with FAR means lower buildings bringing more eyes on the street, higher sense of community, less anonymity, and a higher sense of safety through a more welcoming environment and eyes on the street (Du Y., Jiang, Huang, & Yang, 2023). Public spaces that will attract people are those with reasonable density and good quality city space with adequate population density and acceptable walking and biking areas, which are better options than erecting tall buildings that create high density and poor public spaces (Gehl, Cities for People, 2010).
What is the impact on affordability?	The plot coverage ratio, along with the minimum plot size, is one element to consider for upzoning. With upzoning, city governments can provide more housing units, which can enhance urban regeneration and housing affordability.
What is the impact on economic efficiency?	Lot coverage ratio is one of the other key elements to adjust the density of a district. By granting higher plot coverage ratio would cause similar impact of the high FAR. Expect higher land value capture and a vitalized local economy with higher plot coverage ratio (Suzuki, Murakami, Hong, & Tamayose, 2015).
What is the road safety impact?	Higher plot coverage ratios often lead to increased development density, which can result in more vehicles on the road. This higher volume of traffic can exacerbate congestion, leading to slower speeds, frequent stops, and a greater likelihood of crashes.

Minimum Lot Size

Minimum lot size	
What is it?	The minimum lot size is the smallest allowable size of a parcel of land. In general, the purpose of the minimum lot size policy is to ensure sufficient level of housing supply and development density. The application of the minimum lot size policy differs by the regional context. In the US, large minimum lot size has been criticized as the cause of low-density development, low housing affordability, insufficient housing supply and car-oriented urban form (Gardner, 2023). In the US context, minimum lot size is a zoning restriction particularly related to the residential zones. The single-family-home (SFH) zoning is a zoning restriction which can be found only in the US and Canada. The SFH zone is designed only for single-detached houses, banning the construction of townhouses, duplex, multifamily housing, and apartment (Baldassari & Solomon, 2020). As the original purpose of using the lots was for single-family houses, minimum lot size was set wide (e.g., 6000 sqft or higher in suburban area, and 2500-6000 sqft in major US cities). Given that 75 percent of the residential land of the US is designated as the SFH zone (Badger & Bui, 2019), its impact on low-intense land use across the country is not negligible. In Korea, on the other hand, minimum lot size has been adopted to prevent lot sizes that are way too small. Developers split land parcels into minimal sizes seeking speculative opportunities (e.g., resale margin for the parcel split into minimal area, apartment presale right). Enforcement Decree of the Building Act's Article 80 stipulates different minimum lot sizes for the different land use (e.g., Residential: 60 sqmt, Commercial: 150 sqmt, Industrial: 150 sqmt, Green: 200 sqmt, Other: 60 sqmt) (Ministry of Land, Infrastructure and Transport of Korea).
What is the impact on public transport use?	If upzoning succeeds in providing more housing units in urban areas, urban residents would enjoy better access to public transits.
What is the impact on walking?	If upzoning succeeds in providing more housing units in urban areas, urban residents are more likely to walk densely populated streets with enjoying psychological safety and comfort. Moreover, higher development density would help urban residents to have closer walking distance to the amenities and public transits.

Minimum lot size	
What is the gender-related impact?	Large minimum lot size tends towards either disperse edifications or high buildings. Lower plot size favors the construction of building at a scale that enables more proximity between the interior and exterior and a more welcoming environment that enhances the sense of safety through more eyes on the street (Jacobs, 1961) and less anonymity.
What is the impact on affordability?	Previous studies argued that to make minimum lot size regulations successfully lead to housing affordability, it is important to set them at a low level (Gardner, 2023); (Gray N., 2019); (Gyourko and McCulloch, 2023). As shown in the US zoning history, wide minimum lot size has made US zoning system exclusionary and unaffordable to the low-income households and minor ethnicities. In response, upzoning which constructs additional units (or accessary buildings) on lots has garnered attention across the US. It is equivalent to dividing a lot into smaller minimum lots. In theory, an increase in housing supply should stabilize housing prices and thus increase housing affordability. However, it could not be the case. This is because housing prices and land value can go up in response to the development speculation could increase housing prices and land value more. Thus, to achieve the targeted policy goal, city governments need to push an intense upzoning policy (large-scale provision).
What is the impact on economic efficiency?	When minimum lot size is not small enough, there is no proper housing option for the low-income households so that they lose investment chance. Such an exclusive investment environment can lead to lack in distributional impact (Lall S. , Lebrand, Sturm, & Venables, 2021).
What is the road safety impact?	Upzoning with smaller minimum lot sizes would densify streets with more residents living in the neighborhoods. As (Guerra, 2019) argued, increase in street density would make neighborhood safer with fewer crashes, injuries, and fatalities.

Parking Mandates

Parking Minimums and Parking Maximums	
Similar Terminologies	Parking Requirements
What is it?	Parking mandates are land use regulations controlling the parking spaces for the buildings to develop. Mandated parking lots vary depending on the usage and size of the buildings but for multi-story residential buildings, city governments usually assign a minimum of one parking lot per dwelling unit. Even though parking mandates are land use schemes, their impact is not limited to the parking space supply. It also serves as a strong transportation demand management (TDM) scheme influencing car ownership and travel behavior of residents, employees, and shopping mall users. There are two approaches to mandating parking spaces: parking minimums and parking maximums. While the former sets the lower bound limit, the latter sets the maximum cap in terms of the parking space supply. **Parking Minimums** The parking minimum policy stipulates the least number of off-street parking lots that developers or landowners should install for the buildings to develop. The parking minimum ratio, or the lower bound limit of parking lot supply, is calculated based on parking generation, which usually follows the land use (e.g., business, commercial) and size (e.g., commercial building: floor area, apartment: dwelling units) of the buildings. Parking minimums are the number of parking lots that developers should provide in the development site (property lot or block) regardless of the provision of nearby on-street parking spaces. **Parking Maximums** Most of the city governments have adopted the minimum parking requirements as a default parking policy under the paradigm of the Euclidean zoning. However, it has been criticized that it has caused excessive derivative transport demands and led the city to be car oriented (ITDP, 2023) (Strong Towns, 2020). Instead, parking maximums set the cap on parking lots considering the building's use, size of and proximity to the transit station.

Parking Minimums and Parking Maximums	
	Parking mandates among the parking minimums and parking maximums have been opted for and decide the dominant transport modes the residents rely on. As an effort to avoid car dependency, major global cities have taken up parking reforms which mainly replace parking minimums with parking maximums (e.g., Austin, Texas; California; City of New York; London, England; Mexico City, Mexico; San Francisco) (ITDP, 2024). The scope of parking maximums has been gradually expanding from office and commercial buildings to residential buildings (e.g., Minneapolis, Minnesota) (ITDP, 2023).
What is the impact on public transport use?	The sandbox model showed that increasing parking minimums are negatively associated with public transport ridership. It is a reasonable result as the higher parking minimums allow households to have a higher number of private vehicles and which leads to higher private vehicle dependence. It is expectable that parking maximums are positively associated with public transport ridership. Usually, parking maximums are set at the lower level of the parking minimum regulations. For example, Seoul city applies parking maximums for some commercial zones capping parking lots provision at 50 percent of the usual commercial zones. Therefore, when parking maximums are applied to the development sites, it affects residents to own fewer private cars and rely more on public transport modes and shared mobility.
What is the impact on walking?	Replacing parking minimums with parking maximums would encourage people to divert from cars to public transit and walking.
What is the gender-related impact?	Parking lots by nature violates the principle of eyes on the street. The lowest ranking that safety audit organizations give to visibility (eyes on the street) has to do with no windows or entrances of shops or residences overlook, which are elements absent in parking lots (Viswanath & Basu, 2015).
What is the impact on affordability?	Parking lots are expensive assets. As of June 2022, building a parking stall costs $27,900 on average in the US and could be up to $85,000 in the premium sites like Silicon Valley (Poskey, 2023). This indicates that developers inevitably charge higher housing prices in case they need to build up more parking spaces in the development sites. Thus, parking maximums can increase housing affordability.
What is the impact on economic efficiency?	The key element to ensure the success of parking maximums is to set the cap at the right level. According to the ITDP (2023: 13), if the maximum cap is too low, its effectiveness cannot be counted on. Nonetheless, the appropriate level has yet to be agreed among the experts. In addition, city governments need to pay heed to whether the public parking spaces are sufficient to cover existing level of potential demand at the same time.
What is the road safety impact?	Parking maximums enhance road safety as it basically transforms the car-oriented urban form into a pedestrian-oriented one.

