ENDING GLOBAL SPRAWL

Urban Standards for Sustainable and Resilient Development

WORLD BANK GROUP

Global Platform for Sustainable Cities

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Introduction

We etch our values into the landscape with every new urban development—by how it integrates or isolates people; how it supports or hinders economic vitality; how it reduces carbon emissions or increases climate change; how it reinforces lifestyles that are naturally healthy or locks people into destructive behaviors and environments.

The health and wellbeing of humankind will depend on the kind of cities we build in the next two generations. They will provide the scaffolding for our social, economic and environmental future. In many respects, the way we shape cities will impact humanity's most pressing challenges: climate change and habitat stability; social opportunity and community strength; economic growth and poverty. We now have 4.3 billion people living in cities and that number will increase to 6.7 billion by 2050.[1] Based on our current pattern of global sprawl, this will translate into an 80 percent expansion of city footprints from 2018 to 2030.[2] Moreover, this unprecedented outward expansion is greatest in lower income cities in the Global South, China and India. The current form of global sprawl deepens spatial inequalities and isolates opportunities for those who need the opportunities of urban life the most; it heightens the costs of infrastructure and social services and it intensifies the environmental burdens of poor air quality, carbon emissions, and deteriorating ecosystems. Its alternate, documented by the 7 principles detailed in this book, can mitigate many of the worst outcomes while heightening economic opportunities, social integration, and ecological health.

We etch our values into the landscape with every new urban development—by how it integrates or isolates people and income groups; how it supports or hinders the economic vitality of a place; how it steps lightly on the land or increases our demands on limited ecosystems; how it reduces our carbon emissions or increases the intensity of climate change; how it reinforces lifestyles that are naturally healthy or locks people into destructive behaviors and environments. To paraphrase Winston Churchill's famous statement regarding buildings: we shape the city and thereafter it shapes us. When we build cities, its form locks us into lifestyles and social structures that last.

Urban planning and the future of the city is a whole systems design challenge that can only be addressed with comprehensive, long-term thinking. The next generation of

urban growth can set a standard for sustainable and resilient development that can lead with long-term values rather than one that continues with the various types of sprawl that isolate people from diverse communities, from economic opportunity, from natural systems and, ultimately, from healthy lives.

This book rests on the thesis that while each city is unique, the global challenges resulting from urban sprawl are universal. Three types of sprawl afflict growth throughout the planet: the low-density sprawl of higher income regions that have become auto dominated; the low-income sprawl of the Global South that isolates the poor from economic, social, and cultural opportunities; and the high-density sprawl of superblocks, towers, and isolated uses that has emerged in China and other Asian countries. While each is very different, they share common urban pathologies: isolated poverty; water, air and land pollution; congestion; loss of community; degraded health; and economic headwinds to name a few.

Overshadowing these profound challenges are the accelerating effects of climate change. These effects are now inevitable even if international targets for greenhouse gas reductions succeed. So urban forms must not only reduce per capita greenhouse gas emissions, they must grow in ways that are resilient and adaptable in the face of new climate-related challenges. They must enhance the lifestyles and technologies of mitigation at the same time they shape communities that can withstand the onslaught of extreme weather events. Whether threatened by expanding fire zones, peak heat events, extreme storm deluge, or sea level rise, appropriate urban form, open space systems, and development location can make cities more resilient and sustainable. The protection of adequate drainage-ways, ecological storm surge barriers, fire buffer zones, and generous tree canopies must become foremost in shaping the metropolitan form. The location and resettlement of development away from naturally vulnerable areas is essential to urban resilience, economic preservation and human wellbeing.

The alternate to all these challenges involves the seven fundamental urban principles presented in this book. In order to thrive, cities need to conserve land, preserve history, and nurture community. They need to create walkable and transit-oriented communities that offer many alternates to the car. They need mixed-use neighborhoods that create places for a broad range of incomes, ages, and household types. They need to create compact districts that balance jobs and housing, opportunity and access, services and public space. But more than just advocating for a better urban form, these seven principles set measurable standards, illustrate best practices, and report on analytically validated outcomes.

All three types of sprawl need better land-use forms and ubiquitous transit, but in very different ways. The developed world needs land uses and transit qualities that are good enough to motivate people to get out of their cars. China has robust transit systems in their tier one cities, but their secondary cities need affordable transit and more walkable neighborhoods. The developing world needs massive quantities of affordable, high-capacity transit—most likely bus rapid transit on auto-free streets or in dedicated lanes—along with land tenure and infrastructure for informal settlements. Utopian? Perhaps, but in so many places these strategies are practical and proven.

All cities share a convergence of the co-benefits that result from these principles. As urban form and regional structure improves, all the metrics studied improve air quality, miles driven, fiscal impacts, household cost, infrastructure costs, land consumption, carbon emissions, water consumption, and health costs. It is the convergence of positive outcomes that increase the political and economic basis for significant change. Alone, each strategy or program may be politically difficult or financially stressed; when combined, they represent the opportunity for new political coalitions and more efficent financing. The urbanism strategies presented here reduce per capita environmental demands while making services, infrastructure, and economic development more efficient, more cost-effective, more accessible, and more interconnected.

The outcomes of global sprawl and climate change are clearly producing a growing crisis, especially in the developing world.[3] More than 90 percent of urban growth is occurring in the developing world, adding an estimated 70 million new residents to urban areas each year, much of it in the world's poorest regions. Urban sprawl in the developing world has many manifestations and just as many challenges. Clean water, adequate sewage treatment, consistent power, social services, affordable housing, road congestion, health care, economic development, increased flooding, fire, and environmental decay—this is a short list of the chronic challenges of most emerging cities. These challenges are interconnected in a self-reinforcing cycle that either enhances or destroys opportunity and progress. And, in a systemic way, the form of the city affects each of these challenges.

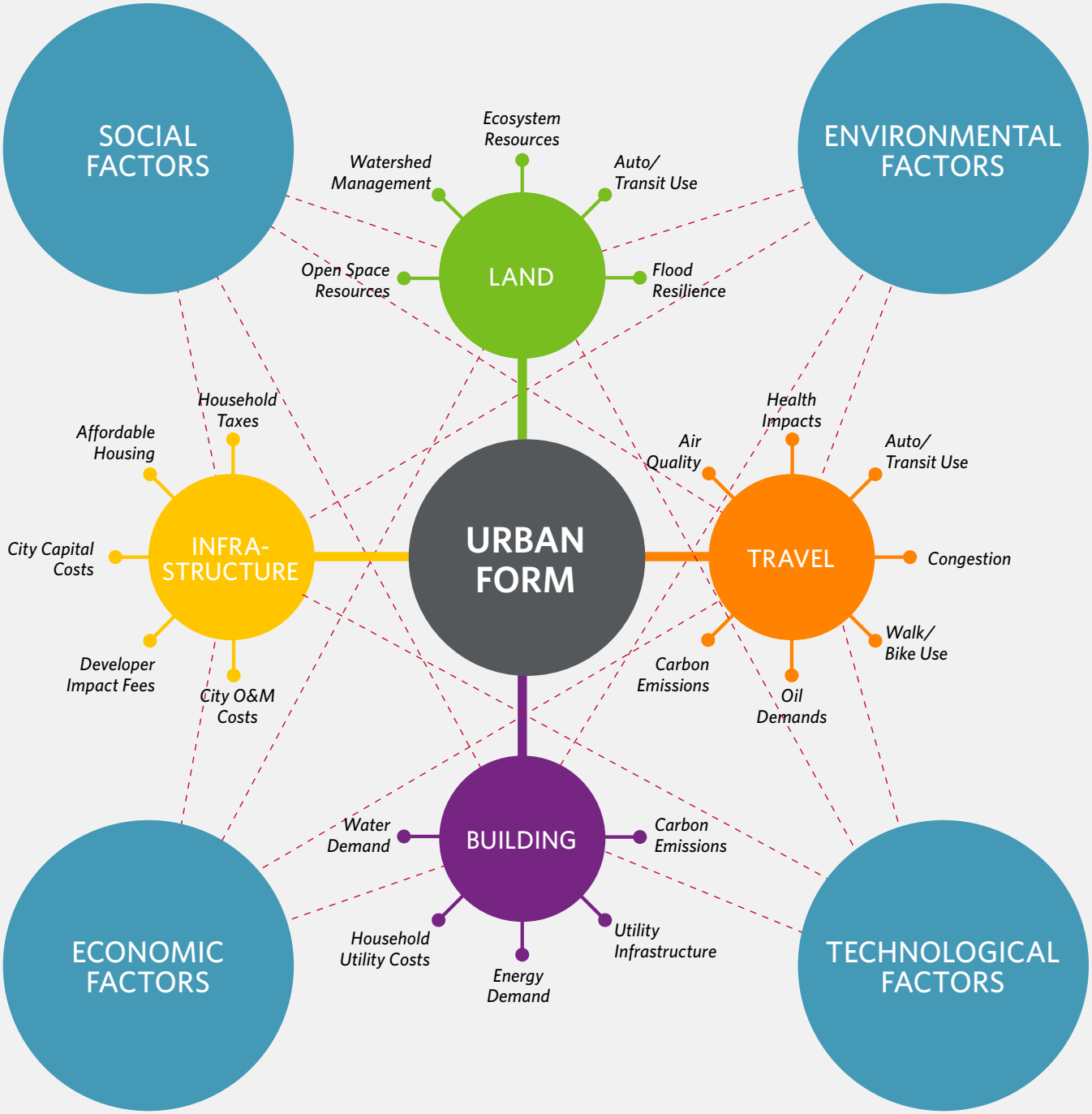
Regions and cities struggling with extreme poverty are not the source of the planet's climate change problem. It is the emerging middle class within cities and in the developed world—not the poor—that drives carbon emissions. In fact, 86 percent of energy-based carbon emissions come from upper-income and middle-income populations as defined by the World Bank. Low-income populations in the developing world typically account for just one-twentieth to one-hundredth of the per capita greenhouse gas emissions of people in high-income nations. The average person worldwide accounted for 4.9 tons of carbon dioxide (CO_2) emissions in 2011, whereas the bottom quarter of the global population emitted only 0.3 tons per capita and the second quarter emitted 1.5 tons. This is slightly below the world target of 1.6 tons per capita for 2050 identified by the Deep Decarbonization Pathways Project. These populations do not own cars or air conditioners, live in large homes, or eat steaks. If they succeed in the next 30 years, their carbon emissions will still be reasonable.[4] It is the upper economic half of the global population that must adjust. Those economies and cities that are transitioning to a higher standard of living in the developing world must lay the groundwork for sustainable, low-carbon futures. In these cities, sustainable urbanism—places that are compact, mixed-use, walkable, and transit-oriented—is essential.[5]

Each city and region will have unique challenges that are critical. For example, in Mexico, it's travel times for low-income workers and air quality; in big Chinese cities, it's smog and gridlock; in western cities, it's affordable housing and new forms of transit; in the Global South, it's adequate infrastructure and social services for informal settlements. The sprawl challenge in the developed world and China is now concerned with quality of life, economic growth, and the environmental impacts of the middle class. Certainly, profound issues surround the needs of the poor in western cities, but these pale in comparison to the fast-growing cities of the Global South.

Many low-income cities lack the central control or investment capacity to direct the form, location or even basic infrastructure of new growth. For China and the developed world, shifting metropolitan forms toward better outcomes is an issue of political will, while in developing economies it is an issue of political and economic capacity. The three sprawls described here need differing implementation strategies to deal with differing governance and economic capacities. But the essential strategies to improve metropolitan form converge for all; better transit, walkable and integrated neighborhoods, higher densities, balanced jobs/housing, and more infill provides a better outcome for all urban futures.

The principles are distilled from successful strategies for healthy urban forms around the world. Positive outcomes have been documented for each principle in widely differing conditions. The universal challenges can be clustered into four interdependent urban issues: land consumption, travel behavior, infrastructure needs, and building design. For example, travel behavior is driven by urban form and affects health, air quality, transit efficiency, congestion, energy demands, carbon emissions, and the quantity of walking and biking. The power of urban form is that it can address all of these issues simultaneously, breaking down professional and

URBAN FORM CONNECTS THE DOTS



political 'stove pipes' and creating coalitions among special interest groups. In addition, each of the four primary drivers of urban design increases the efficacy of the others.

The principles relate primarily to best practice in urban design, not infrastructure or architecture. While urban design establishes the context, overall configurations, and environmental demands of infrastructure and architecture, many detailed design strategies are needed to enhance the benefits of urbanism. The technical and design elements of infrastructure and architecture are too large, complex and varied to be covered here. These detailed policies, standards, and technologies each need local analysis and customized design. For example, green building standards are essential for reducing carbon emissions, energy consumption, heat island effects, and utility costs—but are place- and climate-specific. The same is true of green infrastructure, from recycling programs, greywater reuse, and sewage treatment methods to micro-grids and renewable power generation. Architecture and urban infrastructure involve complex technical and financial analysis tied to local conditions. This book focuses on the strategies that can shape the underlying urban form of a city, the foundation upon which these other detailed technologies can be developed.

Likewise, the principles advanced here set a direction for a city's growth, but do not deal directly with local politics, implementation, or finance. While they represent ideal outcomes and set a direction for the form of growth, they cannot prescribe the specific challenges of governance, consensus building, and capital allocation unique to each city. In the Global South, the lack of capital and land governance are obvious challenges. In the developed world, the patterns of development that evolved over decades of auto dependence are hard to change. But in all cases, understanding best practice, modifying the principles and metrics elaborated here to fit local conditions and possibilities, and analyzing the long-term benefits and costs will always generate better outcomes.

These principles and metrics are enhanced when used together because they create powerful synergies. In fact, each principle builds on the others in a logical order. First a regional plan should preserve critical ecological, agrarian, and historic areas and identify infill and redevelopment zones. Out of this can come a flexible 'urban growth boundary' with designated resilient growth areas sufficient to support years of growth before revision. Within this area, a transit network should be planned to allow easy walking access to most residential and commercial areas. The densities at the stations should be proportional to the level and capacity of transit service. Within these transit-served growth areas, public and ecological open spaces should be reserved along with a network of street right-of-ways defining human-scale blocks. In this framework, mixed-use neighborhoods and commercial districts can be zoned. Each principle and metric nests into the other, creating a comprehensive urban form.

Nevertheless, individual applications of the principles can function well, even if not optimally. For example, disconnected growth within an urban growth boundary is undesirable, but is certainly better than the boundless sprawl that has been afflicting the rapid growth in the Global South. Likewise, a beautiful mixed-use and walkable neighborhood offers many good outcomes even if placed in a poor location. Its results are magnified, however, if placed near regional transit and job centers.

In contrast, urban design since World War II has evolved based on a different paradigm, one that isolates more than connects, that allows the car to dominate urban form, that too often ignores history, climate, and culture. This paradigm damages the environment and too often leaves the poor behind. The principles presented here seek instead to connect people, place, history, and ecology in ways that are derived from humankind's greatest urban traditions.

The purpose of cities is to bring people together in ways that create social, economic, and environmental synergies. Sprawl in its various forms succeeds in undermining the essence of great cities: the formal and informal connections of people to one another, to culture, history, and the environment. We are left with congestion, polluted air, economic isolation, and environmental impacts that are unsustainable.

The antidote rests in patterns of development that have been widely applied; historic preservation, transit-oriented development, walkable neighborhoods, mixed-use zones, and planning for resilience all contribute to this new direction for urban design. These ideas are the foundation of principles that are at once universal and, through local application, unique to a place and a people. This work outlines these critical principles, provides case studies, and identifies metrics and standards for each.

In Saò Paulo, Brazil, an apartment building for the wealthy overlooks a favela, ironically called Paraisópolis or Paradise City.
(Photo: Luiz Arthur Leirão Vieira).

7 SUSTAINABLE DESIGN PRINCIPLES

PRINCIPLE 1: PLAN FOR GROWTH, RESILIENCE, AND PRESERVATION

Plan for compact growth and resilience while preserving natural ecologies, agrarian landscapes, and cultural heritage sites

1A: Create a compact metropolitan form that facilitates preservation of ecologies, agrarian landscapes, and heritage sites and avoids climate hazard zones

1B: Prioritize redevelopment and infill development in areas safe from climate change hazards

1C: Preserve ecological, agricultural, historical, and cultural resources

PRINCIPLE 2: RESERVE OPEN LANDS AND PUBLIC SPACE

Preserve and create parks and open space for community use, green connections, ecological systems, and adequate storm mitigation areas

2A: Provide a variety of public open spaces and parks within an easy walking distance

2B: Provide human-scaled plazas, civic centers, and community services

2C: Preserve and enhance climate resilience with adequate storm management areas and fire zone buffers.