Mixed-Use Zoning

Mixed-Use Zoning	
What is it?	Mixed-use zoning permits properties to have various uses like business, commercial, institutional, and residential in a combined manner (Duarte, Stepner, Roberts, Dickson, & Rosenhall, 2010). It could be a single building or on a single site. Whichever case, a building or site has multiple uses deemed compatible with each other. Examples of mixed-use buildings are the ones with residential units in their upper stories and retail on the ground floor (Transect Homepage). Mixed-use developments permit a broad range of uses at varying densities or in defined neighborhood commercial areas. **Figure A.3 Mixed Use in Ulaanbaatar City Center**  Source: Ok Stella Namkung
What is the impact on public transport use?	By providing convenient access to public transport options, mixed-use zoning can encourage higher public transport ridership. Residents living in mixed-use areas may be more inclined to use public transport for their daily commuting needs, errands, and leisure activities. For example, the city of New York saw a sharp decrease in commuters' car mode share from 90 percent to 59 percent between 2010 and 2011 due to the mixed-use development (Zamorano and Kulpa, 2014).
What is the impact on walking?	Mixed-use zoning places residential, commercial, and recreational facilities within proximity to each other. This proximity makes it more convenient for residents to access daily necessities such as grocery stores, cafes, parks, and schools on foot, encouraging them to walk or bike instead of driving (IBID).

Mixed-Use Zoning	
What is the gender-related impact?	Mixed land use will highly benefit women, given their mobility patterns related to the mobility of care. The availability and closeness of services are particularly relevant for those associated with care activities, which are normally attributed to women (Madariaga and Abril, 2021). The mobility of care includes all travel resulting from home and caring responsibilities (i.e., escorting others, shopping, household maintenance and organization, etc.) (Madariaga, 2013). Mixed land use contributes to improve the accessibility of those in charge of household and remunerated chores by making more proximate different activities through flexible zoning (Madariaga and Abril, 2021). Bringing schools, daycares, shops, and bathrooms closer will contribute to women's autonomy and well-being by contributing to address their constraints in terms of time and be able to have a better balance between care and professional responsibilities (Madariaga and Abril, 2021).
What is the impact on affordability?	Mixed use zoning usually increases housing affordability with higher development density and housing supply. Moreover, being developed nearby transit-oriented development sites, people coming from/to the mixed-use zone can enjoy lower transportation costs (Zamorano and Kulpa, 2014); (Millman National Land Services, 2021).
What is the impact on economic efficiency?	High density mixed-use zoning lowers housing price per unit, transportation costs and living expenses (Millman National Land Services, 2021), while increasing local economic activities (Zamorano and Kulpa, 2014). Pedestrian-friendly retail environments can boost local businesses by attracting foot traffic, leading to economic vitality and job creation within the community.
What is the road safety impact?	Mixed-use zoning promotes compact, walkable neighborhoods where residents have easy access to amenities, services, and employment opportunities. This can lead to shorter trip distances and reduced reliance on cars. This results in lower overall vehicle miles traveled and higher proportion of pedestrian traffics in compact, mixed-use urban environments. With fewer vehicles on the road, there is a potential decrease in the likelihood of traffic collisions (Lee, Zegras, and Ben-Joseph, 2013).

Build-to-Line

Build-to-line	
Similar terminologies	Front Building Limit Line, Build-to-zone Front setback, Frontage zone, Front yard
What is it?	The front building limit line is a front setback line that the façade of building must be built upon (DC Office of Zoning, 2016). It requires landowners to keep minimum or maximum distance between a building and a property line unoccupied (DC Office of Zoning, 2016); (Duarte, Stepner, Roberts, Dickson, & Rosenhall, 2010). This distance is measured from the property line (or street right of way line) to the building façade. The purpose of the front setback is to ensure walking comfort, sight openness, and consistent streetscapes in front of the buildings (Toole, Pietrucha, & Davis, 1999). In the commercial/mixed use zones, consistent streetscape is particularly important to enhance interaction between pedestrians and adjacent shops, cafés and plaza. Front setback zone basically does not allow building garages or carports. Parking setbacks follow separate regulations. When allowed, 10-20 feet setback is required from the right-of-way of public street in either residential or non-residential zones. It is argued that broad parking setbacks could discourage walkability, violating see-and-be-seen principles. **Figure A.4 Front Building Setback (Washington DC, USA)**  Source: Ok Stella Namkung.

Build-to-line	
What is the impact on public transport use?	According to the study authors' sandbox model to examine the association between land use regulations and public transport ridership, setback has a weak negative association with the public transport ridership. This might be because the given-up setback area for the public right-of-way reduces buildable area, resulting in a smaller number of dwelling units and residents in blocks. This also reduces the potential public transport users. Moreover, setback increases walking distances because people must walk longer to get to the sidewalk and from there to the public transport station. Notice that a plaza in front of a high-rise has a similar effect. (Santos, Caccia, Samios, & Ferreira, 2019) recommends only 0.45 m for the maximum setback width.
What is the impact on walking?	Front build-to-line provides clear benefits for the pedestrians. Having wider right-of-way and well-organized building alignment, they feel walking comfort and open sightedness. Also, aesthetic streetscape and lively street encourage more people to walk with psychological security.
What is the gender-related impact?	A reasonably wide sidewalk and low setback that brings the face close to the sidewalk with frequent doors and windows promotes the principle of "eyes on the street" (Du Y. , Jiang, Huang, & Yang, 2023). The best practice to improve visibility would be that the building is constructed at the front line bringing public and private space as close as possible. The front building line allows visibility to provide a more dynamic relationship between the exterior and interior (Toole, Pietrucha, & Davis, 1999). Ground floor should be open for business by making more flexible the compatibility of uses in residential buildings to be able to include shops, offices, and other services at street level (Madariaga and Abril, 2021). A frontage zone that allows restaurants, shops, and other amenities contributed to the principle of eyes on the street (Jacobs, 1961). As mentioned earlier, broad parking setbacks could discourage walkability violating eyes on the street principle. High walls at the frontline also violate the principle of eyes on the street. There is evidence that removing solid walls will significantly increase the perception of safety, particularly for women (Navarrete, Vetro, & Concha., 2023).

Build-to-line	
What is the impact on affordability?	Housing affordability is negatively affected as setback sacrifices the buildable area, providing fewer dwelling units. Lower housing supply can lead to higher housing prices. Moreover, a comfortable walking environment, good safety and security, and pleasant streetscape would make the neighborhood more attractive and competitive in the housing market.
What is the impact on economic efficiency?	Setback is an economically bad policy for the developers and property owners as they limit the amount of space available for development on a given property. It potentially reduces the overall buildable area and constrains the potential return on investment for property owners. It enforces them to consume more land than needed and consolidate land into fewer lots to prevent putting small unusable parcels into waste (PriceA., 2017). This limitation can result in higher development costs per unit area and may deter investment in affected properties. However, for society, setbacks have an economic distribution impact. Because residents and pedestrians can enjoy sight openness, aesthetic streetscape, and lively mood on the sidewalk extended with setback area.
What is the road safety impact?	Positive. Building setback along with other street design elements, such as presence of trees, and cross-sectional sidewalk design could enhance road safety by enhancing drivers' perceived sense of safety and crash risk (Azimi, et al., 2023).

Figure A.5 Example of a Pedestrian-only Street

Source: (WRI Brazil, 2019).

Street Furniture Zone

Street Furniture Zone	
Similar terminology	Furnishing Zone, Curb Zone
What is it?	The street furniture zone includes the end part of sidewalk that extends from the curb to the driveway. Here, various amenities such as lighting, benches, newspaper kiosks, utility poles, tree pits, and bicycle (and e-scooter) parking are typically placed. Additionally, this zone may incorporate green infrastructure features like rain gardens or flow-through planters (NACTO). Currently, extended usage of this zone appeals to the new stakeholders other than pedestrians (Sipe, 2019). The street furniture zone has served for shared mobility pick-up and drop-off and loading and unloading goods for the deliveries. City governments pay attention to this zone as well to earmark the pick-up/drop-off spaces for the autonomous shuttles and taxis.

Figure A.6 Bike-sharing Docking Stations on Street Furniture Zone (Washington DC, USA)

Source: Ok Stella Namkung.

Figure A.7 Bike Racks on Street Furniture Zone (Paris, France)

Source: Ok Stella Namkung.

Street Furniture Zone

What is the impact on public transport use?

Basically, street furniture zones positively affect public transport ridership. Street furniture zones typically include amenities providing transit users with a comfortable and safe environment to wait for buses, trams, or trains. It contributes to the overall attractiveness of public transport systems. If street furniture zones follow universal design guidelines (i.e., wheelchair ramps, tactile paving, and designated seating areas), they cater to all users, including people with disabilities, the elderly, and parents with strollers, and connect them to the public transport networks.

The emerging shared mobility, however, affects street furniture zones to have mixed effects on public transportation use. Basically, street furniture zone facilitates the integration of active transport modes such as cycling and walking with public transport networks. Features such as bike racks, bike-sharing stations, and pedestrian crossings promote seamless intermodal connectivity, allowing commuters to use active modes with public transportation for their journeys. However, increasing mode share for shared mobility can substitute the public transport demand as agued by (OECD ITF, 2018).

Table A.1. Trip Category for the Most Recent Ride Service Trip Taken Instead of Public Transport

	BART (San Francisco rail)	MARTA (Atlanta)	NJT (NE New Jersey)	WMATA (Washington, DC)
Connecting to PT	16%	6%	8%	3%
Instead of PT	11%	16%	17%	39%
PT not an option	32% (26% hour, 6% route)	16% (8% hour, 8% route)	19% (not specified)	13% (4% hour, 9% route)
Haven't used ride services	41%	62%	56%	45%

Source: (OECD ITF, 2018).

What is the impact on walking?

Properly designed street furniture zones provide benches and seating areas along walking routes. These offer opportunities for pedestrians to rest, which is especially important for individuals with limited mobility or those needing a break during longer walks. This can encourage people to walk more by providing comfort along the way.

Amenities like trash receptacles and recycling bins in the street furniture zone promote cleanliness and convenience for pedestrians, encouraging more people to walk rather than drive short distances.

Street Furniture Zone	
What is the gender-related impact?	Equipping sidewalks with abundant benches, trash cans, inclusive signage and trees has been stressed by practitioners working on gender and urban design (Madariaga and Abril, 2021). Some technical criteria have been recommended for the placement of these items; for example, it has been suggested that a good city shall locate suitable places to sit at regular intervals of 100 meters (GehlJan, Life between buildings. Using public space, 2011). However, they should not lose sight of the fact that these elements are designed in a way that there is no obstruction of walkability and visibility. The 12 quality criteria concerning the pedestrian landscape developed by Jan Ghel welcomes the inclusion on sidewalks of amenities and greenery to provide aesthetic experiences and pleasant impressions, but it also incorporates as a criterion the importance of having room for walking and no obstacles (Gehl, 2010). Other authors have even recommended specific measures to facilitate free passage, for example, having sidewalks with well-sized widths so that the free passage is always equal to or greater than 140 cm, considering urban furniture, signage, trees and other types of elements (Madagarial and Abril, 2021).
What is the impact on affordability?	Well-maintained and attractive street furniture zones can enhance the desirability of a neighborhood, potentially leading to increased property values. While this can be positive for homeowners, it may also contribute to higher housing costs, reducing affordability for prospective buyers or renters.
What is the impact on economic efficiency?	As a transition space between sidewalk and driveway, street furniture zone allows people to do something other than walking. People use street furniture zones to wait and access transport modes like taxis, shared mobility and public transportation and take rest on the benches. As space enhances the mobility of the transport vulnerable, its distributional impact is somewhat important.
What is the road safety impact?	Street furniture zones can contribute to improved safety for public transport users and pedestrians by providing well-lit waiting areas, clear sightlines, and surveillance cameras. Enhanced safety measures help alleviate concerns about personal security, particularly during off-peak hours or in locations with low population flow and high crime rates, thereby encouraging more people to use public transport.

Pedestrian Road

Pedestrian Road	
Similar terminology	Pedestrian-only Streets
What is it?	A pedestrian road is a road or street where cars are not allowed to enter as it is designed only for pedestrians. Pedestrian roads are often found in city centers, shopping districts and areas with high pedestrian traffic. Road entrance could be limited by the time of day and only for private cars. **Figure A.8 Pedestrian Street in La Defense, Paris**  Source: Ok Stella Namkung.
What is the impact on public transport use?	Pedestrian roads that are strategically located near public transport hubs, such as bus stops, tram stations, or subway entrances, can enhance accessibility to public transportation (last mile connectivity). By providing a pedestrian-friendly connection between transport nodes and surrounding destinations, pedestrian roads can encourage more people to use public transport as a convenient mode of travel.
What is the impact on walking?	Pedestrian roads are designed and maintained for pedestrian safety and comfort. Separation from vehicular traffic, well-maintained sidewalks, and adequate lighting contribute to a safer and more comfortable walking experience, thereby encouraging more people to walk.

Pedestrian Road	
What is the gender-related impact?	During the day, roads where cars are not allowed to enter can support women's mobility through walkability, as data shows that women rely more on walking. This would need to come together with other regulations such as mixed land use to ensure eyes on the street (Jacobs, 1961). Closing streets at night might have a negative effect on women's perception of safety, as less cars might mean less people, and this could worsen in the absence of business.
What is the impact on affordability?	There are possibilities that pedestrianization projects lead to the gentrification pressures. If this is the case, lower-income residents or small businesses could be displaced to the urban fringe due to increased property values in the surrounding area. Thus, it is necessary to be cautious about its complex implications for public transport use, as changes in population demographics may affect transit demand and accessibility.
What is the impact on economic efficiency?	Pedestrian roads can contribute to local economic development by attracting visitors, shoppers, and tourists. A vibrant pedestrian environment can boost retail sales, stimulate business activity, and increase property values in the surrounding area, thereby supporting local economies and creating job opportunities. Cities which opted for a car-free policy saw no decline in the number of shoppers to come (Herbert, 2023).
What is the road safety impact?	By separating pedestrians from vehicular traffic, pedestrian roads inherently reduce the risk of pedestrian-vehicle collisions. Without the presence of cars or other motorized vehicles, pedestrians can move freely and safely within designated pedestrian zones, significantly decreasing the likelihood of crashes and injuries. While pedestrian roads themselves may be designed for safety, intersections where pedestrian roads intersect with vehicular streets may present challenges for road safety. Proper design and implementation of pedestrian crossings, traffic signals, and signage are essential to ensure safe interactions between pedestrians and vehicles at intersections.

Bibliography

DiPasquale, D., & Wheaton, W. (1996). *Urban Economics and Real Estate Markets*. Englewood Cliffs, NJ: Prentice Hall.

Wikipedia. (2024). *Streets and highways of Washington, D.C.* Retrieved from https://en.wikipedia.org/wiki/Streets_and_highways_of_Washington,_D.C.

(SDSN), S. D. (2015). *Indicators and a Monitoring Framework for Sustainable Development Goals: Launching a data revolution for the SDGs.* Retrieved from https://resources.unsdsn.org/indicators-and-a-monitoring-framework-for-sustainable-development-goals-launching-a-data-revolution-for-the-sdgs.

Acheampong, R. A., & Silva, E. (2015). Land use–transport interaction modeling: A review of the literature and future research directions. *Journal Of Transport and Land Use,* 8(3), 11-38. Retrieved from https://doi.org/http://dx.doi.org/10.5198/jtlu.2015.806.

Alam, M. M., Kurshitashvili, N., Dominguez Gonzalez, K., Gonzalez Carvajal, K., & Baruah, B. (2022). *Is a Mile for One a Mile for All?: A Knowledge Synthesis Report on Gender and Mobility (2000–20).* Washington, DC: World Bank. Retrieved from http://hdl.handle.net/10986/37354.

Appelbaum, B. (2023, Sep. 23). The Big City Where Housing Is Still Affordable. *New York Times.* Retrieved from https://www.nytimes.com/2023/09/11/opinion/editorials/tokyo-housing.html?smid=nytcore-ios-share.

Ardila-Gomez, A. (2004). *Transit Planning in Curitiba and Bogota: Roles in Interaction, Risk, and Change.* Cambridge, MA, USA. Retrieved from https://dspace.mit.edu/handle/1721.1/28791.

Ardila-Gomez, A. (2008, January). BRT and Land Use: The Case of Transmilenio. Bus rapid transit after a third of a century: Lessons of the past, pathways to the future. Washington DC.

Ardila-Gomez, A., & Adriana Ortegon Sanchez. (2016). *Sustainable Urban Transport Financing from the Sidewalk to the Subway: Capital, Operations, and Maintenance Financing.* Washington DC: World Bank. doi:10.1596/978-1-4648-0756-5.