PRINCIPLE 3: ENHANCE SHARED MOBILITY AND TRANSIT

Make networks of transit, new forms of shared mobility, and active transport more desirable, affordable, and ubiquitous

3A: Ensure frequent and direct transit service with an interconnected hierarchy of transit technologies

3B: Locate transit stations within a walking distance of homes, jobs, and services

PRINCIPLE 4: BUILD TRANSIT-ORIENTED DEVELOPMENTS (TODs)

Match land-use density and mix to transit capacity in a walkable environment

4A: Create higher density mixed-use nodes around transit

4B: Design transit stations with convenient walking and bike routes to homes, jobs, and services

PRINCIPLE 5: MIX USES AND USERS

Create diverse mixed-use neighborhoods and districts that integrate affordable housing

5A: Encourage an optimal balance of housing, shops, and services

5B: Create a jobs/housing balance within a short transit commute distance

5C: Integrate affordable and senior housing in each neighborhood

PRINCIPLE 6: CREATE HUMAN-SCALE STREETS AND SMALL BLOCKS

Increase density of road networks with small blocks and human-scaled streets

6A: Create human-scale blocks and streets

6B: Disperse traffic over narrow, parallel routes with a grid of varied street types

6C: Establish car-free corridors that accommodate dedicated and connected biking and walking paths, which may include transit lanes

PRINCIPLE 7: DESIGN FOR WALKING AND BIKING

Prioritize walking and biking with ubiquitous safe, direct, and comfortable routes

7A: Emphasize pedestrian safety, comfort, and convenience

7B: Encourage ground-level activity and create places to relax

7C: Design streets that emphasize bike safety and convenience

ENDNOTES

1 UN-DESA. 2018. 2018 Revision of World Urbanization Prospects. New York: Population Division, UN-DESA.

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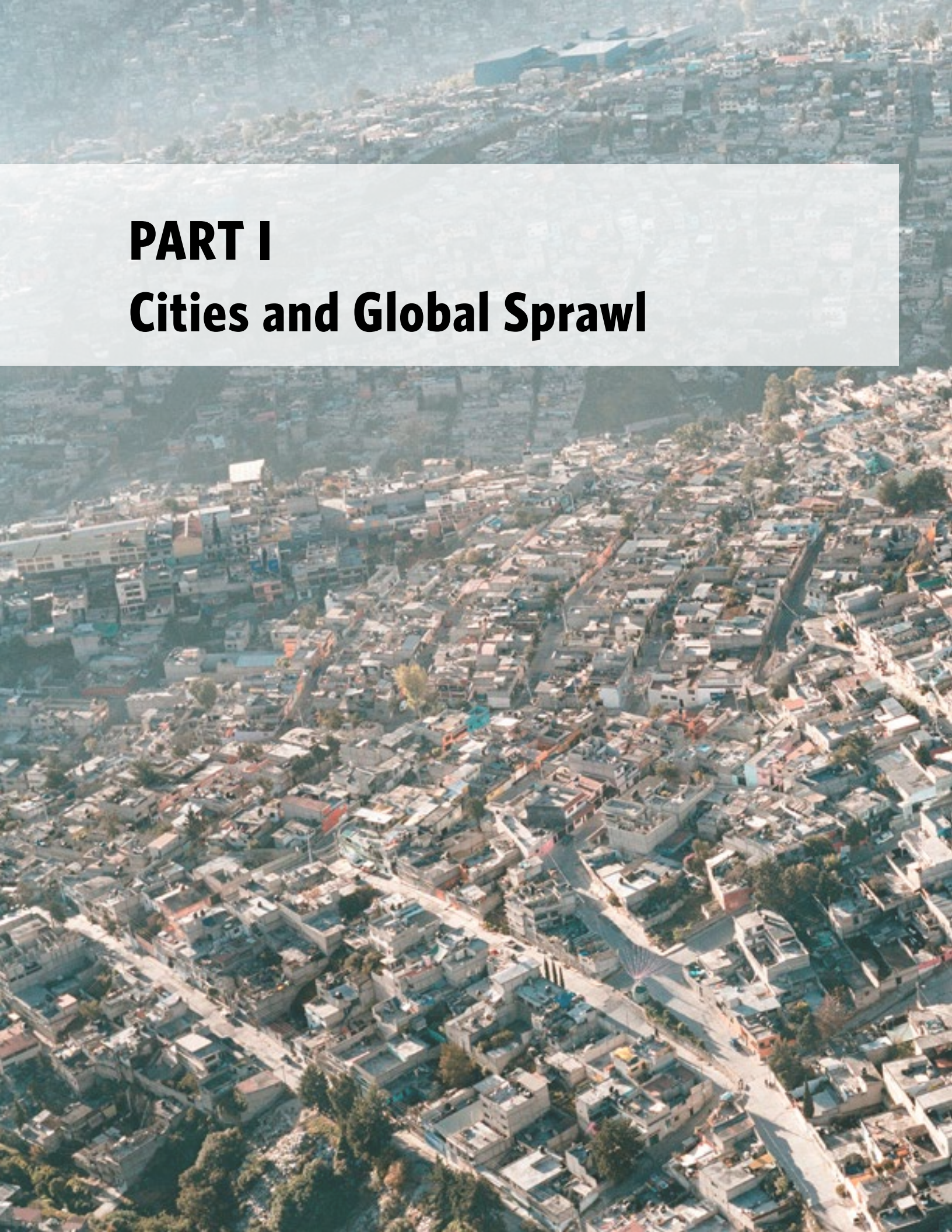
3 Chris Busch and CC Huang, Quantitative Insights into Urban Form and Transportation Solutions (San Francisco: Energy Innovation: Policy and Technology, LLC, 16 October 2014).

4 One twentieth to one hundredth from World Bank, Systems of Cities; per capita emissions from World Bank, Table 3.8 in World Development Indicators 2015, http://wdi.worldbank.org/tables; 2050 target from Sustainable Development Solutions Network and Institute for Sustainable Development and International Relations, Pathways to Deep Decarbonization (New York and Paris: September 2014).

5 2050 target from Sustainable Development Solutions Network and Institute for Sustainable Development and International Relations, Pathways to Deep Decarbonization (New York and Paris: September 2014).



PART I
Cities and Global Sprawl


(c) Pablo Lopez Luz

01
Cities and Global Sprawl

The global urban population is projected to be 4.3 billion by 2050, producing a 80 percent expansion of the urban footprint.

Cities affect our lives in profound, self-reinforcing ways. They can be a source of economic innovation, a pathway for poverty reduction, a brake on logarithmic demographic growth, and a solution to climate change—or they can reinforce economic isolation, heighten environmental impacts, and engender social strife. Cities represent approximately 80 percent of global economic output and 70 percent of total energy and greenhouse gas emissions. Cities are the superstructure for the culture, lifestyles, aspirations, and wellbeing of half of the world's population today and an estimated 70 percent by 2050. If cities fail because of gridlock, poisonous air, economic segregation, and environmental pollution, the planet will surely follow. If they succeed in lifting the next generation into sustainable productivity, integrate immigrants and working families into the next economy, and live lightly on the land, cities will contribute significantly to a civilized and sustainable future.

Although issues and solutions in individual cities are unique, many key urban development strategies are universal. Mixed-use, walkable, economically integrated, and transit-rich places define good urbanism in any city, anywhere on the planet. Cities that persist in the kind of sprawl that separates activities, isolates income groups, consumes valuable landscapes, inhibits pedestrians, and limits transit will heighten economic, environmental, and social ills as well as exacerbate climate change. While this type of development comes in various forms around the world, these common patterns and pathologies can be called 'global sprawl.' This book seeks to describe the global challenge of sprawl in its various manifestations and offer urban design principles, standards, and best practices to reverse these current trends.

GLOBAL SPRAWL

Every city is unique. Climate, history, culture, economy, ecology, geography—their permutations are as rich and varied as our faces. One should not lightly categorize or systematize the complexity and diversity of cities. Their differences are what create identity and are often the essence of what one comes to love about a place. Yet, urban patterns and problems cross national boundaries and override history and culture. They shape the city's underlying structure and common challenges, and create a relentless set of similar place types.

The forces of nature, history, and technology drive these global urban structures—both good and bad. Think of the traditional elements of a medieval city: its gates, walls, and fortifications or the placement of its palace, church, square, and markets. Each is unique to place, culture, and time and yet ubiquitous in what we think of as the feudal city. The contemporary elements of cities—neighborhoods, districts, corridors, centers, and open spaces—can order the map of any contemporary city regardless of location, history or culture. Likewise the technology of mobility—from horse, cart and foot to car, bus and train—sets the scale and proportion of streets in any city across the globe. The city is always a platform for the dynamic of human interaction, the synergy of unintended and structured associations, the economic opportunity that comes from clustered enterprise, and the cross fertilization that comes from diversity. Urban form affects each of these in systemic ways regardless of place, history, or ecology. Each period in human history produces a normative set of urban forms. We are now in the midst of sorting out new norms for the largest transformation of cities in human history.

In the last few centuries, cities have shifted from compact centers of trade, culture, and elites though an industrial city phase to the dispersed forms of auto-centric sprawl. In the last 60 years, cities have come to house more than half of the planet's logarithmic population growth—most in various forms of sprawl. Sprawl is not just low-density, scattered development, it is a new pattern that fundamentally separates activities, people, and places. Sprawl has become the norm across the planet, even though it comes in different forms. While each type of urban sprawl has unique challenges and characteristics, they all have common structural roots and, therefore, shared solutions.

There are three types of global sprawl: low-density sprawl typical in North America and Australia; high-density sprawl as in China, Asia and some new towns in Europe; and the low-income sprawl seen across Latin America, Africa, and much of Asia. This taxonomy is somewhat reductionist and simplistic, but it helps identify characteristics that cluster issues and opportunities in useful ways. These categories of sprawl illustrate the complexity and counterintuitive nature of the term 'sprawl.' While each is profoundly different, they all generate similar negative environmental, social, and economic consequences. As a result, common challenges and opportunities exist across each grouping regardless of location.

The classic North American version of urban sprawl features low densities, isolated uses and an auto-dominated transportation system—and is often called suburban sprawl. In the context of the developing world, its most salient quality is that the middle class migrated from the city to suburb. In contrast, low-income sprawl dominates most of the developing world. In these cases, relatively low income housing, often self-built, at the metropolitan edge isolates the poor from access to jobs and services, while the wealthy and middle class remain in pockets of the urban center close to the concentrations of jobs, culture, and economic opportunity. Finally, high-density sprawl that is typical in China and parts of Asia doesn't isolate the poor at the urban edge, but builds towers in single-use superblocks that compromise local connections, walkability, and transit.

Low-density sprawl is a well-known stereotype in the developed world. It is the auto-oriented development that surrounded and eviscerated core cities in the West after World War II. In the United States, Canada, and Australia it was driven by a middle-class exodus from older urban neighborhoods, subsidized by public investment in highways, underwritten by biased housing financing, and reinforced by social and media stereotypes. While those in the West see this as a middle-class phenomenon, in global terms it is dependent on high-income households. Its challenges and pathologies are well-documented: isolated uses, segregated incomes and age groups, congestion, environmental pollution, and auto dependence to name a few.

The second form of global sprawl is the high-density superblock pattern common in China for the last several decades. It is important because of the sheer size of the built environment it is generating; between 1981 and 2015, China's urban area increased almost tenfold, from about 7,500 square kilometers to over 72,900 square kilometers. In the single largest reduction in poverty in human history, China is moving its rural poor to cities where jobs, services, and education are more accessible. Using this strategy, China has brought over 850 million people out of rural poverty in the last 35 years. But its urban form is unsustainable. Just like low-density sprawl, the new superblocks underlying this growth generate environments where uses are isolated, commutes grow long, congestion and air quality impacts are rising, and traditional street life is lost. Congestion levels are striking even in cities with only 30 percent auto ownership rates. Its density adds to ill effects, not to the vitality that traditional urbanism normally breeds.

Finally, low-income sprawl is perhaps the worst of the three because its negative environmental impacts are matched by its painful social consequences. The poor, living in slums and informal settlements or in social housing at the metropolitan edge, are disconnected from the economic opportunity of the city just as they are starved for basic services. The city sprawls outward along ribbons of undersized roads in low-rise shanty towns, often without sewer, water, power, or decent transit. Nonetheless, these informal developments often result in vital urban forms that support community and social life in ways that government apartment blocks do not. Moreover, without land title, these self-built communities cannot monetize the value of their sweat equity or community investments. Make no mistake, these are low-carbon communities, but have many other tragic environmental and social consequences.

The reality is that all three types of sprawl can emerge simultaneously at a city's edge. In New Delhi, for example, gated high-rise complexes and villa communities, glittering office parks, and posh shopping centers dot the exurban landscape along with decrepit industrial zones, stranded rural areas, and self-built slums. Each brings challenges to the collective functioning of the city; the ratio of each reflects public policy, infrastructure investments, and land-use controls. But they all generate challenges that must be met if cities are to fulfill their potential to lessen environmental impacts, increase social integration, and catalyze economic opportunity.

These three types of global sprawl drive the environmental and social challenges we face across the world. Given this reality, it is important to understand the scale of the environmental challenge we face, its interconnected range of consequences, and the role that the form of human habitat and our resulting lifestyle plays. The principles and standards for sustainable urban forms presented here are in direct contrast to the various forms of sprawl just described. They represent best practice design and policy standards that lead to vital communities, lower environmental impacts, significant offsets to carbon emissions, stronger and more equitable metropolitan economies, and sustainable growth. In sum, they can help shape a more sustainable and prosperous urban form.

In fact, without these fundamental urban design paradigm shifts, growth will dramatically exacerbate environmental, economic, and social costs that many cities cannot shoulder. For example, a study of California over the next 30 years documented the costs of "business as usual" development based on more sprawl. Listed below are some of the savings and benefits of compact transit- and walk-oriented urban growth when compared to typical sprawl.

- ***Land Consumption:*** 67 percent less open space developed, equivalent to more than the land area of Delaware and Rhode Island combined
- ***Carbon Emissions:*** 70 percent fewer tons of carbon emitted, equivalent to the offset of planting forests over half the state
- ***Vehicle Miles Travled (VMT) per Household:*** 10,500 less miles traveled per year, a 40 percent reduction resulting in less air pollution and congestion
- ***Water Consumption:*** 78 million acre feet saved, enough to fill San Francisco Bay 15 times
- ***Energy Consumption:*** 16 quadrillion BTUs saved, which could power all the homes in California for 20 years
- ***Fiscal Impacts:*** $2.7 billion/year in additional revenue and cumulative total of $15 billion saved in operations and maintenance
- ***Public Health Costs:*** Respiratory illness alone saves $1.7 billion per year not counting the positive health consequences of more walking
- ***Average Household Cost:*** A reduction of $10,500 in transportation and utility costs in 2010 dollars or about 20 percent savings of the median household income

This demonstrates a network of benefits that emerges from sustainable growth across a broad range of issues and challenges. The thesis of this book is simply that better metropolitan form and urban design will produce a growing and self-reinforcing set of positive impacts, which when combined become more viable. The existence of these co-benefits means that the cost efficiencies of investments and policies embedded in the seven principles described in these pages enhance viability for systemic change economically and politically. Each goal (affordable housing, land conservation, health, climate change, etc.) gains economic support and political viability by being combined with other goals, investments, and advocates. While a solar farm reduces carbon emissions and improves air quality, urban form accomplishes those along with a long list of other positive outcomes. Co-benefits means powerful political coalitions and cost-effective solutions.

URBANISM VERSUS SPRAWL

For many people, "urban" is a negative word that implies crime, congestion, poverty, and crowding. It represents an environment that moves people away from a healthy connection with nature and the land. Its stereotype is the American ghetto or a slum in a developing nation—a crime-ridden concrete jungle that simultaneously destroys land, community, and human potential. The reaction to this stereotype has seen the middle class retreat into a closeted world of single-family lots and gated subdivisions in the suburbs—or in developing countries' fortress-like enclaves in the city center.

For many others, "urban" represents economic opportunity, culture, vitality, innovation, and community. This positive reading is now manifest in the revitalized centers of many historic cities. In these core areas, the public domain—parks, walkable streets, commercial centers, arts, and institutions—is rich and vibrant, valued and desirable. Certainly, the job opportunities and social services that cities provide are a giant step up for much of the rural poor, even when accessed through a barrio or informal settlement. In the parts of the

world dominated by low-income sprawl, the city center remains the economic and cultural focal point. The challenge there is not the revitalization needed in some city centers of the developed world, but access for the poor.

Unfortunately, much confusion surrounds the difference between suburbs, sprawl, and city. Sprawl is a specific land use pattern of single-use zones, typically made up of isolated subdivisions, residential superblocks, office parks, and shopping malls strung together by arterials and highways. It is a landscape designed for the automobile. We know it when we see it; nevertheless, much of the debate about sprawl and urbanism is rife with misrepresentations.

For example, sprawl is typically described as discontinuous development that wastefully hop-socks across a natural landscape. But healthy forms of growth can also be discontinuous, as villages and towns with greenbelt separations demonstrate. Suburbs are criticized for their low densities, as if we should abolish single-family homes and yards, but many great urban places integrate a full range of densities, from large-lot single-family homes to bungalows, townhomes and apartments. Streetcar suburbs in the United States at the turn of the twentieth century were not sprawl—they were walkable, diverse in use, transit-oriented and compact—but they were relatively low-density and outside the city center.

Conversely, many urban renewal programs transformed decaying urban districts into denser versions of suburban sprawl, substituting residential superblocks and arterials for walkable streets and diverse neighborhoods. They replaced complex, mixed-use neighborhoods with single-use and single-income projects. Much of China's high-density sprawl is built on this modernist model, both within the historic city or on its periphery. It is the quality of the place that is most significant in sprawl—its oversized roads, uniform tracks of housing, isolated employment districts, strip commercial areas, and, above all, its dependence on the car. To be against sprawl is not to be against suburbs or small towns, it is to be against the disaggregation that renders the vitality of city life moribund and that isolates a diverse people into stereotyped enclaves. All suburbs are not sprawl and, unfortunately, not all sprawl is suburban.

Much of the built environment in the developed world, from city to suburb, manifested positive urban traits prior to World War II, while most urban growth built in the post war period contradicted them; public space withered as shared activities were privatized and the wealthy retreated into gated communities, people and activities were segregated by simplistic zoning, and human-scale was sacrificed to a ubiquitous accommodation of the car. In the low-income sectors of the developing world, public space is largely missing, the poor are isolated in remote slums or social housing estates, and streets are overwhelmed with congestion, trucking and inefficient informal transit. The term "sprawl" is defined by what it is missing: a balanced distribution of jobs and housing, mixed-use communities, walkable streets, accessible public space and social services, and robust transit.

This definition of "city" is not new. Jane Jacobs postulated a similar sense of urbanism in her landmark 1961 work titled *The Death and Life of Great American Cities*. The difference now is that urban issues are also being considered in the context of economic opportunity, climate change and environmental decay. In fact, one can arrive at the same design conclusions from the criteria of economic development, environmental quality, and energy efficiency that Jacobs located largely by social and cultural needs. Investigating the technologies and formal systems scaled for limited resources and climate change concerns provides a new and critical element to Jacob's urbanism. If traditional urbanism and sustainable development can truly reduce our dependence on oil, limit both pollution and greenhouse gases, and create socially robust places, then they not only will become desirable, they will be inevitable.

To Jacob's traditional urban values of civic space, human scale, and diversity, the current environmental imperative adds two more: conservation and regionalism. Although the traditional city was by necessity energy- and resource-efficient, it commonly showed a destructive disregard for nature and habitat that would be inappropriate today. Bays were filled, wetlands drained, streams and rivers diverted, and key habitat destroyed. A greener form of urbanism should protect those critical environmental assets while reducing overall resource demands.