Ardila-Gomez, A., & Darido, G. (2023). Public Transport Reform in Developing Countries: Lessons From Experience. Montreal. Retrieved from https://www.researchgate.net/publication/376032036_Public_Transport_Reform_in_Developing_Countries_Lessons_From_Experience Public Transport Reform in Developing Countries: Lessons From Experience.

Ardila-Gomez, A., Bianchi Alves, B., & Moody, J. (2021). *Decarbonizing Cities by Improving Public Transport and Managing Land Use and Traffic.* Washington DC: World Bank. Retrieved from http://hdl.handle.net/10986/36517.

Armus, T. (2024, July 8). Counties and states are ending single-family zoning. Homeowners are suing. The Washington Post. Retrieved from https://www.washingtonpost.com/dc-md-va/2024/07/08/single-family-zoning-lawsuit-arlington-missing-middle-trial/.

Azimi, E., Tayarani, M., Azin, B., Kaniewska, J., Choi, D., Ameli, H., & Bahrami-Rad, D. (2023). *A National Investigation on The Impacts of Lane Width on Traffic Safety: Narrowing Travel Lanes as an Opportunity to Promote Biking and Pedestrian Facilities Within the Existing Roadway Infrastructure.* Johns Hopkins Bloomberg School of Public Health.

Badger, E., & Bui, Q. (2019, June 19). Cities Start to Question an American Ideal: A House With a Yard on Every Lot - Townhomes, duplexes and apartments are effectively banned in many neighborhoods. Now some communities regret it. *The New York Times.* Retrieved from https://www.nytimes.com/interactive/2019/06/18/upshot/cities-across-america-question-single-family-zoning.html.

Baldassari, E., & Solomon, M. (2020, October 5). The Racist History of Single-Family Home Zoning. *NPR.* Retrieved from https://www.kqed.org/news/11840548/the-racist-history-of-single-family-home-zoning.

Baseel, C. (2023, May 3). Gov't study finds only 3,065 homeless people in Japan. *Japan Today.* Retrieved from https://japantoday.com/category/national/gov%27t-study-finds-only-3-065-homeless-people-in-japan.

Bausells, M. (2016). Superblocks to the rescue: Barcelona's plan to give streets back to residents. *The Guardian.* Retrieved from https://www.theguardian.com/cities/2016/may/17/superblocks-rescue-barcelona-spain-plan-give-streets-back-residents.

Bertaud, A. (2003, November). Clearing the air in Atlanta: Transit and smart growth or conventional economics? *Journal of Urban Economics.* Retrieved from https://www.researchgate.net/publication/222575994_Clearing_the_air_in_Atlanta_Transit_and_smart_growth_or_conventional_economics.

Bertaud, A. (2018). *Order Without Design: How Markets Shape Cities.* Cambridge, MA: MIT Press.

Bertaud, A., & Brueckner, J. (2005). Analyzing building height restrictions: predicted impacts and welfare costs. *Regional Science and Urban Economics*, 109-125.

Bertaud, A., & Malpezzi, S. (2003). *The Spatial Distribution of Population in 48 World Cities: Implications for Economies in Transition.* Center for Urban Land Economics Research, University of Wisconsin. Retrieved from https://www.researchgate.net/publication/228593725_The_Spatial_Distribution_of_Population_in_48_.

Bianchi Alves, B., Bou Mjahed, L., & Moody, J. (2023). *Decarbonizing Urban Transport for Development.* Washington DC. Retrieved from http://hdl.handle.net/10986/40373.

Blair, J. P. (1995). *Local Economic Development: Analysis and Practice.* Sage.

Borges, V., & da Silva, H. (2021). Agricultura Urbana e a transformação da vida e da paisagem no Tatuquara, Curitiba-PR. *Revista Franco-Brasileira de Geografia*. Retrieved from https://doi.org/10.4000/confins.41629.

Brosnan, R. (2010). 40 years of Transit Oriented Development - Arlington's County Experience with TOD in the Rossalyn-Ballston Metro Corridor. *A Presentation to the Reston Land Use Task*.

Calder, V. B. (2017, October). Zoning, Land-Use Planning, and Housing Affordability. *Policy Analysis CATO Institute*. Retrieved from https://www.cato.org/policy-analysis/zoning-land-use-planning-housing-affordability.

Calthorpe, P. (2022). *Ending Global Sprawl: Urban Standards for Sustainable and Resilient Development*. The World Bank. Retrieved from https://www.thegpsc.org/sites/gpsc/files/globalsprawl_chap_01-05.pdf.

Centro de Transporte Sustentable de Mexico A.C. (2012). *TOD Guide for Urban Communities*. Mexico DF. Retrieved from https://environmentaldocuments.com/embarq/TOD_Guide_Urban_Communities_English_EMBARQ.pdf.

Cervero, R. (1998). *Transit Metropolis: A Global Inquiry*.

Christafore, D., & Leguizamon, S. (2019). Neighbourhood inequality spillover effects of gentrification. *Papers in Regional Science, 98*(3), 1469-1484.

Cities Alliance . (2019). *Connecting Systems of Secondary Cities*. Brussels: Cities Alliance/UNOPS.

Collins, H. (2023, April 12). Barcelona bets on green to boost city's mental health. *Politico*. Retrieved from https://www.politico.eu/article/barcelona-green-spaces-mental-health-superblocks-eixos-verds/.

Crane, R. (2007). Is there a Quiet Revolution in Women's Travel? . *Journal of American Planning Association, 73*(3), 299.

Daniels, R., & Mulley, C. (2013). Explaining walking distance to public transport: The dominance of public transport supply. *Journal of Transport and Land Use*, 5-20. Retrieved from https://www.jstor.org/stable/26202654.

Davis, M. (2004). *Planet of Slums*. London.

DC Office of Zoning. (2016). DC Zoning Handbook. Retrieved from https://handbook.dcoz.dc.gov/.

De Vos, J. (2015). The influence of land use and mobility policy on travel behavior: A comparative case study of Flanders and the Netherlands. *Journal of Transport and Land Use, 8*(1), 171-190.

Deike, P. (2002). *Breadwinners, Homemakers and Beasts of Burden: a Gender Perspective on Transport and Mobility*. Berlin, Germany: Institute for City and Regional Planning (ISR),.

Dispatch, C. (Producer). (2023). *Why Tokyo has Tons of Affordable Housing but America Doesn't* [Motion Picture]. Retrieved from https://www.youtube.com/watch?v=geex7KY3S7c.

Dominguez Gonzalez, K., Machado, A., Bianchi Alves, B., & Portabales, I. (2020). *Why does she move? A study of women's mobility in Latin America*. Washington: World Bank.

Du, Y., Jiang, H., Huang, Z., & Yang, H. (2023). Associations between neighborhood environment and sense of community belonging in urban China: Examining mediation effects of neighborly interactions and community satisfaction. *Front. Public Health, 10*. doi:10.3389/fpubh.2022.1105473.

Du, Y., Jiang, H., Huang, Z., & Yang, H. (2023). Associations between neighborhood environment and sense of community belonging in urban China: Examining mediation effects of neighborly interactions and community satisfaction. Frontiers in Public Health. 10:1105473. *Frontiers in Public Health, 10:1105473*.

Duarte, T., Stepner, M., Roberts, J., Dickson, C., & Rosenhall, J. (2010). *Understanding the Basics of Land Use and Planning: Glossary of Land Use and Planning Terms*. The Institute for Local Government.

Encyclopedia of Chicago. (2005). *Thompson's Plat of 1830*. Retrieved from Encyclopedia of Chicago: http://www.encyclopedia.chicagohistory.org/pages/11175.html.

Enforcement Decree of the Building Act. (n.d.). Retrieved from Korean Law Information Center: https://elaw.klri.re.kr/eng_service/lawView.do?hseq=63808&lang=ENG.

Engelberg, D., He, H., L.-T., D., & Zegras, P. C. (2021). Accessibility, land use models, and modeling. In *Urban Form and Accessibility*. (pp. 379-409). Retrieved from https://doi.org/10.1016/B978-0-12-819822-3.00019-5.

European Environment Agency. (2022). *Who benefits from nature in cities? Social inequalities in access to urban green and blue spaces across Europe*.

From, L. W. (Producer). (2022). *Why Japan Looks the Way it Does: Zoning* [Motion Picture]. Retrieved from https://www.youtube.com/watch?v=wfm2xCKOCNk.