Indeed, the simple attributes of urbanism are typically a more cost-efficient environmental strategy than many renewable technologies offer. For example, in many climates, a party wall is more cost effective than a solar collector in reducing a home's heating needs. Well-placed windows and high ceilings offer better lighting than efficient lighting in an office. A walk or a bike ride is certainly less expensive and less carbon intensive than even an electric car. A convenient transit line is a better investment than a "smart" highway system filled with autonomous vehicles.

To arrest climate change, a combination of the sustainable development metrics described in this book and green technology will be necessary. But the efficiency of sustainable urban form should precede the costs of alternate technologies. As Amory Lovins of the Rocky Mountain Institute famously advocates: a "nega-watt" of conservation is always more cost effective than a watt of new energy, renewable or not. Urban living, in its many forms, turns out to be the best type of conservation. The idea of conservation in urban design applies to more than energy, carbon, and the environment, it also implies preserving and repairing culture and history as well as ecosystems and resources. Conserving historic buildings, institutions, neighborhoods, and cultures is as essential to a vital, living urbanism as is preserving its ecological foundations.

Regionalism sets city and community into the contemporary reality of the expanding metropolis. At this point in history, most of the key economic, social, and environmental networks extend well beyond individual neighborhoods, jurisdictions, or even cities. Cultural identity, open space resources, transportation networks, social links, and economic opportunities all function at a regional scale—as do many of our most challenging problems, including crime, pollution, and congestion. Major public facilities, such as sports venues, universities, airports, and cultural institutions, shape the social geography of regions as well as extend local lives.

In fact, most of the emerging global cities are regional agglomerations. The regional challenge is one of coherent governance and urban form. The distribution of jobs, services, and housing across the metropolis is critical. The regional mix and location of affordable housing is at the core of the economic integration of the poor, which is one of the primary benefits of urbanization. Finally, regional form must be structured around a robust and diverse transportation system, with a focus on transit.

All of this brings the focus to a regional level. In fact, cities can thrive only within the construct of a healthy regional structure. Urbanism must be extended to an interconnected and interdependent regional network of places, creating polycentric regions rather than a metropolis dominated by a binary city/suburb schism. This last point is critical to understanding urbanism and the climate change challenge. High-density city life is not the only environmental option; a regional solution can offer a range of lifestyles and community types without compromising ecology. A well-designed region, when combined with aggressive conservation strategies, extensive transit systems, and new green technologies, can offer many types of sustainable lifestyles. New York City may have the smallest carbon footprint per capita in the United States, but to solve the climate change crisis we do not all need to live at those densities.

Identifying an appropriate balance between technology, urban design, and regional systems in confronting climate change is now the critical challenge. As a greater percentage of the world's population increases its wealth, the definition of prosperity also will become critical. If progress translates into an American suburban lifestyle, the planet is in trouble. If China and India adopt the development patterns of auto-oriented, low-density lifestyles or even a high-rise, high-density version of the same, even breakthrough green technologies will not accommodate the exploding demands. If they develop an enlightened and indigenous form of urbanism, an opportunity exists to address climate change in a less heroic and more cost-effective way.

In fact, many developing countries are fast approaching a tipping point for their cities. As auto ownership grows, the infrastructure to support it expands. Slowly at first, then in a landslide, the logic of larger arterials, ring-roads, parking lots, superblocks, freeways, malls, and isolated uses becomes irresistible. As cars make remote destinations viable, the historic logic of mixed-use and walkability erodes and the economics of single-use, auto-oriented suburbs grows. The built environment shifts to focus on auto mobility in ways that are hard to reverse—and with this shift, urban culture dies. Traditional landscapes and neighborhoods are demolished at astonishing rates to make way for what is now considered "modern." In many developing cities, the primary cause of energy consumption, poor air quality, and carbon emissions is transportation. Compounding this, transportation becomes a more dominant environmental issue as industry becomes more efficient, jobs continue to shift toward white collar offices, and places like China shift toward a consumer economy.

Nonetheless, much of the global population growth will come to cities with low auto ownership rates. The challenge is to keep these rates low as incomes grow and the city expands. For the poor, the challenge is better transit and more accessible housing locations. In China and India, most major cities still have auto ownership rates below 35 percent of households; in Africa overall, auto ownership is just 4.2 percent, yet the congestion is overwhelming.[1] Beijing is building its seventh ring road, but cannot outpace the backups. What is now called "sustainable transportation," with a focus on walking, biking and transit, is central to healthy cities regardless of wealth, history, or location.

In sum, the good news is that truly livable urban places also happen to be the most environmentally benign form of human settlement and are at the heart of a more sustainable and equitable future. For every one percent increase in urban population, per capita GDP increased by 10 percent in China, four percent in Indonesia, and 13 percent in India. Cities and urban places produce the smallest carbon footprint on a per capita basis.[2] New Yorkers, for example, emit just one-third of the GHG of the average American.[3] In addition, it is generally accepted that fertility rates in developing countries drop as a rural population urbanizes. And incomes often rise as the rural poor transition to the city. Sustainable development leads to a decrease in extreme poverty, lower fertility rates, and people consuming fewer resources. Urbanism is, in fact, our single most potent weapon against climate change, overpopulation, poverty, and environmental degradation.

CITIES, CLIMATE CHANGE AND GLOBAL SPRAWL

Clearly, sustainable growth patterns can help address many of humankind's endemic challenges such as economic development, environmental decay, and lack of social services. However, climate change is new and existential. This book and its strategies take as a given that climate change is an eminent threat and potentially catastrophic—the science is now clear that we are contributing to our own demise every day. The global trend toward climate change presents an economic and environmental challenge of unparalleled proportions and, lacking a coherent response, the potential

for dire consequences. These multiple challenges of climate change will, in turn, bring into urgent focus the way our buildings, towns, cities, and regions shape lives and our carbon footprint. The relationship between urban form and climate change seems indirect and obscure to many. But beyond a transition to clean energy sources and innovative technical efficiencies, sustainable cities will play a central role in addressing humankind's fundamental demands for energy, land, and resources. In fact, responding to climate change and growing populations without a more sustainable form of urbanism may be impossible.

In fact, the emerging middle class across the globe will drive urban form carbon emissions and, therefore, human well-being for all. It is this segment that will shape our cities, our environmental impacts, the economics of growth, and the level of social equity we can achieve. For the emerging middle class, auto ownership, security, social segregation, shared infrastructure, and the design of buildings become central issues shaping the form of our cities, as well as the impact on the environment, level of social equity, and the health of humankind.

Profound differences exist between global cities in terms of wealth distribution, urban form, and density. Nonetheless, many cities face similar challenges as they grow—congestion, rising infrastructure costs, stressed social services, and lack of affordable housing to name a few. Urban solutions are powerful in that they can address all these challenges simultaneously.

Such urban solutions involve both technology and design. For example, we will need to dramatically reduce the number of miles we drive as well as develop less carbon-intensive vehicles. It will mean living and working in buildings that demand significantly less energy as well as powering them with renewable sources. It will involve the kinds of food we eat, the size of homes we build, the ways we travel, and the kinds of communities we inhabit. It will certainly involve giving up the idea of any single "silver bullet" tech solution (whether solar or nuclear, conservation or carbon capture, adaptation or mitigation) and understand that such a transformation will involve all of the above—and, perhaps most important, that they are all interdependent.

In fact, the viability of new technologies and clean energy sources will depend on the success of conservation efforts at the regional, community, and building scales, which in turn will be determined by basic lifestyles and the urban forms that support changing demographics. The key will be designing the right mix of strategies, a "whole systems" rather than a "checklist" approach to climate change, energy, and economics.

There are three interdependent approaches to the climate change challenge: enhance city life, support conservation, and transition to clean energy. As population shifts to cities across the world, the first fix, urban form, will affect where and how people live—the way they get around, the size of homes, their economic opportunity, their vulnerability to flooding and sea level rise, and the quantity of goods consumed. The second fix, conservation, revolves around technical efficiencies—in our buildings, cars, appliances, utilities and industrial systems—as well as preserving the natural resources that support us all: our global forests, ocean ecologies, and farmlands. These conservation measures are simple, they save money, and they are possible now. The third fix, clean energy, is what we have been most focused on: new technologies for solar, wind, wave, geothermal, biomass, and even a new generation of nuclear power. These renewable energy sources are an essential element, they are less and less expensive, and are increasingly being deployed. All three approaches will be essential, but the sustainable growth metrics presented here focus on the first two—city life and conservation—because they are, in the end, our most cost effective and easily available tools.

Consider that in the United States, industry represents 29 percent of GHG emissions in the energy sector; agriculture and other non-energy-related activities just nine percent; and freight, planes and 'other' another nine percent. This 47 percent total represents the GHG emissions of the products purchased, the food we eat, the embodied energy of all our possessions, along with all the shipping involved in getting them to us.[4] The remaining 53 percent depends on the urban landscape: the nature its of buildings and mobility systems.[5] Globally, the numbers are somewhat different with 32 percent for industry, 25 percent for agriculture, and 10 percent for miscellaneous, leaving 49 percent in buildings and transportation. But the resulting conclusion is the same: urbanism, with heightened transit investments, more walkable neighborhoods, and more efficient buildings, can deliver much of our needed GHG reductions.

However, while the sectors of carbon emissions are similar, vast differences exist in carbon emissions per capita. The world average carbon emission is currently around five tons per person per year, while in the United States it averages 16.5 tons and Europe is 6.4 tons. China now averages around 7.5 tons per person, up from four tons eight years ago. India emits an average of only 1.7 tons per person. These differences are why the issue of environmental equity and proportioning responsibility for climate change is hotly debated in the political arena. The fundamental fact remains, though, that all countries need deep, systemic change. While some countries have and do contribute less carbon, all need more sustainable forms for urban growth—and therein lies common purpose.

Combining World Bank 2014 data for population and carbon emissions per capita by economic quartiles clarifies the climate change burden created by the poor, middle class and wealthy of the planet. The upper middle and wealthy represent 3.9 billion of the 7.28 billion population on the planet at that time—just over half the population—but emit 90 percent of the carbon. The average for a wealthy person is around 11 million tons per capita, while the average for the very poor is 0.3 million tons and the lower middle income is just 1.5. The global average emission per capita is 4.7 million tons.[6]

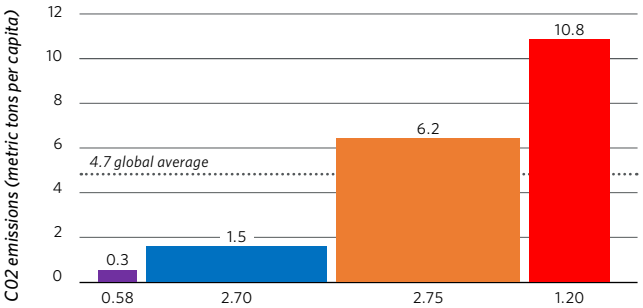


Figure 1-1: Global Population by Economic Quartile (Billions) (Source: World Bank Data)

In Sweden, one of the planet's wealthiest economies with a harsh climate, the per capita average is currently under 5 million tons.[7] It demonstrates that the wealthy could meet the reduced targets through smart, cost-effective urban forms and innovative technology. Reducing demand in the primary end uses—buildings and transportation—will not only have a direct impact on emissions, but will also indirectly lower the GHG targets that need to be met by industry and utilities. For every kilowatt of energy saved at the building, three are saved at the utility because of its generating and transmission inefficiencies.[8] That means urbanism, as it affects buildings and transportation, amplifies or dampens emissions in the industrial and utility sectors by significant multiples.

A WEB OF CO-BENEFITS

Perhaps just as important as greenhouse gas reductions and oil savings is the fact that sustainable urban forms generates a fortuitous web of co-benefits. Cities are our most potent weapon against climate change because they do so much more. Urbanism's compact forms lead to less land consumed and more farmland, parks, habitat, and open space preserved. A smaller urban footprint results in less development costs and fewer miles of roads, utilities, and services to build and maintain.

That, in turn, leads to less embodied energy in construction materials and fewer impervious surfaces, less polluted storm runoff, and more water directed back into aquifers. In much of the developing world, these infrastructure savings are essential to providing a stepping stone out of rural poverty.

More compact development leads to lower housing costs as lower land and infrastructure costs affects both first costs and taxes. Sustainable urban forms provide more housing choices for a more diverse population, and more affordable housing in accessible locations. That results in less private space but more shared community places—which is more efficient and less expensive overall. Residential options are more suited to an aging population and to a working population seeking lower utility bills and less time spent commuting. For the global urban poor, the sustainable growth standards presented here would provide better transit, more infill sites and mixed income communities—in essence, more integration into the economic and social opportunities of the city.

Compared to sprawl, urbanism leads to fewer auto miles driven and more transit use, which then leads to less gas consumed and less dependence on oil supplies, less air pollution, and less carbon emissions. Fewer miles also leads to less congestion, lower road construction and maintenance costs, and fewer auto accidents or pedestrian fatalities. This, then, leads to lower health costs because of cleaner air, which is reinforced by more walking, bicycling, and exercising that subsequently contributes to lower obesity rates. Finally, increased walking leads to more people on the streets, safer neighborhoods, and perhaps stronger communities.

The feedback loops go on and on. More sustainable development means more compact buildings that need less energy to heat and cool, less irrigation water and emit less carbon in the atmosphere. This then leads to lower demands on electric utilities and fewer new power plants, which again results in less carbon and less costs. As Bucky Fuller exhorted us, urbanism is inherently "doing more with less."

But for the past 50 years, the western economy and society have been operating on the premise of "bigger is better" including bigger homes, bigger yards, bigger cars with bigger engines, bigger budgets, bigger institutions, and, finally, bigger energy sources. In contrast, urbanism naturally tends toward a "small is beautiful" philosophy and what has now been called the 'sharing economy.' This philosophy involves trade-offs: less private space but perhaps a richer public realm; less private security but perhaps a safer community; less auto mobility but more convenient transit and proximity. Compact development does mean smaller yards if any, fewer cars, and less private space for some. On the other hand, it can dramatically reduce everyday costs and leave more time for family, friends and community.

The question is not which is right and which is wrong or that it must be all one way or the other; urbanism works best with blends. Differing parts of the world will strike differing balances, but they will all be enhanced by better urban form and efficient infrastructure. The question is how such trade-offs fit with each place's emerging demographics, desires, needs, and economic means—and its sense of what a "good life" is.

Urban design is part art, social science, politics, engineering, geography, ecology and economics. It is necessarily all of the above; it cannot be measured by just one outcome. Additionally, great urban places are qualitative as well as quantitative—ultimately defined by the coherence of their public places, the integration of a diverse population, and the opportunity they create for collective aspirations. We will never treasure cities and towns because they are low-carbon or energy efficient; we will treasure them when we come to love them as places, as vessels of our cultural identities, theaters for our social interaction, and landscapes for our personal narratives. But that does not mean that they should not also play a role in the climate change challenge and the opening of opportunity for those most in need.

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02 High-Income Sprawl

02

High-Income Sprawl

High-income sprawl can be a part of any city where the wealthy and middle class leave the central city for landscapes dominated by autos, single-family subdivisions, shopping malls, and office parks.

High-income sprawl is largely present in the wealthy countries in the Global North that have a large middle class. It is also the product of post-WWII policies that supported certain types of housing, infrastructure, and industrial policy. High-income sprawl resulted when upper- and middle-class populations migrated to low-density, single-use, and auto-oriented environments. A pattern of high-income sprawl has emerged in the United States, Canada, parts of Europe, and Australia since WWII in coordination with the dominance of the auto. High-income sprawl can be a part of any city where the wealthy and middle class leave the central city for landscapes dominated by single-family subdivisions, shopping malls, and office parks. Here we will focus on its most dramatic manifestation and the country that has become the poster child for high-income sprawl: the United States.

Sprawl was not always the nature of American cities. In fact, it is actually a 50-year experiment in a radical form of settlement driven largely by the post-WWII policies mentioned above and technology. Over this 50-year period, the United States transitioned from a country of villages, towns, and cities to a country of subdivisions, malls, and office parks. In 1950, just 23 percent of the population lived in suburbs[1]; in 2016, that number climbed to 55 percent.[2] During that rise, cities spread out. For example, from 1970 to 1990, the Chicago region expanded geographically by 24 percent while its population increased by only 1 percent; cities such as Detroit and Pittsburgh urbanized over 25 percent more land even while their population shrank.[3]

America became a country dominated by cars within a landscape designed specifically for them. Between 1960 and 2018, the Vehicle Miles Traveled (VMT) per year by each American doubled to an average of 10,000 miles.[4] [5] The U.S. became a decentralized service economy rather than an urban industrial economy, which resulted in people spending more and more time in cars. In 1970, only 25 percent of jobs were in suburbs[6]; by 2010, that share had grown to 77

percent.[7] Simultaneously, as a result of market segmentation in housing developments, the country became more segregated by age, income, and culture as well as by race. All of these shifts found physical expression in development patterns, specfically suburban sprawl and urban decay, diminished natural resources, and lost history. The United States became the global model for low-density sprawl and a unique form of social and economic segregation manifest by gated communities and age-specific complexes. All of this suburban growth also resulted in abandoned and degraded low-income neighborhoods of the inner cities.

But just when auto suburbs became the norm, the United States began to outgrow its basic assumptions. Most significantly, demographics shifted away from nuclear families. Only 23 percent of American households are now married couples with kids at home, and less than half of these subsist on one income.[8] Today, the largest household type is made up of single individuals and single parents.[9] What's more, over the past 50 years, the number of women working has more than tripled.[10] The "stay-at-home mom" foundation upon which the suburbs were built is effectively replaced with the growing need for a parental chauffeur service.

As the suburban version of the good life faded, other fundamental changes accelerated: the globalization of capital and labor, the growing dominance of an information economy, a decaying and sometimes toxic environment, the decades-long disintegration of inner cities, intensifying geographic segregation of income groups, and the near-collapse of faith in public institutions, to name just a few. One hears about these challenges every day, but cannot seem to find a comprehensive response or even a coherent vision of a unifying personal or collective future. Filling the void, politicians vacillate between scapegoating by blaming immigrants and big government or bandages that create regulations addressing symptoms rather than root causes. Many respond by withdrawal or anger, cocooning in special interest groups and retreating to private communities. Unfortunately, this cycle of withdrawal has been feeding on itself. The less invested in high-quality public facilities and community services, the more the need to retreat into gated or distant suburbs—and the more we seem to distrust government.

DEMOGRAPHICS, HEALTH, AND MOBILITY

In architecture, "form follows function" has been the mantra of modernist design. In urbanism, the equivalent might be "form follows demographics." The form of cities and communities is ultimately shaped by demographic trends: age, household size, income, and culture, to name a few. Consider housing, for example. Over the past 60 years, share of single-person households in the United States has grown from 13 percent in 1960 to 28 percent in 2018.[11] In Australia, that number has grown from 19 percent in 1986 to 24 percent in 2018.[12] In the European Union, 32 percent lived alone in 2018, with single men actually doubling as a household type. At the same time, married couples with children slipped from 40 percent down to 23 percent in the United States and over three-quarters of households are childless.[13] Overall, Americans live alone more, with the national average of 3.3 persons per household in 1960[14] falling to 2.6 in 2017.[15] This means that the standard single-family home in an isolated subdivision may have been a good fit in the past, but may no longer be the best lifestyle for many today.

Ironically, while household occupancy was falling, the size of houses was growing. In 1950, the average size of a new US home was 980 square feet; today it is 2,457 square feet.[16] This increase in size is certainly a luxury, but one that, after the housing crash of 2008, seems to have been subsidized in unsustainable ways. In addition, this growth in size is tied to more and more remote locations, as people have accepted longer commutes to find larger, more affordable homes. From an energy standpoint, both home size and distance translate directly into greater carbon emissions, environmental

impacts, and household expenses. From a cost-of-living standpoint, the long commutes more often than not offset the savings in home cost, but that calculation seems to elude both home buyers and banks.

One underlying cause of the 2008 financial meltdown in the United States was a mismatch between the cost of ever-more distant housing and its implicit transportation costs with the stagnant incomes of the lower middle class. This hidden gap spurred a new definition of housing affordability, aiming to include the combined housing and transportation costs (H+T), which has become a benchmark metric for many planning and development policies.[17] Rather than a traditional goal of 30 percent of income allocated to housing, a combined 45 percent of income on housing and transportation was studied. Under this equation, the number of affordable neighborhoods in the United States fell from 55 percent to 26 percent. That resulted in 74 percent of Americans pushed to live above their financial means, and a housing debt crisis that inevitably led to the worst recession since 1929. With sprawl patterns accelerating in the United States post recovery, a recurrence of such market failure may soon be on the horizon. Aiming for a more sustainable economy, long-term policies in several metropolitan areas in the United States (El Paso, Texas; the Chicago metropolitan region; and the San Francisco Bay Area) employed the H+T index to guide long-term policy decisions.[18]

The same radical shifts seen in housing can be seen in Americans' relationships to cars and driving. In 1960, the country averaged just one car per house; now it has 1.9, with the biggest increase coming in the 1970s.[19] In the 1960s, only 2.5 percent of households owned three cars[20] but now it is 15 percent[21]. One-fifth of homes had no cars in the 1960s; today that figure is down to less than one-tenth.[22] Today, the average US driver spends 55 minutes behind the wheel every day.[23]

America has never been a paragon of transit use, or of walking for that matter, but just after World War II, when streetcars and trolleys were ubiquitous along with Chevrolets and Fords, we drove about 11,100 miles per household each year. Today we drive an average of 24,000 miles annually.[24] None of this is a mystery; as cities spread out and became more car dependent, driving increased and daily lives changed.

One startling, unintended consequence of increasingly auto-dependent lives has been public health. People walk less, produce more air pollution from cars, and are involved in more auto collisions. In the past 50 years, the total miles driven annually in the United States increased from 718 billion to over 3 trillion.[25] Although great strides in auto safety have been made, emissions, collisions, and air pollution have grown with the rise of miles driven. A 2013 study attributed 52,800 premature deaths to air pollution caused by autos.[26] Summing all the health costs due to air pollution caused by autos results in $450 billion annually.[27]

Harmful exhausts may have been reduced through higher emission standards, but air pollution still remains a problem. Many metropolitan areas in the United States are still struggling to meet their air quality standards. As of 2016, more than 4 in 10 people in the United States live in counties that have unhealthful levels of either ozone or particle pollution. That means more than 134 million predominantly lower income Americans live with air quality concentrations exceeding healthy levels established by the U.S Environmental Protection Agency.[28] The Organization for Economic Co-operation and Development (OECD) estimates show that 50 percent of health impact costs of air pollution are caused by road transport.[29] In countries outside of OECD, mainly in the Global South, deteriorating air quality is becoming a crisis.

Over the years, auto collisions may have dropped per mile of driving because of safer vehicles, but they have actually risen per capita because VMT has grown steadily.[30] Currently, over 35,000 people are killed and 2.4 million are injured on US roads per year.[31] The medical costs that result exceed $300 billion annually.[32] Interestingly, traffic fatality rates are highest in exurban areas, not cities.[33] Contrary to common impressions that cities are dangerous, combining traffic deaths with crime rates, living in cities is actually safer on average than living in the suburbs.

In addition to air quality health impacts, the United States has experienced what now qualifies as an epidemic of obesity and obesity-related diseases, primarily diabetes, partially attributed to sprawl. The US Centers for Disease Control and Prevention (CDC) estimates around 200,000 to 300,000 deaths per year occur prematurely as a result of obesity-related illness.[34] On average, obesity shortens life by almost 9.5 years.[35] Many causes underlie this epidemic, but most prominent are diet and lack of exercise.

Between 1970 and 2009, the United States' mode share for walking and biking fell 56 percent[36] while auto use increased at three times population growth.[37] A comprehensive study for the US Secretary of Health and Human Services compiled years of research into a recommended 30 to 60 minutes of moderate daily physical activity, five days a week.[38] This easily attainable goal in walkable neighborhoods can help to reduce risk of disease and lower obesity rates.[39] In fact, the evidence is so clear that the CDC issued recommendations that call for improved access to transit, mixed-use development, and investments in pedestrian and biking facilities as strategies to help counter obesity.[40] Considering air pollution, collisions, and obesity, the costs of the 50-year experiment with auto suburbs must be measured not only in gas and road construction but also in its significant impacts on public health.

Beyond these profound health, demographic, and social shifts, the economic and technical changes of the past two generations have been dramatic. Many have documented and decried the country's declining industrial base. In 1958, 49 percent of jobs were in production, and now only 14.1 percent are.[41] Meanwhile, service jobs increased from 36 percent of total jobs to 80.3 percent.[42] In the emerging information economy, white-collar workers dominate. This has painfully affected regions that lack a diversified economy and an educated workforce. This shift has affected blue-collar middle-class incomes, and ultimately the kinds of neighborhoods and lifestyles that are affordable.

The land-use manifestation of this economic transformation was a shift from urban factory sites to suburban office parks, and from heavy industry to sprawling light industrial zones. As a measure of this change, the country's energy consumption in the industrial sector has dropped 32 percent per capita since 1960. Meanwhile, energy consumption in office buildings (home of the white-collar worker) has almost doubled.[43] One opportunity presented by this shift is the possibility of reintegrating the workplace within residential areas. Noisy, dirty urban factories were one of the reasons the middle class fled the city in the first place. Now, in both city and suburb, the workplace can easily be integrated as part of walkable districts and neighborhoods.

Much has been written about the stagnation of middle-class incomes since the 1970s. In fact, the median inflation-adjusted hourly wage for salary and wage workers in working age rose only six percent between 1973 to 2017 or just 0.14 percent per annum.[44] But, ironically, this stagnation has not had a big impact on land-use patterns or housing densities. Houses, yards, and cars all grew bigger even though paychecks didn't. This partly explains the housing bubble of 2008.

The way US households spend money did change. In the 1950s, the average house spent 27 percent of its income on housing and 13 percent on transportation, for a total of 40 percent. For many low- and working-income households today, the combined expenditure now reaches 51 to 56 percent. In 2017, people in the lowest 20-percent income percentile spent 41 percent of their budget on housing and 15 percent on transportation.[45] The increase in spending on cars is, of course, a key reflection of auto-oriented land-use patterns. For larger households, multiple car ownership has long since shifted from a luxury to a necessity.

Perhaps the largest economic shift of the past 50 years has been the emergent global economy and its implications for cities and regions. As industrial production shifts to low-wage centers around the world and is automated, the United States' and other developed nations' economies depend more and more on clusters of innovation, creative intelligence, and place-specific industries.

An educated workforce and regional forms that create vital urban environments, expedite transportation, and balance jobs and housing opportunities are key to a robust regional economy. Global competitiveness highlights the need for communities with amenities that attract the creative, mobile, value-adding people who tend to drive the information economy. These workers typically have the freedom to choose where they live and work, and they commonly prefer a rich urban lifestyle. As American urban studies theorist Richard Florida summarizes: "Place still matters in the modern economy—and the competitive advantage of the world's most successful city-regions seems to be growing, not shrinking."[46]

AFFORDABLE HOUSING & URBANISM IN AMERICA

The mismatch between the cost of sprawl and household economic capacity is camouflaged because of a lack of full accounting. The challenge extends beyond housing costs to the 10 to 15 percent of a household's budget that is spent on transportation—auto ownership, insurance, maintenance, gas, and parking.[47] Housing affordability further erodes as the incremental price of road maintenance, improvements, and construction is added to the cost of new housing through development fees and local taxes. In addition, these costs do not include the burden of time lost to longer commutes and congestion. Finally, deferred environmental impacts are beginning, through government regulation and mitigation requirements, to filter down to the consumer's checkbook. In sum, the economics of sprawl are collapsing for all but higher incomes.

In many regions, the most affordable single-family homes are currently the most distant from key job centers on cheap remote land. These distant suburbs average a higher number of cars per household and greater travel distances. Average cars per household in 2017 nears pre-2008 peaks, with almost two cars per household.[48] The average three-car household spends close to $13,300 in auto ownership, maintenance, gas, and insurance annually; a two-car house, around $8,900; and a single-car home (which was the average back in 1960), about $4,450.[49] The average American's per vehicle spending averaged $8,558 in 2016.[50] The savings of not owning that car applied to a home mortgage would finance about $125,000 of home value at current rates.[51]

In addition to the increased transportation costs associated with low-density development are also increased infrastructure costs. Many "costs of sprawl" studies over the past few decades have documented this. The cost of providing and maintaining local roads and utilities for

low-density growth over more compact alternates is a simple linear relationship. The hard costs end up between $20,000 and $30,000 more per household for large-lot subdivisions when compared to more compact mixed-use growth. That leaves aside the increased operating expense of extended public services, such as police, fire, school bus, and emergency response. Additional capital expense include developing new water and energy sources for less efficient land use patterns.

Strategies for creating affordable housing often trend toward subsidies, cheap and distant land, density bonuses, special financing, and lower construction quality. But each of these strategies has problems. Affordable housing on cheap land isolates the poor, subsidies are scarce, density is anathema to many neighborhoods, creative financing can only delay the true costs of home ownership, and construction quality is already cut to the bone. Solutions can no longer come only from the mindset of cutbacks and subsidies.

A broader picture of how to form communities is central to rethinking this chronic economic problem. Affordable housing must start with affordable neighborhoods, affordable lifestyles, and affordable infrastructure. Imagine a neighborhood in which transit was within walking distance and ran frequently—a neighborhood where one could stop on a short walk at a daycare center, favorite shop, bank, health club, or café, where the tree-lined streets were free of sound walls and speeding cars. In these neighborhoods, trips could be made conveniently on foot, transit, or bike. Think of a neighborhood in which a three-car family could be a two-car family, or a two-car home might choose to have only one. Imagine a place in which driving was an option rather than a necessity, where the money spent on driving a car could be used for mortgage or rent—and where the time spent in the car could be traded for time in the community, with the family, or reading on the train. For a struggling family, the benefits of these economies can be profound.

Affordable housing in this comprehensive form is rare because of piecemeal public policies that treat symptoms rather than systemic causes. We misallocate massive funds in ways that limit choices. We choose to subsidize highways rather than transit and in so doing commit the working poor to own several cars. We choose to make building mixed-use neighborhoods difficult because of single-use zoning and mortgage underwriting standards that reinforce single-family development. In addition, many communities blatantly practice exclusionary zoning by establishing minimum lot-size requirements or simply by limiting new construction.

Rethinking such standard policies and practices will not only begin to resolve some of our affordable housing problems but also can break the logjam of traffic congestion, deteriorating air quality, and loss of open space—and help respond to the climate change challenge. These are integrated solutions for complex interconnected problems. And they are just one example of the many ways an environmentally sustainable future can also be affordable and socially robust.

There is no doubt that for those who can afford it, a large house on a large lot with several big cars is a very comfortable lifestyle. Chris Leinberger, in *The Option of Urbanism*, gives the most concise list of sprawl's allure: privacy and land, affordable homes due to low-cost construction and federal tax deductions, communities filled with similar people, better public schools, relative safety, and free parking.[52] These items have all been attractive for decades, but now they are compromised by another list: congestion, suburban crime, loss of open space, smaller lots, rising taxes, declining services, decaying infrastructure, and increased commuting. The "pull" of new sprawl has lost its glitter as well as its fit with evolving demographics and a crisis in affordability. To top it all off, the climate change implications of more sprawl are becoming apparent to all who are willing to look at the numbers.

Perhaps the biggest impact of low-density sprawl is ironically its effect on development in other parts of the world. In emulating this model of the "good life," the growing middle class of developing regions are laying the groundwork for land-use patterns that will generate all the negative health, environmental, economic, and social impacts plaguing the wealthier regions. The results of China's urban growth is a good example of these transferred problems. Congestion is choking its cities, air quality is damaging health, obesity is on the rise, carbon emissions are growing, and critical farmlands are being consumed.

The economic limits of low-density sprawl in the United States and other similar developed countries are now painfully apparent on many levels. The true environmental and health costs of climate change, air pollution, imported oil, overtaxed resources, and lost open space may be deferred but never fully avoided. Beyond these pressing environmental and health impacts, the economics of our current development patterns are hard to sustain for working families. The soaring costs of transportation, services, infrastructure, and housing all raise questions about the viability of a land-use pattern that is affordable only to a diminishing percentage of the population.

More and more, the costs of auto-oriented development cannot be absorbed by the average new home buyer, by local government, or by the environment. The housing crisis of 2008 should be seen as clear evidence of the unsustainable costs of sprawl rather than just the excesses of overextended credit and precarious financial tools. The good news is that shifting the paradigm of development toward more sustainable development patterns is synonymous with changes that can ensure the economic, social, and ecological health of middle-class cities and towns—as the following case study of California's futures demonstrates. Redirecting land-use patterns can accommodate a broad array of agendas, goals, and needs that cover a broad range of pressing challenges. But history shows that big shifts are possible and, in fact, inevitable. Demographics in the developed world will propel new housing needs; economics will mandate a less costly form of prosperity; and environmental impacts will propel new technologies. Certainly, profound barriers to change star with inertia, cultural norms, vested interests, existing infrastructure and political gridlock. But innovation, ingenuity, and flexibility have always been deeply embedded in the West. And as can be seen from the past 50 years, change is inevitable. The only question is: What type?

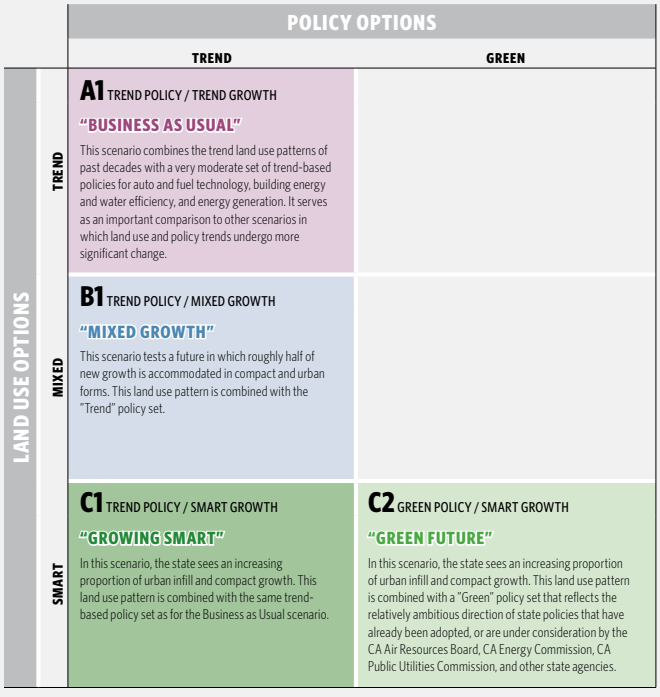
CASE STUDY

Vision California

A good example of the potential impacts of changing urban forms are demonstrated by a 2014 study of future growth for the State of California. This study, called "Vision California 2050," [53] compared a series of growth scenarios including a 'Trend' future of standard sprawl and a "Smart' growth alternate that embodied the design principles documented in this book. By 2050, California's population is projected to grow to nearly 60 million people and 24 million jobs. Most of the state's past growth is similar to the middle-income sprawl just described. State leaders worried that the impacts of such growth could undermine the quality of life, economic viability, and social coherence of California's future. Given the high environmental and economic goals of the state, this study provided critical information shaping important policy debates, directing infrastructure spending, and developing reasonable regulations for buildings and transportation.

The California Global Warming Solutions Act (Assembly Bill 32) of 2006 set challenging targets for reducing greenhouse gases across the state. It called for compliance with the Kyoto targets of reducing emission to 20 percent of 1990 levels by 2050. To complement this legislation, the Sustainable Communities and Climate Protection Act of 2008 (SB375) was designed to support new energy conservation standards and renewable energy targets with low-carbon land-use/ transportation planning. Under SB375, each Metropolitan Planning Organization (MPO) in the state is required to develop a Sustainable Community Strategy (SCS) that reduces carbon emissions while accommodating growth.