Gao, X., Asami, Y., & Katsumata, W. (2006). Evaluating land-use restrictions concerning the floor area ratio of lots. *Environment and Planning C: Government and Policy*, 515-532. Retrieved from https://journals.sagepub.com/doi/10.1068/c0531.

Gardner, C. (2023, 8 14). *Urban Minimum Lot Sizes: Their Background, Effects, and Avenues to Reform*. Retrieved from Mercatus Center At George Mason University: https://www.mercatus.org/research/policy-briefs/urban-minimum-lot-sizes-their-background-effects-and-avenues-reform#:~:text=Perhaps%20more%20than%20any%20other,%2C%20exurban%2C%20or%20even%20rural.

Gehl, J. (2010). *Cities for People*. Washington, London: Island Press.

Gehl, J. (2011). *Life between buildings. Using public space*. Washington: Island Press.

Geoff, B. (2019). Urban spatial order: street network orientation, configuration, and entropy. *Applied Network Science*. doi:https://doi.org/10.1007/s41109-019-0189-1.

Glaeser, E. (2011). *The Triumph of the City: How Our Greatest Invention Makes us Richer, Smarter, Greener, Healthier, and Happier. Macmillan*. Macmillan.

Global Designing Cities Initiative. (2016). *Global Street Design Guide*. Island Press. Retrieved from https://globaldesigningcities.org/publication/global-street-design-guide/.

Global Platform for Sustainable Cities, World Bank. (2021). *Transit Oriented Development Implementation, Resources, and Tools*. Washington, DC.: World Bank Group. Retrieved from https://documents.worldbank.org/en/publication/documents-reports/documentdetail/261041545071842767/transit-oriented-development-implementation-resources-and-tools-second-edition.

Grabar, H. (2023). *Paved Paradise: How Parking Explains the World*. Penguin.

Gray, N. (2019, February 27). *8 Things Your Town Can Do to Add More Housing (Without Spending a Dime*). Retrieved from Stong Towns: https://www.strongtowns.org/journal/2019/2/27/8-things-your-town-can-do-to-add-more-housing-without-spending-a-dime.

Gray, N. (2022). *Arbitrary Lines: How Zoning Broke the American City and How to Fix It*.

Guerra, E. D. (2019). Do denser neighborhoods have safer streets? Population density and traffic safety in the Philadelphia region. *Journal of Planning Education and Research*.

Guʒman, L. A., & Gomeʒ, S. (2021). Density-oriented public transport corridors: Decoding their influence on BRT ridership at station-level and time-slot in Bogota. *Cities: the International Jornal and Urban Policy and Planning*.(110). Retrieved from https://www.sciencedirect.com/science/article/pii/S0264275120314190?via%3Dihub.

Guʒman, L. A., Peña, J., & Carrasco, J. A. (2020). *Assessing the role of the built environment and sociodemographic characteristics on walking travel distances in Bogotá*. Retrieved from https://www.sciencedirect.com/science/article/pii/S0966692319310786.

Guʒman, L., & Bocarejo, J. (2017). Urban form and spatial urban equity in Bogota, Colombia. *World Conference on Transport Research - WCTR 2016, 25*, pp. 4491–4506. Retrieved from https://www.sciencedirect.com/science/article/pii/S235214651730652X.

Gwilliam, K. (2002). *Cities on the Move: A World Bank Urban Transport Strategy*. Washington DC: World Bank. Retrieved from https://documents.worldbank.org/en/publication/documentsreports/documentdetail/928301468762905413/cities-on-the-move-a-world-bank-urban-transportstrategy-review.

Gyourko, J., & McCulloch, S. (2023). Minimum Lot Size Restrictions: Impacts on Urban Form and House Price at the Border. *National Bureau of Economic Research*.

Hall, E. (2006). Divide and sprawl, decline and fall: A comparative critique of Euclidean zoning. *University of Pittsburgh Law Review, 68*, 915.

Hawken, S., Leao, S., Gudes, O., Izadpanahi, P., Viswanath, K., & Pettit, C. (2019). Safer Cities for Women: Global and Local Innovations with Open Data and Civic Technology. In *Open Cities | Open Data: Collaborative Cities in the Information Era*. Singapore: Springer.

Henry, P. (2021, October 21). *These innovative projects are tackling homelessness around the world*. Retrieved from World Economic Forum: https://www.weforum.org/agenda/2021/10/innovative-projects-tackling-homelessness-around-the-world/.

Herbert, G. (2023, Septermber 21). *European cities are increasingly becoming more pedestrianised and bike-friendly. Does this have an economic cost or is it a win-win situation?* Retrieved from Euronews: https://www.euronews.com/next/2023/09/21/what-are-the-economic-benefits-of-car-free-cities.

Hess, D. B., & Rehler, J. (2021). Minus MinimumsDevelopment Response to the Removal of Minimum Parking Requirements in Buffalo (NY). *Journal of the American Planning Association, 87*(3), 396-408. Retrieved from https://www.tandfonline.com/doi/epdf/10.1080/01944363.2020.1864225?needAccess=true.

Hobbs, J., Baima, C., Durán-Ortiz, M., Alves, D., Ribeiro, K., & Seabra, R. (2021). *Transit Oriented Development: how to make cities more compact, connected and coordinated: recommendations for Brazilian municipalities*. Washington, DC.: Inter American Development Bank. Retrieved from https://publications.iadb.org/en/transit-oriented-development-how-make-cities-more-compact-connected-and-coordinated-recommendations.

Hsieh, C.-T., & Moretti, E. (2019). Housing Constraints and Spatial Misallocation. *American Economic Journal: Macroeconomics, 11*(2), 1-39. doi:https://doi.org/10.1257/mac.20170388.

Huang, R., Moudon, A. V., Zhou, C., & Saelens, B. E. (2019). Higher residential and employment densities are associated with more objectively measured walking in the home neighborhood. *Journal of transport & health, 12*, 142-151.

Hunt, J. D., Kriger, D. S., & Miller, E. J. (2005). Current operational urban land use–transport modeling frameworks: A review. . *Transport Reviews, 25*(3), 329–376. Retrieved from https://doi.org/10.1080/0144164052000336470.

Iacono, M., Krizek, K., & El-Geneidy, A. (2008). *Access to Destinations: How Close is Close Enough? Estimating Accurate Distance Decay Functions for*. St. Paul, Minnesota: Estimating Accurate Distance Decay Functions for. Retrieved from https://www.lrrb.org/pdf/200811.pdf.

Inter-American Development Bank. (2013). *Guía para la Integración de la Perspectiva de Género en los Sistemas de Transporte Urbano que Optimizan la Movilidad*. Washington, DC: División de Género y Diversidad, Inter-American Development Bank.

International Energy Agency. (2021). *Empowering Cities for a Net Zero Future*. Retrieved from https://www.iea.org/reports/empowering-cities-for-a-net-zero-future.

International Organization of Motor Vehicle Manufacturers, OICA. (2015). *Motorization rate 2015 – Worldwide*. Retrieved from https://www.oica.net/world-vehicles-in-use-all-vehicles-2/.

ITDP. (2024). *Atlas of Sustainable City Transport*. Retrieved from https://atlas.itdp.org/.

ITDP. (2017). *TOD Standard*. ITDP. Retrieved from https://www.itdp.org/2017/06/23/tod-standard/.

ITDP. (2023). Breaking the Code: Off-Street Parking Reform.

ITDP. (2024, February 1). In These US Cities, Parking Reform is Gaining Momentum. Retrieved from https://www.itdp.org/2024/02/01/in-these-us-cities-parking-reform-is-gaining-momentum/.

Jacobs, J. (1961). *The Death and Life of the Great American Cities*. New York: Random House.

Jaramillo-Gonzalez, S. (2009). *Hacia una Teoría de la Renta del Suelo Urbano*. Bogota: Ediciones Uniandes.

Jones, D., & Jha, M. K. (2010). The effect of urban form on traffic accident incidence. *Recent Advances in Computer Engineering and Applications*, 212-222.

Kigali City Council. (2020). *Zoning Regulations: Kigali Master Plan 2050*. Retrieved from https://masterplan2020.kigalicity.gov.rw/portal/sharing/rest/content/items/b9e31b07d8684053b0f3eac8649e1213/data.

Kim, Y., & Zangerling , B. (2016). *Mexico Urbanization Review: Managing Spatial Growth for Productive and Livable Cities in Mexico*. Washington, DC: The World Bank. Retrieved from https://openknowledge.worldbank.org/handle/10986/24930.