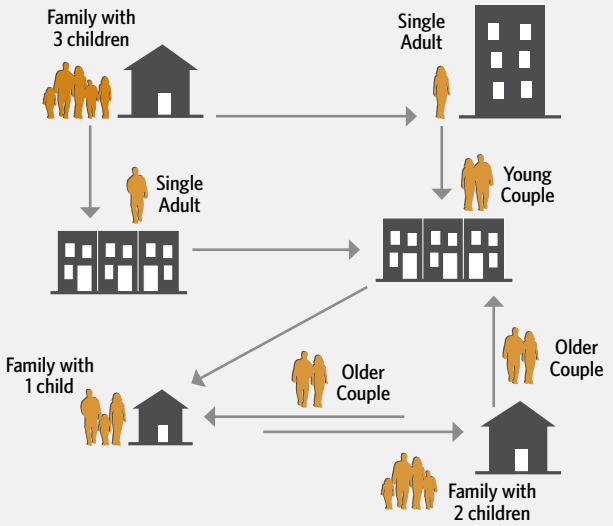
The UrbanFootprint software allowed state MPOs to easily study differing land-use and transportation scenarios and document compliance. The software also enabled each city to understand the larger implications of alternate development patterns by analyzing a broad range of impacts. Vision California looked at the whole state with the same methods; first understanding growth pressures, then developing alternate development patterns to accommodate demands, and finally analyzing the outcomes of each approach with various environmental, economic, and social metrics.



All charts, diagrams and tables included in this case study, except where noted, were prepared for the Vision California 2050 report, produced by HDR | Calthorpe Associates.

Figure 2-1 (left): Three land use options and proposed policies to support each growth scenario

Figure 2-2 (below): The Housing LIfe Cycle



COMBINING LAND-USE, TRANSPORTATION AND POLICY OPTIONS

The study developed three rapid-fire scenarios—Trend, Mixed, and Smart—by combining various land-use patterns, transport infrastructure, and conservation policies. It did this by first defining three typical land development categories (LDCs): Urban, Compact, and Standard. Each represents distinct forms of land use, ranging from dense, walkable, mixed-use urban areas that are well served by transit, to lower-intensity, less-walkable places where land uses are segregated and most trips are made via automobile. These development types were then used as the building blocks of each scenario, which vary by proportion of each.

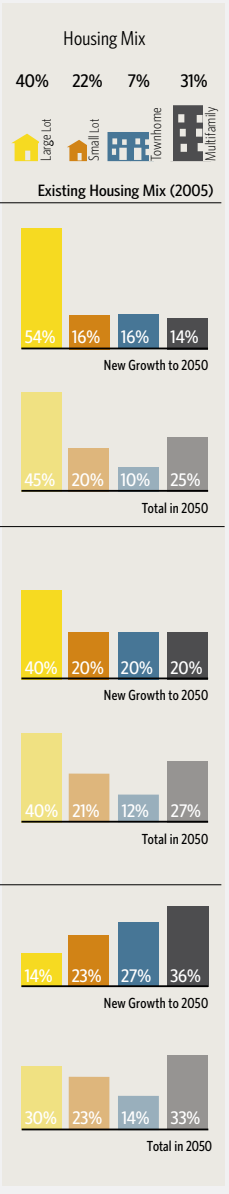
Since growth always includes a mix of these general development types, the differing scenarios are largely defined by the ratio between the Urban, Compact, and Standard types of development. For example, California historically had grown with patterns of about 70 percent low-density housing subdivisions, office parks and shopping—commonly thought of as sprawl. The Trend Growth scenario matches this ratio with only 30 percent urban and compact development. The mixes of development types then produces variations of overall housing, jobs, and transportation for each scenario in the study.

Figure 2-3: Land Development Types

The most progressive land-use/transport scenario was also studied with two policy packages to understand the impact of improvements in technology and building practices. The land-use/transport options varied the patterns of growth, while the policy packages vary potential state standards for automobile technology and fuel composition, building energy and water efficiency, and energy generation. The three land-use scenarios highlight the impacts of land use on GHG emissions and other critical metrics, as well as the combined impacts of land use and policy, which were vital as California reached toward aggressive climate, energy, water, and fiscal efficiency targets.

All scenarios accommodate the same total amounts of housing and job growth. The pie charts below show the mix of development types in each scenario, which in turn result in different housing type mixes. The housing type mix for new growth in each option is shown in the bar charts; the total end-state housing type mix in 2050—new development plus the existing housing stock.

Figure 2-4: Land Use Options



Land Use Option A: Trend Growth

The Trend growth option represents a future based on historic market trends, development patterns, and transportation investments in California.[54, 55, 56] This option is comprised of 70 percent Standard development, with Compact and Urban development totaling 30 percent. The resulting housing type mix aligns with historic market trends in California, in which single-family detached homes have comprised the majority of new construction in major metropolitan areas.[57]

Land Use Option B: Mixed-Growth

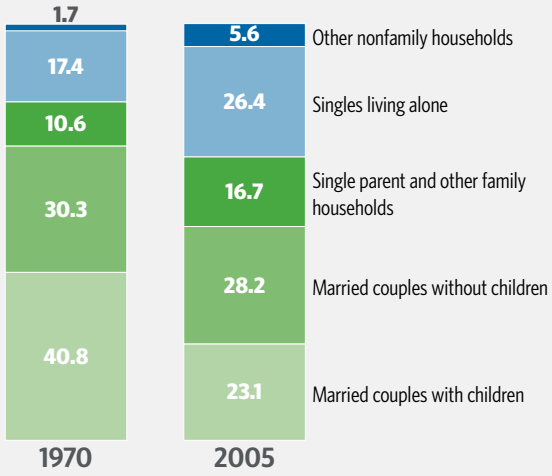
The Mixed Growth option reflects the least-aggressive end of projected market and development trends, which indicate that 50 to 70 percent of development in California between 2010 and 2020 should be Compact or Urban. These trends stem from changing demographics and lifestyles, trends in construction, the undersupply of compact units on the market, and projected energy price increases. The Mixed Growth option accommodates 50 percent of growth in Compact or Urban forms.

Land Use Option C: Smart Growth

The Smart Growth option assumes that a greater share of new growth will occur in Urban and Compact forms to meet a current and projected undersupply of compact development and align with projected demographic, regulatory, and market trends.[58] This option accommodates 55 percent of new growth in Compact and 35 percent in Urban forms by 2050. Despite these high proportions, the 2050 end-state housing mix of the Smart Growth option tracks the current (2005) housing mix, with nearly 70 percent of housing in single-family detached or attached (townhome) types. It is assumed that significant investments in transit and other infrastructure will be made to support Smart Growth.

The proportion of higher density housing types in the Mixed Growth and Smart Growth land-use options are supported by real estate market analysis that indicates that demand is moving away from larger, single-family detached homes toward smaller detached or attached housing units.[59] Affordability, accessibility, and demographics are key factors behind this change. Nationally, market analysts predict that apartment and townhouse living near transit will drive much housing demand going forward.[60] Lifestyle preferences also play a role. For example, a survey of households in Atlanta, Georgia, found that 40 percent of those living in single-family detached neighborhoods would trade large lots for smaller ones with more community-friendly amenities, including sidewalks, narrower streets, shops, services, and parks.[61]

Figure 2-5: Change in US household demographics, 1970–2005
(Source: US Census Bureau, 2005)



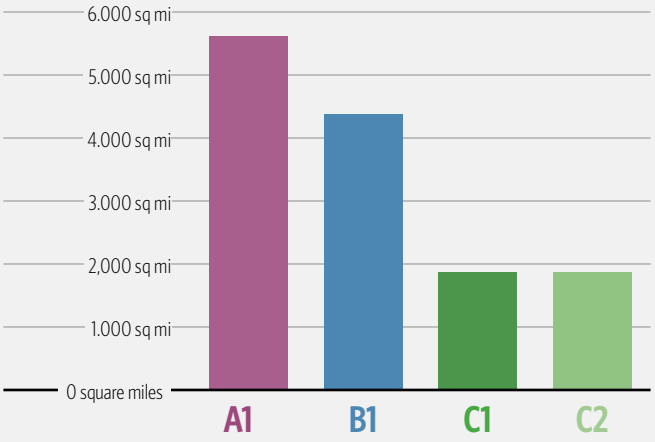
Results

LAND CONSUMPTION

The amount of land consumed to accommodate new population growth varies substantially among the rapid fire scenarios. New land consumption includes all land that will be newly urbanized, including residential and employment areas, roadways, open space, and public lands. The rapid fire model estimates land consumption based on per-capita rates of land consumption by LDC (Urban, Compact, and Standard).

Scenario A1, which accommodates 70 percent of growth through 2050 in the Standard LDC, consumes more than twice the land of Scenarios C1, which accommodate from 80 percent to 90 percent of new growth in the Compact and Urban LDCs. The C Scenarios include a very low proportion of low-density greenfield growth, focusing instead on infill and redevelopment within existing urban areas and on more compact forms of new growth.

Figure 2-6: Cumulative New Land Consumption to 2050

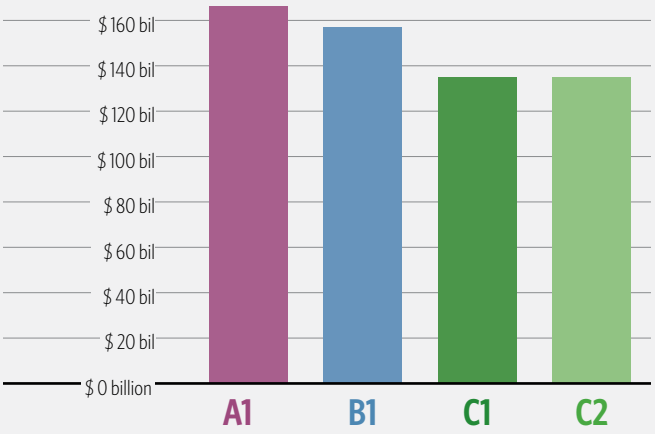


CAPITAL INFRASTRUCTURE COSTS

Increased land consumption leads to higher costs for local and sub-regional infrastructure as new greenfield development requires significant capital investments in new local roads, water and sewer systems, and parks. Conversely, growth focused in existing urban areas takes advantage of existing infrastructure and capitalizes on the efficiencies of providing service to higher concentrations of jobs and housing. When comparing Scenario A1 to Scenarios C1 and C2, local and sub-regional infrastructure cost savings add up to more than $4,000 per new household by 2050—a cumulative savings of more than $18 billion through 2035, and $32 billion through 2050.

Note that the capital infrastructure costs and other fiscal impacts detailed here represent those associated with residential growth only. The rapid fire model does not yet analyze the fiscal impacts of non-residential growth; these would provide a clearer picture of cost variations among land-use patterns. It is expected that the inclusion of non-residential fiscal impacts would compound the cost and revenue differences that have been evidenced between dispersed and compact development patterns.

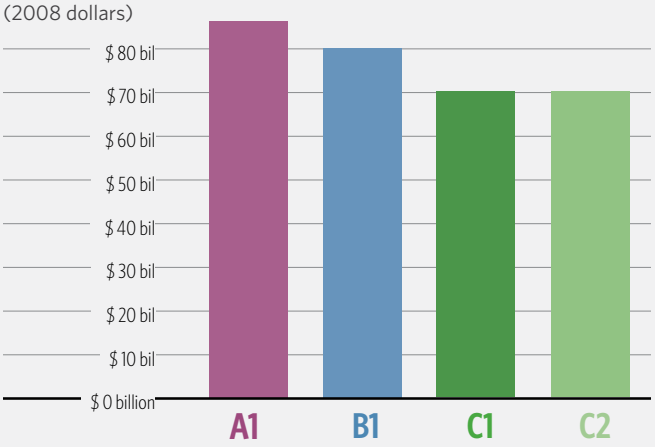
Figure 2-7: Cumulative Capital Infrastructure Costs to 2050 (2008 dollars)



OPERATIONS AND MAINTENANCE COSTS

Operations and maintenance (O&M) costs include the ongoing city general fund expenditures required to operate and maintain the infrastructure serving new residential growth. These engineering and public works costs are strongly linked to the physical form of infrastructure. More dispersed development, which entails greater lengths of roads and sewer pipes, incur higher costs to local jurisdictions than more compact development, which capitalizes on the economic efficiencies of shared infrastructure capacity. When comparing Scenario A1 to Scenarios C1 and C2, local and sub-regional infrastructure cost savings add up to a cumulative savings of more than $6 billion through 2035, and $15 billion through 2050.

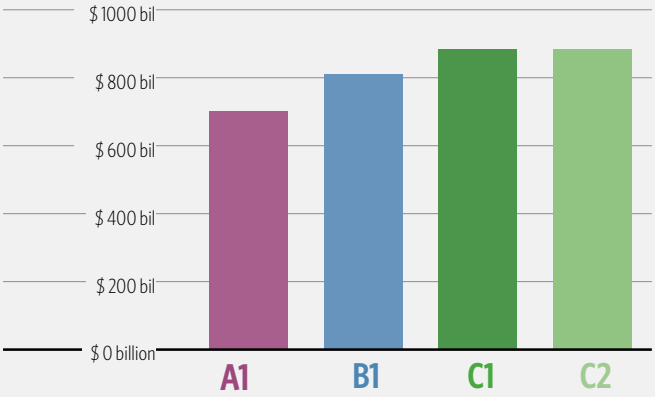
Figure 2-8: Cumulative Operations and Maintenance Costs to 2050 (2008 dollars)



LOCAL REVENUES

The model estimates potential revenues from property and property transfer taxes, sales taxes, and vehicle license fees generated by new housing units. Due to the price premiums of higher-intensity locations, more compact development generates significantly higher local revenues than more dispersed development. This is true on both a per-unit and per-acre basis; by 2050, Scenarios C1 and C2 generate nearly $14,000 more per acre, per year than Scenario A1. Comparing the cumulative revenues of Scenario A1 with Scenarios C1 and C2 demonstrates the magnitude of these benefits: the revenues of Scenarios C1 and C2 add up to an additional $53 billion through 2035, and $120 billion through 2050.

Figure 2-9: Cumulative Local Revenues to 2050 (2008 dollars)



VEHICLES MILES TRAVELED (VMT)

The model calculates VMT by applying assumptions about per-capita annual VMT to population growth. These assumptions, which differ by land development category, are based on research and empirical evidence that per-capita VMT of both incremental (new) population and base year (existing) population vary based on the form of new growth.[20] Moreover, this variation is expected to change over time as areas become either more urban or compact, or more sprawling.

Variations in VMT across the scenarios is a result of year-by-year variation in per capita VMT by the form of new growth, and also the impact of new growth on the travel behavior of those already living in California in the base year. For example, if one is living in an area 20 years from now that has seen increased transit service and/or new retail development in close proximity to their home or workplace, it is likely that they will drive less and walk, bike, or take transit more because daily destinations and services are closer.

It is an *a priori* assumption of the rapid fire model that requisite transportation investments go hand-in-hand with growth patterns, such that scenarios with a greater focus on compact and urban development would see increased transit, bicycle, pedestrian, streetscape, and livability investments. Conversely, scenarios dominated by standard development would see large budget outlays to highway and road expansion.

Scenario results for VMT indicate a wide variation in passenger vehicle use related to the form of new growth. Scenario A1, which accommodates 70 percent of growth in auto-oriented Standard development, see much higher VMT rates than Scenarios B and C. Total annual VMT in the C scenarios is 38 percent lower than that in Scenario A1 in 2050. Average per-capita passenger VMT in 2050 ranges from 9,160 in A1, to 7,850 in B1, to 5,660 in C1 and C2. Note that VMT is determined by the land-use option in a scenario, and is independent of the policy packages selected; C1 and C2, with the same land-use option, result in identical VMT estimates.

Figure 2-10: Total Annual Vehicle Miles Traveled in 2050

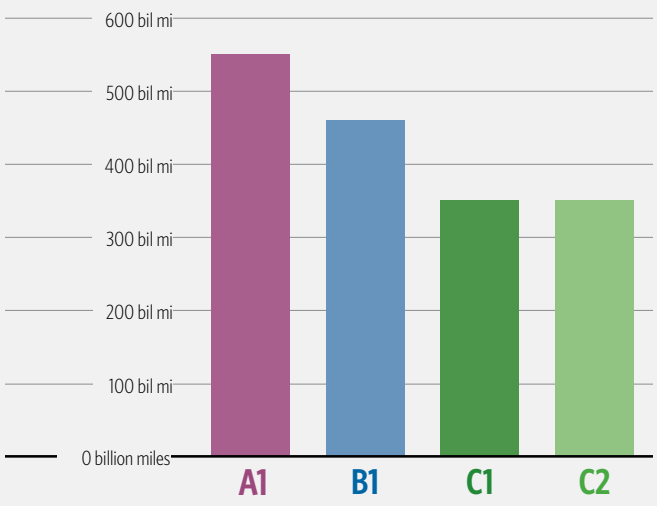
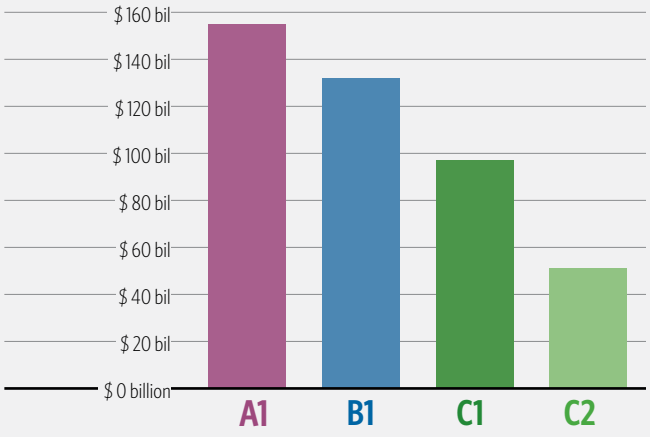


Figure 2-11: Total Annual Fuel Costs in 2050 (2008 Dollars)



AUTOMOBILE FUEL USE AND COST OF DRIVING

Variations in passenger VMT lead to substantial differences in the amount of automobile fuel (gasoline equivalent) used in each of the scenarios. Scenarios A1, B1, and C1, which all include the same modest vehicle fuel economy assumption, show significant differences in fuel use due to land use-related VMT variations. When combined with policy variations for automobile efficiency and fuel cost, the scenarios illustrate the combined impact of land-use and policy packages.

Assuming the more aggressive efficiency standards of the "green" policy set brings auto fuel use in Scenario C2 down further: annual auto fuel use in 2050 is 68 percent lower in C2 than in Scenario A1. Between 2005 and 2050, the savings amount to over 275 billion gallons of fuel.

Reduced VMT and fuel use leads to lower costs for all households in California. When compared to Scenario A1, Scenario C2 saves the average California household more than $9,300 per year in driving-related costs in 2050. Statewide, the savings total $106 billion per year.

GHG EMISSIONS FROM PASSENGER VEHICLES

GHG emissions from passenger vehicles are determined by VMT (which is related to land-use patterns), vehicle fuel economy, and the carbon intensity of automobile fuel. Scenarios A1, B1, and C1, with the same trend-based policy set, reveal the emissions differences among land-use options. Scenario C2 demonstrates the additional impact of adding the green policy package to a Smart Growth future.

Figure 2-12: Cumulative Passenger Vehicle Fuel Consumption to 2050 (gallons gasoline equivalent)

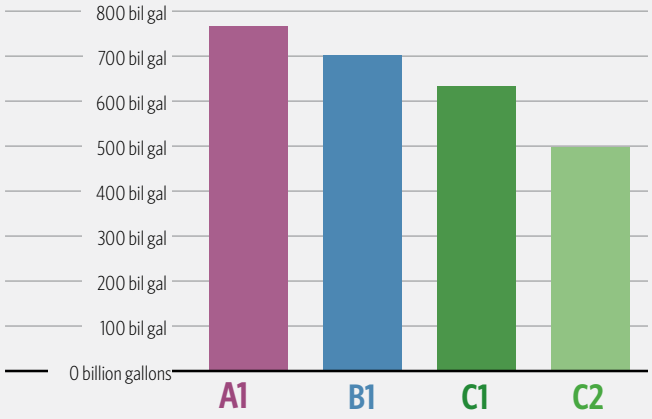


Figure 2-13: Total Annual Transportation GHG Emissions in 2050 (MMT CO2e)

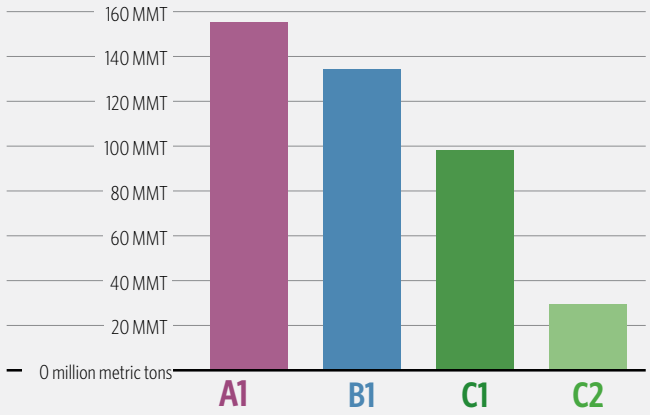


Figure 2-14: Annual Driving Costs per Household*

	2035	2050
A1 BUSINESS AS USUAL	$13,000	$18,200
B1 MIXED GROWTH	$11,300	$15,600
C1 GROWING SMART	$9,200	$11,200
C2 GREEN FUTURE	$8,000	$8,900

* Driving costs include fuel and auto ownership, maintenance, and insurance costs calculated on an average per-mile basis.

AIR POLLUTANT EMISSIONS FROM PASSENGER VEHICLES

Differences in VMT lead to different levels of air pollutants (including nitrogen oxides, carbon monoxide, sulfur dioxide, volatile organic compounds, and particulate matter) among the rapid fire scenarios. The California Air Resources Board assumes that rates of these pollutants will decline over time as vehicle technology improves. With higher VMT, Scenario A1 sees 2035 passenger-vehicle pollutant emissions that are 27 percent higher than emissions in Scenario C2.

Figure 2-15: Total Annual Air Pollutant Emissions

	2005	2035	2050*
A1 BUSINESS AS USUAL	2,525,200 tons	587,200 tons	626,570 tons
B1 MIXED GROWTH	2,525,200 tons	519,770 tons	537,200 tons
C1 GROWING SMART	2,525,200 tons	426,480 tons	387,480 tons
C2 GREEN FUTURE	2,525,200 tons	426,480 tons	387,480 tons

* Air pollutant emission rate assumptions are based on statewide EMFAC projections to 2040, which decline significantly. EMFAC rates for 2040 are assumed for 2050, since pure extrapolation would see pollutant emission rates approach zero.

HEALTH INCIDENCES AND COSTS

Auto-related air pollution results in a spectrum of health incidences, including cases of chronic bronchitis; acute myocardial infarction; respiratory and cardiovascular hospitalizations; respiratory-related ER visits; acute bronchitis; work loss days; premature mortality; asthma exacerbation; and acute lower and upper respiratory symptoms. Health incidences, and their related costs, are reduced along with miles driven. The rapid fire model estimates savings (rather than absolute totals) in health incidences and costs to 2035 according to research-based rates and valuations.[62]

Scenarios C1 and C2 highlight the significant impact of land use on public health impacts. Relative to Scenario A1, they reduce the total number of health incidences by 27 percent, or 142,800 incidences in 2035. In terms of health costs, Scenarios C1 and C2 save 27 percent annually, or $1.9 billion in 2035.

Figure 2-16: Reductions in Total Annual Health Incidences in 2035

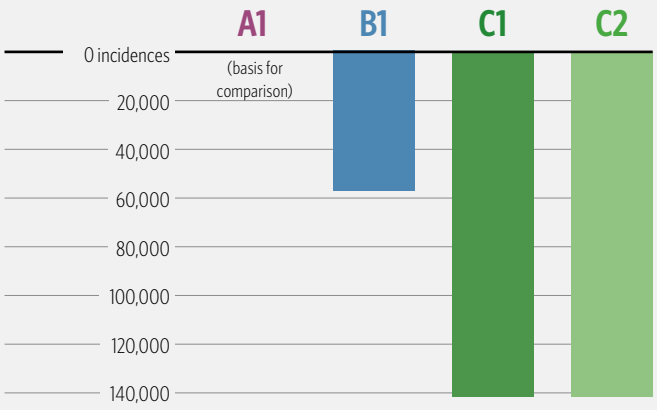
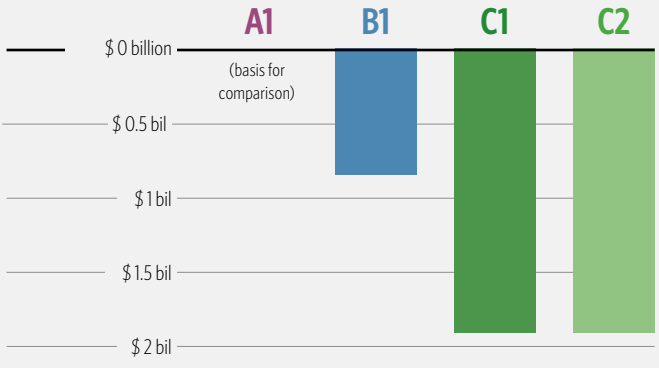


Figure 2-17: Reductions in Total Annual Health Costs in 2035 (2009 dollars)



ENERGY CONSUMPTION, COST, AND EMISSIONS

The rapid fire model calculates building energy use for the base/existing population (residential and commercial buildings already built by the 2005 baseline year) and for the growth increment (new buildings built during the time span of the model). To estimate energy use for base/existing buildings, the model assumes rates of building retrofits, upgrades, and replacement. For new buildings, the model assumes that, year-upon-year, new construction will be built to meet higher efficiency standards. Energy use varies by building type and according to changing policies for building efficiency .

The smart land use of Scenario C1 brings energy use in 2050 to 15 percent lower than that of Scenario A1, which has the same policy assumptions but a more sprawling, trend-based land pattern. Applying green building and energy policies in Scenario C2 increases this annual difference to 43 percent.

The cumulative residential cost savings to 2050 amount to more than $225 billion, or approximately $6.4 billion per year in 2035, and $15 billion in 2050. Greenhouse gas emissions generally track energy use, with the most substantial reductions seen in scenarios that combine smarter land patterns and green building and energy policies.

Figure 2-18: Annual Residential and Commercial Building Energy Use in 2050 (Btu)

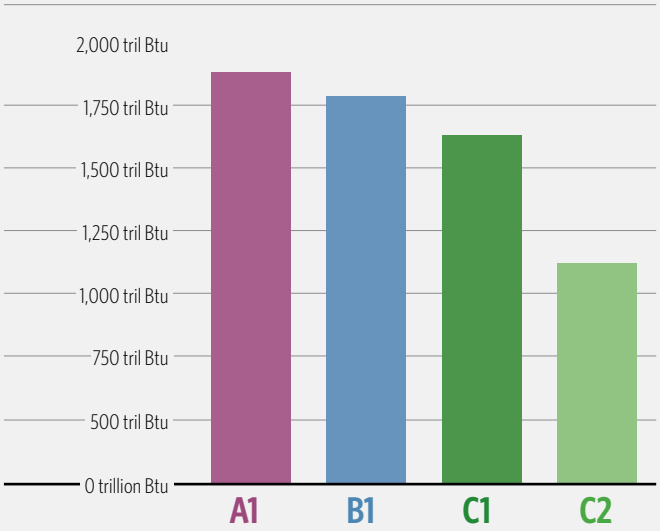


Figure 2-19: Total Annual Residential and Commercial Building Energy CO2e Emissions in 2050 (MMT CO2e)

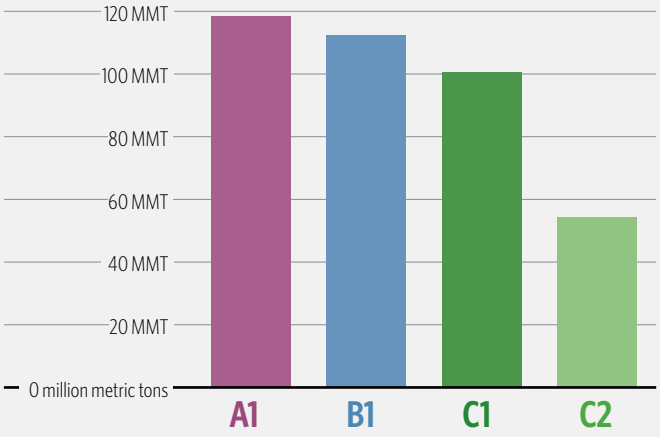
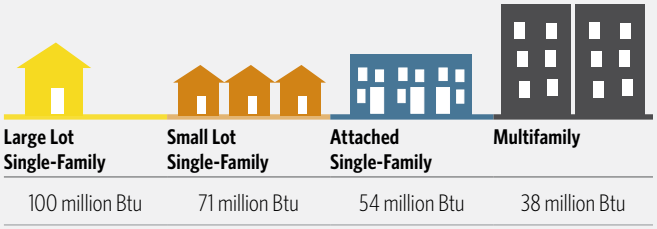


Figure 2-20: Baseline Annual Household Energy Use by Building Type*



Large Lot Single-Family	Small Lot Single-Family	Attached Single-Family	Multifamily
100 million Btu	71 million Btu	54 million Btu	38 million Btu

* Includes residential electricity and natural gas use. Statewide baseline average consumption data derived from California Energy Commission Statewide Residential Appliance Saturation Survey (RASS), 2004.

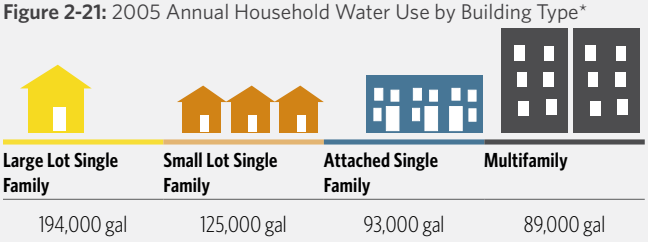
RESIDENTIAL WATER USE

The building program and policy variations among the Vision California rapid fire scenarios lead to significant differences in water use and cost. Residential water use is a function of both indoor and outdoor water needs, with outdoor use (landscape irrigation) accounting for the majority of the difference among housing types. Because homes with larger yards require more water for landscape irrigation, lot size is generally correlated with a household's overall water consumption. Thus, scenarios with a greater proportion of the Standard land development category, which includes primarily large-lot single-family homes, require more water than scenarios with a greater proportion of Compact or Urban areas, which include more attached and multifamily homes.

Residential water use in Scenario C1, with smart land-use and trend policies, is almost 10 percent lower than that of A1, with its more dispersed land pattern. Residential water use in Scenario C2, with both smart land-use and green policies, is over 40 percent lower than that of A1. The difference in cumulative water use between A1 and C2 amounts to nearly 78 million acre feet by 2050. The average household uses 40,000 gallons less per year by 2035, and 55,000 gallons less per year by 2050. Cumulative cost savings to 2050 amount to more than $96 billion. Total water use in Scenario C2 costs $5 billion less per year in 2050.

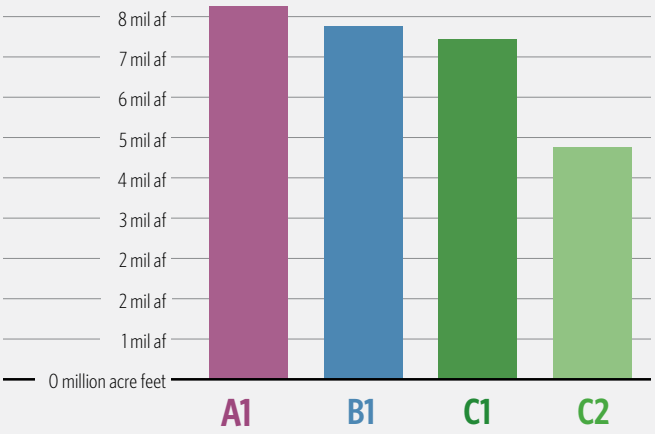
Water-related GHG emissions result from two main categories of energy use: a) system uses, including the transport, treatment, and distribution of water consumed; and b) end uses, including all uses of water that occur within homes (e.g., water heating).[63] Total emissions for Scenario C2 are 64 percent lower than A1 in 2050, a significant knock-on effect of saving water.

Figure 2-21: 2005 Annual Household Water Use by Building Type*



* Statewide baseline average consumption figures include indoor and outdoor water use. Indoor use is based on per-capita averages; outdoor use is based on generalized assumptions about landscape area and irrigation requirements.

Figure 2-22: Total Annual Residential Water Use in 2050



GREENHOUSE GAS EMISSIONS FROM TRANSPORTATION AND BUILDINGS

Total GHG emissions for the scenarios—including those from passenger vehicles, and emissions associated with residential and commercial building energy consumption—vary greatly across scenarios ddue to differences in land use and policy. Scenario A1, with its business-as-usual land use pattern and policy set, sees the highest total GHGs from both buildings and transportation. Scenarios B1 and C1, with the same trend policy set, highlight the impact of land-use patterns in total greenhouse gas emissions savings from buildings and transportation with aggressive increases in building conservation policies or vehicle millage standards. Scenario C1, with only its more efficient land use pattern, produces 20 percent fewer GHG emissions than A1. Scenario C2, which adds green policies, is able to further reduce total GHG emissions by 70 percent. This combination of strategies brings the state close to its Kyoto target.

Figure 2-23: Total Annual Transportation and Building Energy GHG Emissions in 2050 (MMT CO2e)

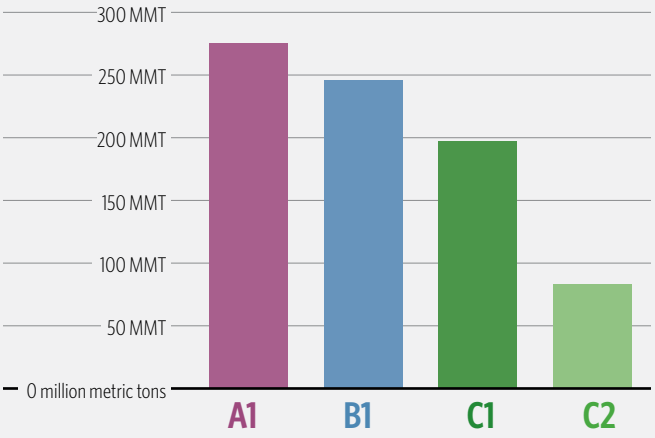


Figure 2-24: Total Annual GHG Emissions from Transportation and Buildings (MMT CO2e)

	2005	2035	2050
A1 BUSINESS AS USUAL	247 MMT	250 MMT (1%)	274 MMT (11%)
B1 MIXED GROWTH	247 MMT	230 MMT (- 7%)	246 MMT (- 0.4%)
C1 GROWING SMART	247 MMT	201 MMT (- 19%)	198 MMT (- 20%)
C2 GREEN FUTURE	247 MMT	128 MMT (- 48%)	83 MMT (- 66%)

HOUSEHOLD EXPENDITURES AND INFRASTRUCTURE COSTS

The total cost burden for the four Vision California rapid fire scenarios varies along with the resource consumption of each of the scenarios. Infrastructure costs, as well as household transportation, energy, and water costs, are much higher in scenarios with greater land consumption, higher VMT, and building programs that rely more on larger lot single family construction. Thus, Scenario A when compared to Scenario C1 reduces accumulative costs more than $2.6 trillion by 2050. Adding the green policies in Scenario C2 extends these savings to more than $4 trillion by 2050.

Breaking costs down to the household level exposes the impact of land use and policy choices on California households pocketbooks. Households in Scenario C2 save an average of $10,450 per annum over the trend future. This doesn't include the savings on local infrastructure cost burdens, which are typically passed on to homeowners and renters in the form of taxes, fees, home prices, and assessments. A key issue for the state is housing affordability, which the study demonstrates could be cut in half by Smart Growth combined with green policies.