Kit, O., Ludeke, M., & Reckien, D. (2013). Defining the Bull's Eye: Satellite Imagery-Assisted Slum Population Assessment in Hyderabad, India. *Urban Geography , 34.*, 413-424. doi:10.1080/02723638.2013.778665.

Kleineberg, T., Murray, S., Tang, Y., & Kaw, J.-K. (2022). The welfare and productivity effects of transit improvements in Amman. Unpublished manuscript.

Kumar, A., Zimmerman, S., & Arroyo-Arroyo, F. (2021). *Myths and Realities of 'Informal' Public Transport in Developing Countries: Approaches for Improving the Sector*. https://www.ssatp.org/sites/ssatp/files/publication/SSATP_Informal_v_final_double_compressed.pdf: SSATP.

Kurshitashvili, N. (2022). *Integrating Gender Considerations into Public Transport Policies and Operations*. Washington: World Bank.

Labs, City Planning, and CAPSUS. (2020). *Urban Planning Tools as Agents of Change: Collaborative Spatial Data for Sustainable Urban Development in Indonesia*. Washington DC: World Bank. Retrieved from https://pubdocs.worldbank.org/en/895401614014851662/WB-Indonesia-urban-planning-final-reportv3.pdf.

Lall, S., Lebrand, M., Park, H., Sturm, D., & Venables, A. (2021). Pancakes to Pyramids: City Form to Promote Sustainable Growth. Washington DC: The World Bank. Retrieved from https://openknowledge.worldbank.org/entities/publication/38f61a22-e924-593d-b406-a3ba916bc87f.

Lall, S., Lebrand, M., Sturm, D., & Venables, A. (2021). *Pancakes to Pyramids : City Form to Promote Sustainable Growth*. Wahington, DC: World Bank.

Lee, J., C.. Zegras, and E. Ben-Joseph. (2013). Safely active mobility for urban baby boomers: The role of neighborhood design. *Accident Analysis & Prevention*.

Levine, J. (2005). *Zoned Out: Regulation, Markets, and Choices in Transportation and Metropolitan Land Use*. Routledge.

Lin, L. (2014, Sep. 10). A short history of world metro systems – in pictures. *The Guardian*. Retrieved from https://www.theguardian.com/cities/gallery/2014/sep/10/-sp-history-metro-pictures-london-underground-new-york-beijing-seoul#:~:text=The%20Tokyo%20subway%20opened%20in,and%20entertainment%20centre%2C%20in%201950.&text=Now%20Tokyo's%20metro%20system%20carri.

Liotta, C., Avner, P., Viguie, V., Selod, H., & Hallegatte, S. (2022). Climate Policy and Inequality in Urban Areas. *World Bank Policy Research Working Paper, 10185*.

Liu, X., Li, X., Chen, Y., Zhangzhi, T., Li, S., & Ai, B. (2010). A new landscape index for quantifying urban expansion using multi-temporal remotely sensed data., 25, 671-682. *Landscape Ecology, 25*, 671-682.

Lowry, I. S. (1964). A Model of Metropolis. Concepts and Techniques in Urban Analysis. *The RAND Corporation*, 1–136. Retrieved from https://doi.org/10.4324/9781315105352-12.

Madariaga, I. S. (2013). From women in transport to gender in transport: challenging conceptual frameworks for improved policymaking. *Journal of International Affairs*.

Madariaga, I. S., & Abril, I. N. (2021). *Proyectando con perspectiva de género. Guía para planificar ciudades y pueblos inteligentes y sostenibles*. Junta de Extremadura.

Manville, M. (2021, May). How Parking Destroys Cities: Parking requirements attack the nature of the city itself, subordinating density to the needs of the car. *The Atlantic*.

Margolies, J. (2023, March 9). Awash in Asphalt, Cities Rethink Their Parking Needs. *New York Times*. Retrieved from https://www.nytimes.com/2023/03/07/business/fewer-parking-spots.html?smid=nytcore-ios-share&referringSource=articleShare&sgrp=c-cb.

McDonald, J. F., & McMillen, D. P. (2012). The Economics of Zoning. In N. Brooks, *The Oxford Handbook of Urban Economics and Planning* (pp. 438-459). Oxford: Oxford University Press. doi:10.1093/oxfordhb/9780195380620.013.0020.

Mehndiratta, S., & Peralta, T. (2014). Are women 'forced' to work closer to home due to other responsibilities? Does this contribute to gender wage differentials? *Safe, Clean, Affordable Transport for Development*. Retrieved April 10, 2015, from http://blogs.worldbank.org/transport/are-women-forced-work-closer-home-due-other-responsibilities-does-contribute-gender-wage.

Meloni, I., Bez, M., & Spissu, E. (2009). Activity-Based Model of Women's Activity-Travel Patterns.". *Journal of the Transportation Research Board, 26*.

Millman National Land Services. (2021). *Zoning Issues: Can Zoning Improve The Housing Affordability?* Retrieved from Millman National Land Services: https://millmanland.com/company-news/can-zoning-improve-the-housing-affordability/.

Ministry of Land, Infrastructure and Transport of Korea. (n.d.). *Enforcement Decree of the Building Act*. Retrieved from Korean Law Information Center: https://elaw.klri.re.kr/eng_service/lawView.do?hseq=63808&lang=ENG.

Ministry of Land, Infrastructure, Transport, and Tourism of Japan. (2024). I*ntroduction of Urban Land Use Planning System in Japan*. Retrieved from https://www.mlit.go.jp/common/001050453.pdf.

Moeckel, R., Llorca Garcia, C., Moreno Chou, A. T., & Okrah, M. B. (2018). Trends in integrated land use/transport modeling: An evaluation of the state of the art. *Journal of Transport and Land Use, 11*(1), 463-476. Retrieved from https://doi.org/10.5198/jtlu.2018.1205.

Mushkani, R. A., & Ono, H. (2021, December 2021). The role of land use and vitality in fostering gender equality in urban public parks: The case of Kabul city, Afghanistan. *Habitat International, 118*. doi:102462.

NACTO. (n.d.). *Urban Street Design Guide - Sidewalks*. Retrieved from National Association of City Transportation Officials (NACTO): https://nacto.org/publication/urban-street-design-guide/street-design-elements/sidewalks/.

Navarrete, P., Vetro, A., & Concha., P. (2023). Building safer public spaces: Exploring gender differences in the perception of safety in public space through urban design interventions. *Landscape and Urban Planning*.

Navarrete-Hernandez, P., Vetro, A., & Concha, P. (2021). Building safer public spaces: Exploring gender differences in the perception of safety in public space through urban design interventions. *Landscape and Urban Planning, 214*. doi:104180.

Nieuwenhuijsen, M., de Nazelle, A., Cirach Pradas, M., Daher, C., Dzhambov, A., Echave, C., . . . Mueller, N. (2024). The Superblock model: A review of an innovative urban model for sustainability, liveability, health and well-being. *Environmental Research*. Retrieved from https://doi.org/10.1016/j.envres.2024.118550.

Noack, E. (2010). *Stuck in the countryside? Women's transport mobility in rural Aberdeenshire, Scotland – experiences, behaviour and needs*. Vienna: Facultas Verlags.

OECD. (2020, Nov 11). *The changing shape of cities: Density and suburbanisation*. Retrieved from OECD Regions and Cities at a Glance: https://www.oecd-ilibrary.org/urban-rural-and-regional-development/oecd-regions-and-cities-at-a-glance-2020_959d5ba0-en.

OECD ITF. (2018). *The shared-use city: Managing the curb*. OECD Publishing.

Ollivier, G., Ghate, A., Bankim, K., & Mehta, P. (2021). *Transit-Oriented Development Implementation Resources and Tools, 2nd Edition*. Washington DC: World Bank. Retrieved from http://hdl.handle.net/10986/34870.

Paller, J., Kherigi, I., Lust, E., Bob-Milliar, G., & Post, A. (2024). *Political Change and Local Governance in Emerging CitiesUniversity of Gothenburg*. Retrieved from University of Gothenburg: https://www.gu.se/en/research/political-change-and-local-governance-in-emerging-cities#:~:text=Short%20description,-As%20the%20world&text=Most%20of%20our%20knowledge%20about,located%20close%20to%20rural%20populations.

Pirouz, N., Samaneh, R., Kotryna, V., & Sevil, S. (2018, July 13). Modelling walking and cycling accessibility and mobility: The effect of network configuration and occupancy on spatial dynamics of active mobility. *Smart and Sustainable Built Environment, 7*. doi:10.1108/SASBE-10-2017-0058.