Figure 2-25: Total Costs per Household in 2050 (2008 dollars)

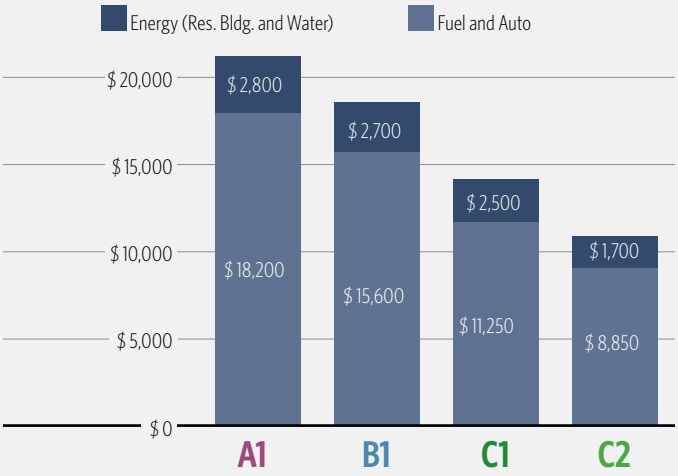


Figure 2-26: Average Annual Household Expenditures: Fuel and Auto Costs, Residential Electricity, Gas, and Water

	2035	2050
A1 BUSINESS AS USUAL	$15,500	$21,000
B1 MIXED GROWTH	$13,800	$18,300
C1 GROWING SMART	$11,500	$13,750
C2 GREEN FUTURE	$9,900	$10,550

SUMMARY OF CARBON SAVINGS

The chart below summarizes how land-use and specific green policy options contribute to GHG emission savings in California by 2050. The bottom set of bars represents emissions from passenger vehicle transportation, while the top set represents emissions from residential and commercial energy use. Moving from left to right, each column applies one additional land-use change or policy based on the scenario options outlined in this report. Overall, the results make it evident that meeting Assembly Bill 32's goal of reducing GHG emissions to 80 percent below 1990 requires comprehensive and progressive land-use action, as well as policy moves across multiple sectors and agencies throughout the state.

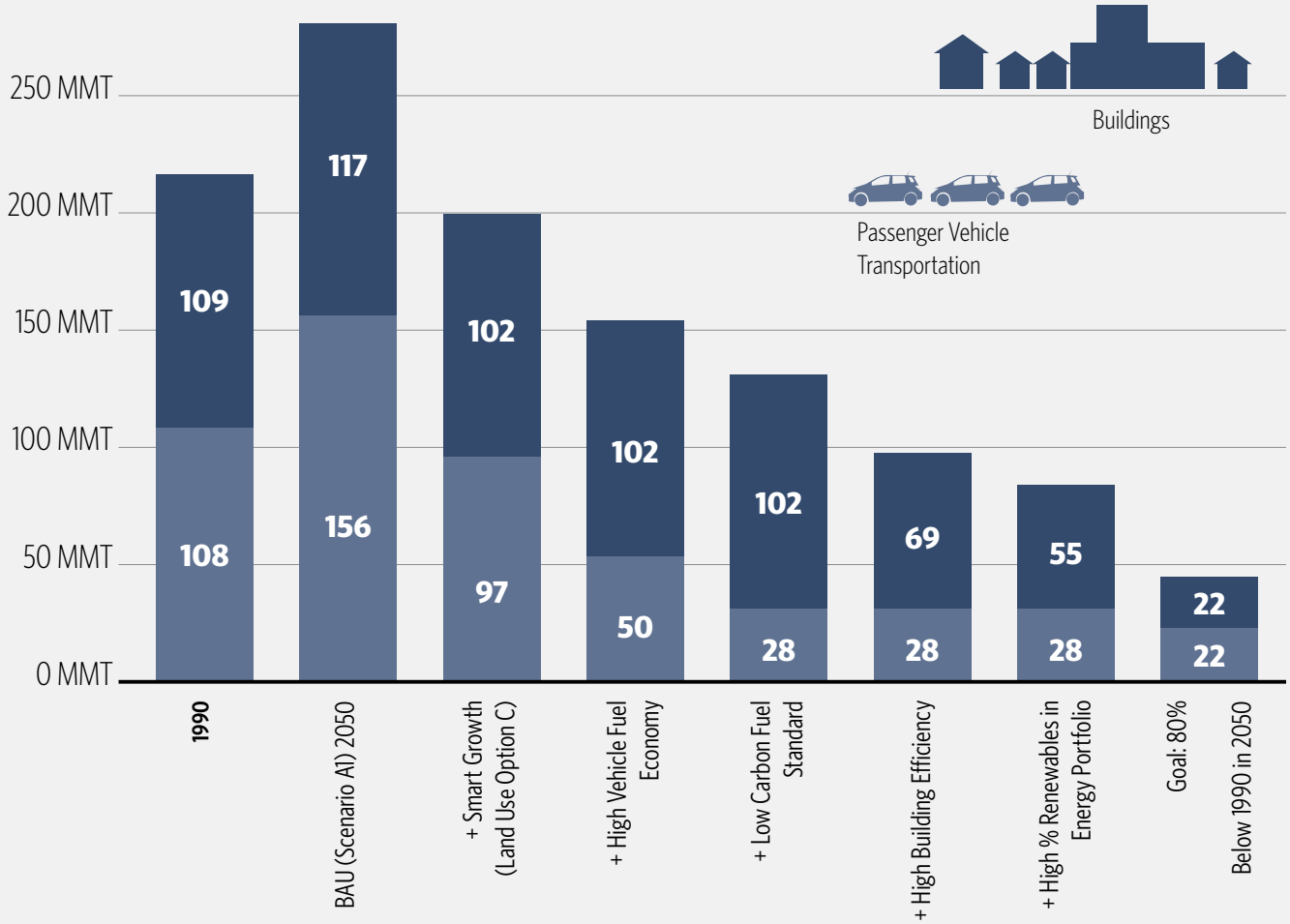


Figure 2-27: Summary of Carbon Savings

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03 High-Density Sprawl

www.pikrepo.com/fboit/shanghai-aerial-photo-of-buildings-at-daytime

03

High-Density Sprawl

In 2009, China surpassed the United States as the world's largest car market. By 2025, the country will need to pave up to an estimated 5 billion square meters of road just to keep moving.

Of the three types of sprawl infecting global growth, high-density sprawl, found mainly in China and parts of Asia, is unique, ironic, and tragic. Density alone does not characterize the kind of urbanism defined by sustainable development standards. It is more about connections, human-scale, walkability and mixed-use than it is about gross density. China's pattern of gated 'superblocks' and isolated uses is a variation on the failed American urban renewal projects of the 1950s and 1960s or the modernist new towns around Paris; in many ways, it is a high-rise version of the American suburb. Single-use residential blocks of largely identical units are clustered in superblocks surrounded by major roads every quarter mile just as cul de sac subdivisions are surrounded by a one-mile grid of arterials in Western nations.

Vast distances separate everyday destinations and create environments hostile to pedestrians. Sidewalks are rarely lined with useful services and street crossing are death-defying. Job centers are distant and commutes grow longer—especially for lower income groups. In major Chinese cities, the gridlock grows to all hours of the day. The simple truth is that an auto-based city, even at low densities, cannot work. At the scale of China's development and density it is impossible, no matter how may freeways and ring roads are built.

By 2018, China's expressway network reached 140,000 kilometers (87,000 miles). In 2018 alone, 6,000 kilometers (3,700 miles) of national expressways and 20,000 kilometers (12,427 miles) of provincial highways were built.[1] China surpassed the US highway infrastructure in 2011,[2] and built it at a pace four times faster than the United States built its interstate highway system. Over 12 years, the number of cars on Chinese roads grew tenfold, from over 18 million in 2005, to 185 million in 2017,[3] and China surpassed the United States as the world's largest car market in 2009.[4] By 2025, the country will need to pave up to an estimated five billion square meters of road just to keep moving.[5] With this growth

has come gridlock and poisoned air. Unfortunately, much of what China is building was based on outdated Western planning models that put cars at the center of urban life rather than people. And the bill will be paid in the form of larger waistlines, reduced quality of life, choking pollution and congestion—not to mention carbon emissions.

Like the US cities of the 1950s and 1960s, Chinese cities are working to accommodate the explosive growth of automobile travel by building more highways, ring roads, and parking lots. If anything, due to China's high population density, the Chinese mobility challenge will be even more severe than America's. Already, traffic in Beijing is frequently at a standstill despite the incredible pace of road construction. The situation is so dire that Beijing, Guangzhou, and Shanghai are using a lottery to allocate a limited number of vehicle registrations. In August 2010, a 60-mile traffic jam stopped a highway outside Beijing for 11 days. There's a reason no high-density city has ever been designed around the car: It simply doesn't work.

As Beijing orders up ever more freeways and parking lots, walking, biking, and public transit are declining. Since 1986, auto use has increased sixfold in Beijing, while bike use has dropped from over 60 percent of trips to just 14 percent in 2014.[6] The congestion, air quality, and greenhouse gas impacts of this shift have been massive: Beijing remains one of the world's most polluted major cities. Merely to ensure blue skies during the 2008 Olympics, the city spent some $17 billion restricting traffic and shutting down factories; it even employed 50,000 people to fire silver iodide at clouds to release rain.

Across China, injuries to drivers, pedestrians, and bikers are on the rise. Approximately 260,000 people die in China as a result of road accidents each year and around six in 10 of the total estimated deaths are vulnerable road users such as pedestrians, cyclists, and people on motorcycles, according to 2016 World Health Organization (WHO) estimates.[7] From 1992 to 2004, the bicycle-related mortality rate increased 99 percent in Shanghai, the municipal government found. According to a WHO report published in 2015, 716 people die each day in traffic collisions in China, the world's highest rate, and traffic accidents are the leading cause of death for people under age 45.[8] The underlying reason for these trends is no mystery.

For many cities in China, rapid growth and a steady increase in automobile ownership have become key factors in increasing traffic congestion. In 1998, the total number of automobiles in Beijing was about 1.1 million or one vehicle for every 11.3 residents. In 2003, the total number of automobiles in Beijing was about 2 million or one vehicle for every 7.3 residents. In 2017, the number of automobiles in Beijing totaled 5.9 million[9] or one vehicle for every four residents.[10] The increase in automobiles in this city has far exceeded the growth in residents over the last decade or so, and Beijing is now reaching the vehicle ratios of New York City[11] or the United States, which averages one vehicle for every two people.[12]

The decline of biking in China is directly correlated with the rise of cars and a street design that allowed automobiles to dominate the roads. During the 1960s and 1970s, bicycles were the most popular product in China—they were even given as wedding presents. (The Chinese government gifted two bicycles to President George H.W. Bush in 1986.) From 1995 to 2005, bicycle use in China declined by 35 percent, from 670 million to 435 million. During the same period, private car ownership doubled from 4.2 million to 8.9 million. In the past decade, the Chinese government has made significant strides to revitalize the public's appetite for biking. China now boasts the biggest and highest number of municipal bike-sharing programs compared to other countries in the world, and dockless bike-sharing app-based providers offer 20 million bikes in cities across the country.[13]

Despite this revitalized interest in biking, street design and biking infrastructure have not caught up. Moreover, much of

the street design that is dedicated for traditional bicycles is now out of date due to the rise of electric bikes and e-bikes. There are now over 200 million electric bikes in China[14] and only 170 million private vehicles.[15] However, cars still get the majority of the road space. With the declining prices of e-bikes and their ability to avoid a lot of congestion, e-bikes are being used for many trips previously completed by traditional bicycles. Local governments in China must innovate on new ways to incorporate this new transit mode into their planning practices.

Traffic accidents in China are also a significant problem. Better and more human-scaled street design can have a major impact on decreasing traffic fatalities. According to the World Health Organization, over 250,000 traffic deaths occur in China each year.[16] Worldwide, traffic accidents are the leading cause of death for people aged 15 to 29.[17] This highlights the importance of designing streets that are safe for pedestrians and bikers; traffic speeds must be decreased, sidewalk crossings must be buffered with safety features, and cities should also consider adding more greenways and roads that are only for bikes and pedestrians.

Finally, the financial cost of congestion in China is enormous. According to the 2010 Statistical Yearbook, the cost of traffic congestion for Beijing was calculated to be 58 billion renminbi (RMB), which is about 4.22 percent of GDP.[18] In 2014, a study conducted by Peking University's National Development Research Institute calculated the total cost of congestion to be 70 billion RMB, a 20 percent increase from the cost calculated in 2010.[19]

If a budding American-style love of cars provided the impetus for China's urban reinvention, Swiss architect Charles Édouard Jeanneret supplied the intellectual inspiration. Better known as Le Corbusier, Jeanneret's vision of isolated modernist towers soaring above orderly streets below left an indelible mark on the field of urban planning before his death in 1965. To Le Corbusier, the organically developed cities of his era, with their row houses and street-level retail, were messy, blighted, and inhumane. (He called New York "a catastrophe" and proposed replacing its ragged skyline with enormous "Cartesian skyscrapers.") To Jane Jacobs, his American urbanist counterpoint, Le Corbusier's vision of the city was "like a mechanical toy," but one based on "nothing but lies." Still, his ideas proved irresistible to a generation of planners struggling to redesign American cities, Soviet housing policies, and Chinese cities.

Le Corbusier's weapon of mass urban destruction was the superblock, laid out in his utopian 1935 manifesto *La Ville Radieuse*—a form China's efficiency-minded traffic engineers have wholeheartedly embraced. Based on a network of wide arterial streets, China's superblocks feature large, single-use development areas, often more than a quarter-mile per side and designed like barracks, inconveniently located far from workplaces and shopping centers.

The goal was to move cars efficiently and produce massive quantities of housing quickly—people seemed an afterthought. The ironic result is an alienating landscape that makes walking and biking difficult, which in turn increases congestion on the streets and comes with attendant social and environmental costs. Culturally, it's a tragedy for Chinese cities, which are seeing traditional neighborhoods where friends and family could easily visit for tea and conversation or walk to local shopping streets, destroyed by misguided development. Now people have to take a crowded bus or, if they're lucky, a car to generic malls and office complexes.

The congestion will only get worse. Almost 74 percent of the total population in China will live in urban areas by 2035, up from 49 percent in 2010, according to United Nation's data; at that time, more than 173 Chinese cities will have more

than 1 million people.[20] Transportation already accounts for 61 percent of China's energy consumption, according to the U.S Government Department of Energy, and will increase on average by 2.7 percent per year until to 2040.[21]

The figures are daunting. But the engineers who run the Chinese ship-of-state are nothing if not good at math, and they have committed to making real changes—building mass-transit systems, introducing alternative fuels such as ethanol, and promoting fuel efficiency and electric cars. There are still other things Chinese cities can do at the margins, such as introducing the sorts of "congestion pricing" schemes—taxes on vehicles as they enter certain areas—that have worked wonders in places like London and Singapore.

It might seem strange to think that a budding superpower must make shorter commutes, public transport, walking, and bicycling its top priorities. But unless it does, China's powerful economic engines—its cities—will slowly grind to a halt. The good news is that the central government has adopted a set of urban design standards based on the principles articulated here. They recognize that speed of development must give way to quality of development and are agressively pursuing a new direction established in 2017.

SUPERBLOCKS AND MOBILITY

The problem is not just the increase in cars throughout China, it is the nature of their standards for road networks as well as the prevailing urban design paradigm. The current urban pattern in China is an unholy alliance of superblocks and their natural result: oversized arterials. This pattern not only frustrates pedestrians and bikers, it fails for cars as well. An arterial system of wide streets every 400 to 500 meters creates a hostile environment for pedestrians and bicyclists. Wider streets lead to increased crossing distances, increase distances to intersections for pedestrians, higher traffic concentrations on fewer roads, few alternative routes for emergencies, and complex traffic movement at intersections that slow cars, threaten pedestrian and bicycle safety. Drivers are inconvenienced because of more circuitous routes when mid-block left-turning movements are disallowed and intersections are overloaded. Often with few entrances, superblocks add to the circuitous access routes for cars as well as pedestrians.

Figure 3-1: *Superblock development in China. (Source: HDR | Calthorpe)*

The list goes on. Due to lack of parallel roadway capacity, traffic dispersal is limited and loads on big arterials quickly back up. For the same reason, traffic management due to an event or accident is much more difficult with fewer alternative paths to re-route traffic. Increased congestion along conventional boulevards also negatively affects bus transit performance. Finally, large two-way streets with extended spacing between intersections reduce the effectiveness of signal coordination and traffic flow efficiency along corridors.

The alternate is a more traditional city grid of streets with higher intersection density and a broader range of street types. In this tried-and-true street network, high volumes of through-traffic are dispersed over parallel and smaller roads or onto one-way pairs. Pedestrian and bike zones can be protected and enhanced on all streets. Transit lines and BRT systems can gain dedicated lanes and auto-free streets enhance alternate modes.

Figure 3-2: Illustrative diagrams depicting the urban form of superblocks (left) and walkable development (right). The diagrams are at the same scale. (Source: HDR | Calthorpe)

Such a street network creates a radically different urban landscape, one that replaces China's isolated superblocks with small courtyard blocks. Streets are the DNA of a city; their scale and how they mix public spaces, shops, pedestrians, bikes, transit and cars is critical to the health of a city.

The use of 'small blocks'—a result of a more diverse and fine-grained street network—is a radical departure from the superblock pattern prevalent in most of China. It is also an essential element of good urban design. In contrast to the superblock system, small blocks create a human-scaled environment, a network of public spaces around the blocks, and easily allows a greater land-use mix in a smaller area. This generates social, economic, and environmental advantages.

With small block zoning, urban design focuses on creating lively and walkable street frontages that are typically missing from development in China. Each block has a central private courtyard in residential blocks and a public courtyard in commercial blocks. This courtyard pattern recalls the historic city forms throughout China from the Hutong to the Palace. It emerges here in a different form, but provides the same urban layering—from public street to courtyard to private home.

In small blocks, building heights can respect building separation requirements typical in China while creating a more varied skyline. In a small block, buildings naturally change more frequently with orientation and placement. Each block can contain a variety of building configurations dependent on solar orientation and street frontage. For example, buildings on east-west streets can be taller to maximize south-facing units and proportional in spacing to the next set of buildings. Buildings on north-south streets without good solar orientation can be lower in height, with non-residential uses mixed in.

Within the block itself, small blocks have several advantages over superblocks. First, the social scale is socially convivial. The typical small block should have dimensions of approximately 100 to 200 meters per side, with a block area of 1 to 1.5 hectares. This area will result in 400 to 700 dwellings, housing about 1,500 people. This number is small enough for most people to recognize one another and establish strong social connections. In contrast, superblocks can contain up to 15,000 people, a scale in which many people become anonymous and children are more frequently exposed to strangers.

Second, the common courtyard area is directly visible and accessible to all the housing units. In fact, in most cases all the units have a street view and a courtyard view along with cross-ventilation. This makes the common area more visible, safer, and more community-focused. In the superblock configurations, many units are placed in parallel rows with no visual or direct connection to common open space areas.