Planetizen (Producer), & Youtube (Director). (2022). *A brief history of zoning* [Motion Picture]. Retrieved from https://youtu.be/M6pytpA1BCs?si=qwOZxAuSonWBfhDG.

Poskey, J. (2023, April 4). *America is addicted to parking lots*. Retrieved from Business Insider: https://www.businessinsider.com/america-parking-lot-spaces-addiction-economy-housing-costs-inflation-2023-4.

POT. (2021). Retrieved from https://www.sdp.gov.co/micrositios/pot/que-es.

Price, A. (2017, October 25). *The Problem with Setbacks*. Retrieved from Strong Towns: https://www.strongtowns.org/journal/2017/10/23/the-problem-with-setbacks.

Priemus, H., Nijkamp, P., & Banister, D. (2001). Mobility and spatial dynamics: An uneasy relationship. *Journal of Transport Geography, 9*(3), 167-171.

Pulido, D., Darido, G. B., Munoz-Raskin, R., & Moody, J. C. (2018). *The Urban Rail Development Handbook*. Washington, D.C.: World Bank Group.

Quinn-Smith, T. (2020, March 6). *Parking Reform for 21st Century Communities*. Retrieved from www.formbasedcodes.org: https://formbasedcodes.org/webinar-recap-parking-reform-21st-century-communities/.

Reimann, A., & Chriqui, J. (2019). *Lessons learned in implementation of pedestrian-oriented zoning provisions: A research brief*. Illinois Prevention Research Center. Retrieved from https://p3rc.uic.edu/wp-content/uploads/sites/561/2020/02/PAPRN_brief_and_profiles508v2Sept5.pdf.

Ritzdorf, M. (1994). A Feminist Analysis of Gender and Residential Zoning in the United States. Altman, I., Churchman, A. (eds). In W. a. Environment. Boston, MA: Springer.

Rodriguez, D. A. (2021). *Transit Oriented Development: An Appraisal of Trends and Opportunities for Latin America*. Washington, DC.: Inter American Development Bank. Retrieved from https://publications.iadb.org/en/transit-oriented-development-appraisal-trends-and-opportunities-latin-america.

Rodríguez, D. A., Evenson, K. R., Roux, A. V., & Brines, S. J. (2009). Land use, residential density, and walking: The multi-ethnic study of atherosclerosis. *American journal of preventive medicine, 37*(5), 397-404.

Rogers, R. (2015, July 10). *Relation between building typologies & density*. Retrieved from URBIUMETORBI: https://urbiumetorbi.wordpress.com/2015/07/10/building-typologies-and-density-by-richard-rogers/.

Sabate, M. (2020, February 15). Las cajas olvidadas en un almacén que muestran la historia del transporte público en Barcelona. *eldiario.es*. Retrieved from https://www.eldiario.es/catalunya/cultura/olvidadas-muestran-historia-transporte-barcelona_1_1135766.html.

Salat, S., & Ollivier, G. (2016). *Transforming the Urban Space through Transit-Oriented Development: The 3V Approach*. Washington, DC: World Bank. Retrieved from https://hdl.handle.net/10986/26405.

Sallis, J., Bull, F., Burdett, R., & Frank, L. (2016). Use of science to guide city planning policy and practice: how to achieve healthy and sustainable future cities. *The Lancet, 388*(10062), 2936-2947.

Sanchez de Madariaga, I. (2013). From Women in Transport to Gender in Transport: Challenging Conceptual Frameworks for Improved Policymaking. *Journal of International Affairs, 67*(1), 43–65.

Sanchez de Madariaga, I., & Novella Abril, I. (2021). *Proyectando con Perspectiva de Genero. Guia para planificar ciudades y pueblos inteligentes*. Junta de Extremadura.

Santos, P., Caccia, L., Samios, A., & Ferreira, L. (2019). *The 8 Principles of Sidewalks: Building More Active Cities, 2nd Edition*. World Resources Institute Brasil. Retrieved January 21, 2022.

Shlomo, A., Blei, A., Lamson-Hall, P., Parent, J., & Handal Gonzalez, C. (2016). *Atlas of Urban Expansion*. New York: NYU Urban Expansion Program at New York University, UN-Habitat, and the Lincoln Institute of Land Policy. Retrieved from http://atlasofurbanexpansion.org/.

Shoup, D. (2017). *The High Cost of Free Parking*. London and New York.: Routledge.

Sims, R., Schaeffer, R., Creutzig, F., Cruz-Núñez, X., D'Agosto, M., Dimitriu, D., . . . Tiwarig. (2014). *Transport. In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. (O. Edenhofer, R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, . . . J. Minx, Eds.) Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.

SIMUR Sistema Integrado de Informacion sobre Movilidad Urbana y Regional. (2024). *Encuestas de Movildad*. Retrieved from SIMUR: https://www.simur.gov.co/encuestas-de-movilidad#collapse-accordion-232-4.

Sipe, N. G. (2019, June 26). *Competition for the kerb is rising, and cities are going to have to manage it*. Retrieved from The Conversation: https://theconversation.com/competition-for-the-kerb-is-rising-and-cities-are-going-to-have-to-manage-it-117410.

Smart Growth Online. (2016, June 27). *Arlington County, Virginia* . Retrieved from Principle: Provide a variety of transportation choices: https://smartgrowth.org/arlington-county-virginia/.

Speck, J. (2013). *Walkable City: How Downtown Can Save America, One Step at a Time*.

Strong Towns. (2020, November 25). Parking Minimums: From 101 to Taking Action. Retrieved from https://www.strongtowns.org/journal/2020/11/25/parking-minimums-from-101-to-taking-action.

Suzuki, H., Cervero, R., & Iuchi, K. (2013). *Transforming Cities with Transit: Transit and Land-Use Integration for Sustainable Urban Development*. Washington DC: The World Bank.

Suzuki, H., Murakami, J., Hong, Y. H., & Tamayose, B. (2015). *Financing transit-oriented development with land values: Adapting land value capture in developing countries*. World Bank Publications.

Szell, M. (2018). Crowdsourced Quantification and Visualization of Urban Mobility Space Inequality. *Urban Planning, 3*(1), 1-20. Retrieved from https://www.cogitatiopress.com/urbanplanning/article/view/1209/1209.

Tennøy, A., Knapskog, M., & Wolday, F. (2022). Walking distances to public transport in smaller and larger Norwegian cities. *Transportation Research Part D: Transport and Environment*. Retrieved from https://www.sciencedirect.com/science/article/pii/S1361920922000013.

The Bowery Mission . (2024). *Homelessness is a Shared Experience in New York City*. Retrieved from Bowery: https://www.bowery.org/homelessness/#:~:text=Today%2C%20more%20New%20Yorkers%20are,100%2C000%20men%2C%20women%20and%20children.

The Economist. (2022, December 20). The decline of the city grid: The oldest form of city planning is falling out of fashion. *The Economist*`. Retrieved from https://www.economist.com/interactive/christmas-specials/2022/12/20/the-decline-of-the-city-grid.

Tokyo Real Estate. (2022, July 8). *Floor-Area Ratio (FAR) and Building Coverage Ratio (BCR) in Japan*. Retrieved 2021, from Real Estate Tokyo: https://www.realestate-tokyo.com/news/floor-area-ratio-and-building-coverage-ratio/.

Toole, J., Pietrucha, M. T., & Davis, J. (1999). *FHWA Course on Bicycle and Pedestrian Transportation-Instructor's Guide. (Publication No. FHWA-HRT-05-133)*. United States. Federal Highway Administration. Office of Safety Research and Development. Retrieved from https://www.fhwa.dot.gov/publications/research/safety/pedbike/05085/pdf/lesson9lo.pdf.

Transect Homepage. (n.d.). *Zoning Overview and Definitions*. Retrieved from Transect Homepage: https://www.transect.com/resources/zoning-overview-definitions.

Tsivanidis, N. (2018). The aggregate and distributional effects of urban transit infrastructure: Evidence from Bogota's Transmilenio. Unpublished manuscript.

Tsivanidis, N. (2019). *Evaluating the Impact of Urban Transit Infrastructure: Evidence from Bogotá's TransMilenio*. University of California, Berkeley. Retrieved from https://static1.squarespace.com/static/55bb98e2e4b0ba843f39599e/t/64c98e1aa0fcf82d1bda8d52/1690930717404/TsivanidisTransMillenio_8.2023.pdf.

UNDESA, U. N. (2018). *Around 2.5 billion more people will be living in cities by 2050, projects new UN report*. Retrieved from The United Nations.

Urban Street Design Guide. (n.d.). Retrieved from NACTO Homepage: https://nacto.org/publication/urban-street-design-guide/street-design-elements/sidewalks/.

van Soest, D., Tight, M., & Rogers, C. (2019). Exploring the distances people walk to access public transport. *Transport Reviews*. Retrieved from https://www.tandfonline.com/doi/full/10.1080/01441647.2019.1575491.

Vergel-Tovar, C., & Rodriguez, D. (2018). The ridership performance of the built environment for BRT systems: Evidence from Latin America. *Journal of Transport Geography, 172-184*, 172-184.

Viswanath, K., & Basu, A. (2015). SafetiPin: An innovative mobile app to collect data on women's safety. *Gender & Development, 23*(1), 45-60. doi:https://dx.doi.org/10.1080/13552074.2015.1013669.

Waddell, P. (2011). Integrated Land Use and Transportation Planning and Modelling: Addressing Challenges in Research and Practice. *Transport Reviews, 31*(2), 209–229. Retrieved from https://doi.org/10.1080/01441647.2010.525671.

Wegener, M. (2004). *Overview of land-use transport models. In Transport Geography and Spatial Systems*. Pergamon/Elsevier.

Wheaton, W. (2008, September). Real Estate Economics. Cambridge, MA: MIT Open Course Ware. Retrieved from https://ocw.mit.edu/courses/11-433j-real-estate-economics-fall-2008/pages/lecture-notes/.

Wheaton, W., & DiPasquale, D. (1995). *Urban Economics and Real Estate Markets*. Prentice Hall.

Wikipedia . (2024, March 3). *The Cerdá Plan*. Retrieved from Wikipedia The Free Encyclopedia: https://en.wikipedia.org/wiki/The_Cerd%C3%A1_Plan.

Wikipedia. (2024, January). *Commissioners' Plan of 1811*. Retrieved from WikipediaThe Free Encyclopedia: https://en.wikipedia.org/wiki/Commissioners%27_Plan_of_1811#cite_note-manhmaps-1.

Wikipedia. (2024, March 22). *Streets and highways of Washington, D.C*. Retrieved from Wikipedia: https://en.wikipedia.org/wiki/Streets_and_highways_of_Washington,_D.C.

World Bank. (2002). *Cities on the move: a World Bank urban transport strategy review*. Washington DC: World Bank.

World Bank. (2020). *Module 1. "The Case for Upgrading." In Urban Upgrading for Inclusion, Sustainability, and Resilience in a Time of Global Pandemics*. Washington DC: WBG Open Learning Campus.

World Bank. (2021). *Land Pooling/Land Readjustment An Alternative to Compulsory Acquisition, Module 1*. Washington DC: World Bank Open Learning Campus.

WRI Brazil. (2019). *The 8 Principles of Sidewalks: Building More Active Cities*. WRI Brazil. https://www.wribrasil.org.br/sites/default/files/8-Principles-of-Sidewalks.pdf.

Zamorano, L. (2016). *Rumbo a la Reforma Urbana | Retos y Oportunidades de la Iniciativa de la Ley General de Ciudades y Territorio*. WRI. Retrieved from https://wriciudades.org/research/publication/rumbola-reforma-urbana-retos-y-oportunidades-de-la-iniciativa-de-la-ley.

Zamorano, L., & Kulpa, E. (2014, July 23). *People-Oriented Cities: Mixed-Use Development Creates Social and Economic Benefits*. Retrieved from World Resource Institute: https://www.wri.org/insights/people-oriented-cities-mixed-use-development-creates-social-and-economic-benefits#:~:text=Finally%2C%20mixed%2Duse%2C%20public,businesses%20by%20increasing%20foot%20traffic.

Zarate, R. D. (2022). *Spatial misallocation, informality, and transit improvements: Evidence from Mexico City*. The World Bank.

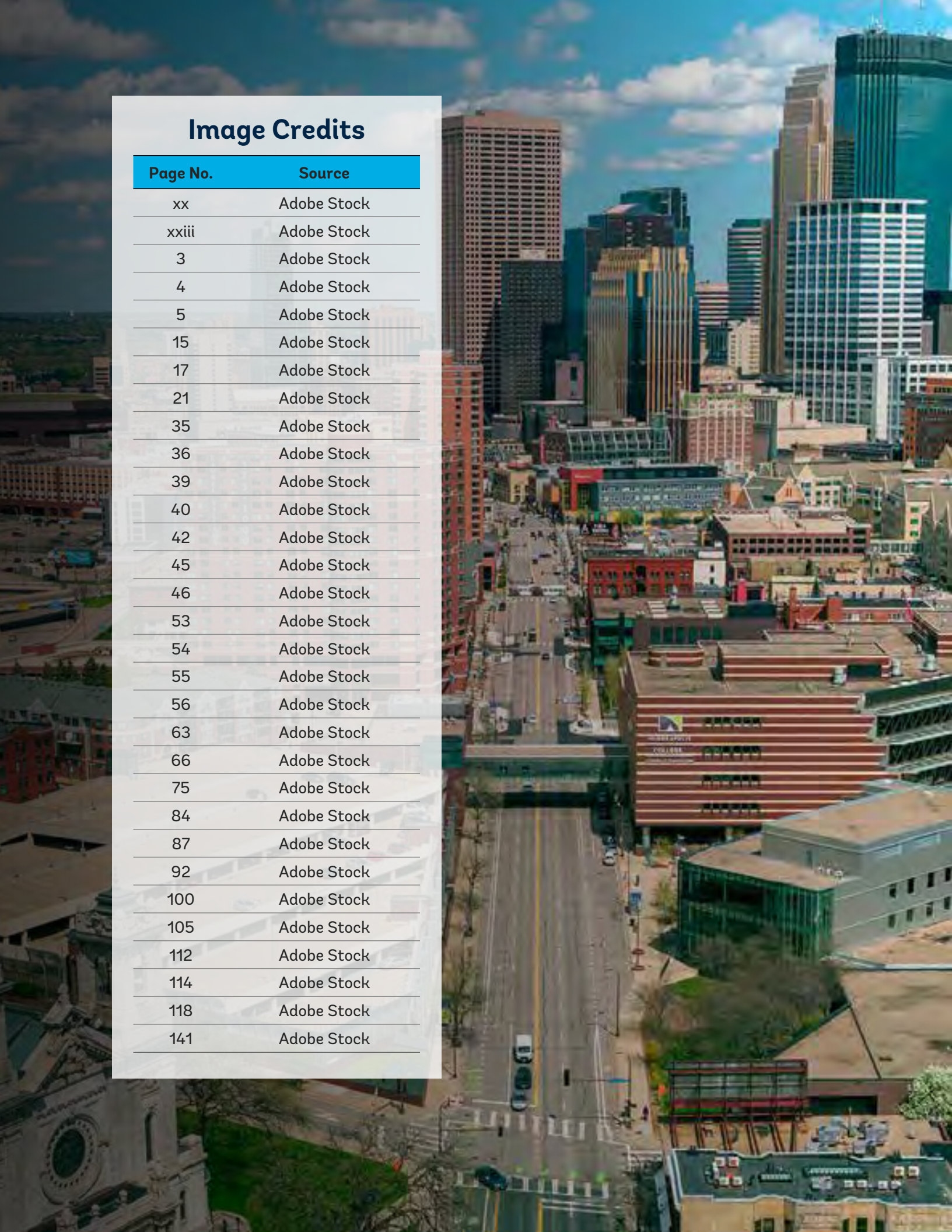


Image Credits

Page No.	Source
xx	Adobe Stock
xxiii	Adobe Stock
3	Adobe Stock
4	Adobe Stock
5	Adobe Stock
15	Adobe Stock
17	Adobe Stock
21	Adobe Stock
35	Adobe Stock
36	Adobe Stock
39	Adobe Stock
40	Adobe Stock
42	Adobe Stock
45	Adobe Stock
46	Adobe Stock
53	Adobe Stock
54	Adobe Stock
55	Adobe Stock
56	Adobe Stock
63	Adobe Stock
66	Adobe Stock
75	Adobe Stock
84	Adobe Stock
87	Adobe Stock
92	Adobe Stock
100	Adobe Stock
105	Adobe Stock
112	Adobe Stock
114	Adobe Stock
118	Adobe Stock
141	Adobe Stock

WORLD BANK GROUP