Finally, small blocks increase the opportunity for street-side shops and local services. For residential developments, each building would front a secure internal courtyard and open space as well as a public street. As most buildings are sited at the perimeter of the block, the ground floor naturally provides for valuable commercial and civic opportunities that enhance the street life of the surrounding neighborhood. Therefore, few dwelling units have to be located on the ground floor, whch is an undesirable living location for most.

The mixed-use quality of a neighborhood or district is achieved by mixing different small blocks side by side. In small block zoning, there is a range of residential small blocks and commercial small blocks, each varied by density and the range of uses. Most buildings in the blocks, rather than simple residential slabs and towers, are a mix of either residential units over shops and commercial uses or office buildings over shops and multi-story retail. Some blocks allow more mixed building types such as high-rises that combine residential or hotel uses over commercial multi-story bases. Typically, though, the ground floor is sidewalk-related shops and commercial uses, while the upper stories are either dwelling units or office space. The street-level shops unify the pedestrian environment while the floors above provide a balance of housing and jobs for the district.

Overall, small block zoning creates development that is more varied and human-scaled while allowing smaller developers to participate in city building. At the same time, multiple blocks can be combined to accommodate larger development plans. In either case, the urban pattern is more varied, walkable and human-scaled. It is the most fundamental building block of sustainable development.

AN EMERGING CONSENSUS

Many Chinese officials, including at the highest levels, recognize the need to move beyond the automobile. Planners and local politicians understand that their country is on a collision course with Mother Nature. Qiu Baoxing, past vice minister of housing and urban-rural development, as well as the author of several books on ecology and urban development, claims that reducing auto dependence and enhancing transit and walkable neighborhoods are the keys to China's urban future. In 2017, China's State Council issued its first revision of urban design standards in 27 years, which in essence reflect the sustainable development standards presented in this book.

In light of economic, environmental, and socio-cultural challenges, the central government has begun to push forward policies and directives that are guiding the country to a better path. In 2014, China released the National New Urbanization Plan (2014–2020) that promoted "people-centered" development as the core strategy for China's future urban development trajectory.[22] This plan provides specific quantitative targets for a variety of aspects, including public transportation, renewable energy consumption, and access to public services.

The Central Urban Work Conference held in December 2015 brought together top central government leaders including President Xi Jinping and Premier Li Keqiang. This conference had not met for 37 years and, in an unprecedented move, China embraced a new approach to urban development called the "New Normal." At this conference, the State Council and the Communist Party's Central Committee, the highest levels of authority in China, issued a directive that all future urban development must feature dense road networks, small blocks, and other sustainable urban design principles. The new guidelines prioritize walking, biking, and public transit and require cities to grow within the limits of their natural resources.

The guidelines also set an important precedent with promoting "people-centered urbanization," which is also the underlying theme of the principles described later in this book. In fact, the directives in the New Normal are consonant with these sustainable development dtandards. The New Urbanization Plan sets an important precedent with promoting "people-centered urbanization," which is also the underlying theme of the design principles defined in these pages. The new directive from the Central Urban Work Conference emphasizes using remote sensing technologies to enforce urban growth boundaries as outlined in our first principle, Planning for Growth, Resilience, and Preservation. Beyond the physical boundary, the directive also mandates preservation of historical and cultural character, which we also illustrate as a major component of preservation.

It directs cities to optimize public transit so that the mode share of large and mega-cities for public transit reaches 40 percent and that all residents live within 500 meters of transit in urban centers, which is consistent with our third and fourth principles, Enhance Shared Mobility and Transit and Build Transit-Oriented Developments.

Public amenities are also a key component of the new directive, which covers our fifth principle, Mix Uses and Users, and it encourages construction of schools, supermarkets, retirement centers, and cultural centers within walking distance of housing.

Dramatically, the State Council requires the elimination of new superblock development and even calls for existing gated superblocks to be opened up with pedestrian and public access. This is the basis of the sixth principle, Create Human-Scale Streets and Small Blocks. Through this directive, the State Council is also explicit that cities must have "narrow roads [and a] dense road network" which departs from the wide boulevards and superblocks that dominated urban planning in high-density cities like those developed in China. This is also consistent with our seventh principle, Design for Walking and Biking. The directive mandates cities to improve walking and biking networks in addition to advocating transit-only lanes and better parking management.

Public squares, parks, and public activity spaces are also listed as distinct and important types of public space for cities to construct, which Reserve Open Lands and Public Space, our second principle covers in detail. Green buildings are called for with directives to build durable, energy-efficient buildings with state-of-the-art water and waste systems. The directive also calls for simple, functional and well built architecture.

Finally, sustainable infrastructure is mentioned in the directive's policies to expand Sponge City development, which is focused on water re-use and water efficiency technologies. The directive also promotes building energy efficiency technology, heat re-use technologies, green lighting, metering, and building construction quality.

These two directives, along with the increasing momentum built by China's interest and pilot projects in models such as eco-cities, garden cities, smart cities, and low-carbon cities, shows that a consensus is emerging on what new goals cities should set for their development patterns. The remaining challenge will be how Chinese cities can adopt these principles and put them into practice.

The following three case studies for Chongqing demonstrates the outcomes of applying the sustainable design standards at telescoping scales: regional, district, and community. At the largest scale, it shows how the standards function to balance jobs and housing within a framework of environmental preservation and transit accessibility. The plan for Liangjiang, a critical growth area within the larger regional framework, demonstrates how transit and open-space corridors shape community planning and the distribution of density and land-use types. And, finally, the example of Yuelai, a transit-oriented development (TOD) within the growth area shows how the detail of small blocks, human-scaled streets, mixed-use, and transit station areas all come together.

CASE STUDY

Chongqing Smart Growth

Planning at Three Scales:
Region, District, and Community

With a population of nearly 34 million and an area of 824,000 square kilometers^2, Chongqing municipality is one of the largest provinces in the world. Located in the southwest of inland China, it is strategically positioned as a gateway to China's west, a key connection in the Yangtze River Economic Belt, and a strategic base for China's Belt and Road Initiative. Administratively, it is equivalent to Beijing, Shanghai, and Tianjin in its status as a provisional city that reports directly to the central government.

Figure 3-3: Chongqing municipality located in the southwest of inland China (This diagram and all other charts, diagrams and illustrations in this case study first appeared in "Chongqing 2035 : Urban Growth Scenarios," World Bank, 2019)

In two decades, Chongqing has made an extraordinary transformation, growing its GDP per capita by 16 times between 1996 and 2016, and seeing its urban population rise from 29.5 percent to 62.6 percent of total inhabitants in the area. The city's formerly agricultural and heavy industry-based economy is now more economically balanced, with the secondary and tertiary sectors contributing to 44.2 percent and 48.4 percent of GDP, respectively. Today's Chongqing is the largest automobile and motorcycle manufacturing base in China and produces one-third of the world's laptops and 90 percent of the world's IT network terminals.

Chongqing's growth in the past 20 years reflects China's own development trajectory. As China enters a new growth era, however, it has moved away from pursuing GDP growth targets and is instead focusing on a model of development that emphasizes sustainability and a high quality of growth. Cities like Chongqing play a critical role in China's new engine for growth, offering an opportunity for a new modality of urban development that aims for quality, equality, and sustainability.

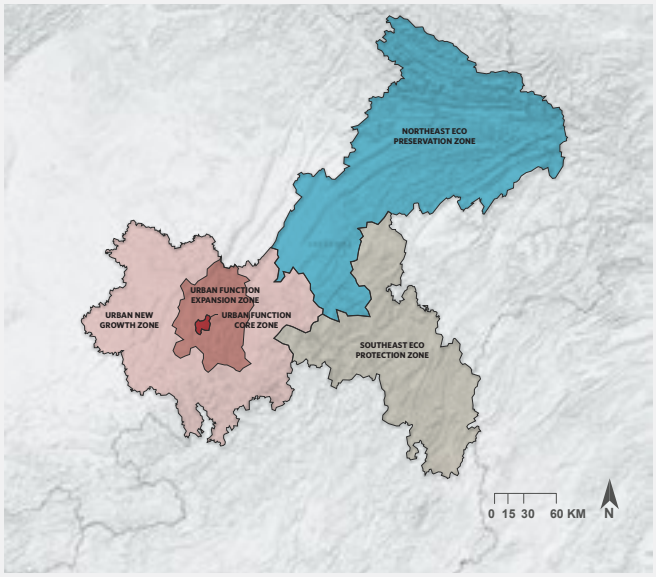

Figure 3-4: Functional zones within Chongqing municipality. The study covers the areas in red and orange.

Figure 3-5: The Chongqing central study area with location designations and district boundaries

REGIONAL PLAN SCENARIOS

The World Bank sponsored and published a growth study for the regional center of Chongqing province.[23] With an urban area of approximately 5,500km² with a population of 7.4 million, the central city itself functions as an interconnected metropolitan area, the geographic extent and transportation infrastructure of which are comparable to other metropolitan "regions." The outlying areas of Chongqing municipality will see significant growth and are subject to the challenges posed by dispersed development patterns..

For the purposes of scenario definition and analysis, the city was divided into three subareas—Core, Core-Adjacent, and Extension—identified based on the extent of Chongqing's existing development and its mountainous topography. The Core corresponds to the highly built-up historic urban center of Chongqing; the Core-Adjacent areas directly adjoin the Core and are bounded by the ridgelines to the east and west; and the Extension areas lie beyond largely as isolated satellite communities.

These three plans for Chongqing represent the telescoping nature of the sustainable development standards (SDSs). At the regional scale, primary decisions about the nature of the metropolis are made. Will it have satellite communities and a polycentric character? How should the differing job and industry types be distributed? What are the significant environmental and landscape features? What modes and connections should weave the region together? And perhaps, most important, what is the economic and cultural role of the metropolis in relation to its surrounding cities and the country at large?

At the district scale, the sustainable design standards help define a development pattern that reinforces the best environmental and livability outcomes. A transit-based land-use pattern will help provide equitable access to economic activity, better air quality outcomes, and less congestion. Locally, human-scaled blocks, mixed-use, and walkable neighborhoods support more livable and socially coherent lifestyles.

The three scales nest in one another and ultimately reinforce a more humane and sustainable city. This, then, represents best practice in creating alternates to sprawl in the high-density cities of China and other parts of the developing world.

TREND AND COMPACT GROWTH SCENARIOS

The Chongqing 2035 land-use scenarios in the study were created to highlight the differences between a status quo growth pattern and growth reflective of the SDS. The scenarios account for the same amount of growth—5.8 million people and four million jobs—roughly constituting a 78 percent increase over current population and jobs in the central city.

THE TREND SCENARIO represents the future as an extension of the past, with more isolated land uses in superblock configurations spreading outward from the Core. It stands as a "status quo" representation of the kind of development that will take place by default if regional policy development, coordination, or implementation efforts fall short.

THE COMPACT GROWTH SCENARIO is driven by a need to contain urban expansion and grow as a much more compact city. Compared to the rate of development in Chongqing municipality from 2005 to 2015, during which the average rate of additional land consumption per new inhabitant was 139m², the Compact Growth scenario consumes less than half as much land. Focusing growth in walkable, mixed-use centers largely accessible by transit makes best use of the land capacity and maximizes the investments made in transit infrastructure.

The scenarios also vary significantly in where new housing and jobs growth occurs. The Trend scenario continues to locate new jobs in the Core, reflecting a monocentric employment focus for higher-level services employment. Housing, meanwhile, is allowed to grow in the Core-Adjacent and distant Extension areas, exacerbating a jobs/housing imbalance that increases long in-commutes and inefficiencies of infrastructure provision.

By contrast, the Compact Growth scenario represents a polycentric urban structure that adds fewer jobs to the Core and instead steers them to the Core-Adjacent area to anchor new mixed-use TOD centers. Fostering the growth of employment clusters outside the existing Core area—largely in the Core-Adjacent area—will help Chongqing achieve better local jobs/housing balance, alleviating the negative impacts and inefficiencies of a monocentric pattern. Accordingly, the Compact Growth scenario also locates the majority of new housing in the Core-Adjacent area and limits the amount of housing in Extension areas.

The plans and patterns represented by the Trend and Compact Growth scenarios contribute to substantially different spatial structures for the central city that determine how people move around, how efficiently economic activity is supported, and how livable the region will be. The Trend scenario locates most new homes and jobs in superblocks, while the Compact Growth scenario locates most in walkable places of varying densities.

Key Scenario Results for the two scenarios were analyzed for their performance using a modified version of the UrbanFootprint model focused on a range of indicators tied to the city's goals to become more environmentally sustainable, economically competitive, socially inclusive, and culturally rich. Scenario metrics include measurements for land consumption, auto vehicle kilometers traveled, travel mode share, travel time, auto pollutant emissions, building energy use and emissions, infrastructure costs, and household driving and utilities costs. The following is a summary of the outcomes.

URBAN FORM

The plans and patterns represented by the scenarios contribute to substantially different spatial structures for the central city that will determine how people move around, how efficiently economic activity is supported, and how livable the region will be. Differences in urban form and the relative location of housing and jobs are the basis for all performance variations between the scenarios. The Trend scenario locates most new homes and jobs in superblocks, while the Compact Growth scenario locates most in walkable place types of varying densities.

Figure 3-6: New population growth (left) and job growth (right) by urban form type

JOB ACCESSIBILITY

The ratio of jobs to population over a given area reflects the level of opportunity people have to live within a reasonable distance from where they work. While the Trend and Compact Growth scenarios have the same overall jobs to population ratio regionwide of .70 jobs per capita, they differ significantly in the Core and Extension areas. The Trend scenario's Core area becomes more imbalanced with the addition of more jobs, moving from 1.02 jobs per capita to 1.12, thus significantly worsening the long distance commuting regionwide. In contrast, the Compact growth scenario moved toward a more balanced configuration with .92 jobs per capita.

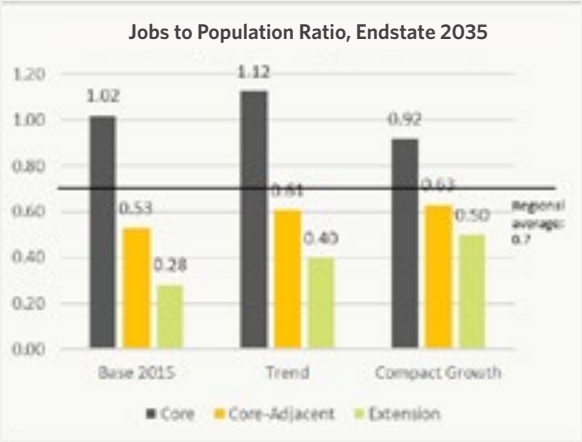

Figure 3-7: Jobs to population ratio in 2035 by subarea

ACCESSIBILITY TO SERVICES AND AMENITIES

The proportion of population in walkable, transit-oriented development areas is a measure of livability. The Compact Growth scenario locates over 40 percent more population and 15 percent more jobs in TOD areas. The ability to access destinations via non-auto transportation options is particularly important for seniors, the proportion of whom is projected to grow into the future as Chongqing's population ages.

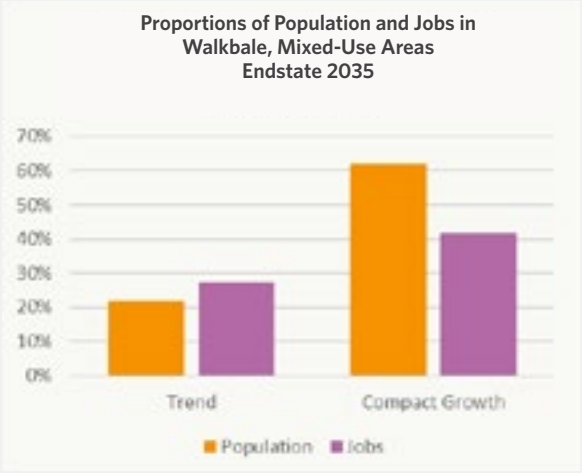

Figure 3-8: Proportions of population and jobs in walkable, mixed-use areas

NEW LAND CONSUMPTION

The amount of land consumed for growth has implications for ecological systems and agriculture, as well as the relative compactness and efficiency of urban areas. A compact urban footprint enables shorter travel distances, more efficient infrastructure networks, and building forms that are more energy- and water-efficient. Compared to the Trend scenario, the Compact Growth scenario saves 195km² of land from development. Relative to existing built-up area in the central city study area, the Trend scenario increases the urban footprint by 87 percent, as compared to a 57 percent increase with the more compact, focused development in the Compact Growth scenario.

Figure 3-9: New greenfield land comsumption by subarea

TRANSPORTATION MODE SHARE

How people travel to commute to work and meet their daily needs is a measure with environmental as well as social implications. While transportation choices determine transportation energy use and GHG emissions, they also have a bearing on household costs, health, and quality of life. The Compact Growth scenario results in a nine percent higher mode share for walk and transit trips combined. This corresponds with a 9 percent lower auto mode share, meaning that residents in the Compact Growth scenario are significantly less auto-dependent than in the Trend scenario.

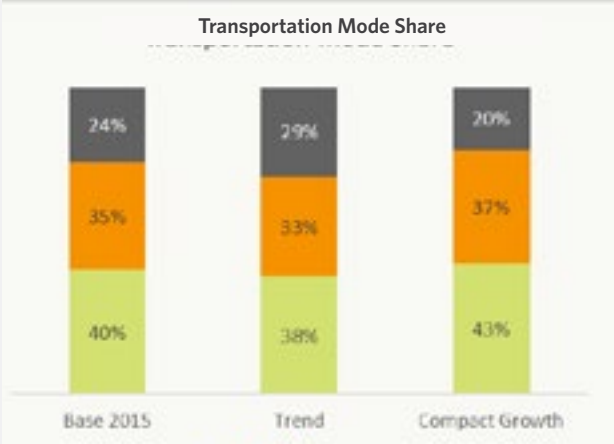

Figure 3-10: Transportation mode share

GREENHOUSE GAS EMISSIONS FROM AUTO TRAVEL

Compact Growth scenario reduces annual CO_2 emissions from auto travel by 2.6 MMT as compared to the Trend scenario. Cumulatively to 2035, the emissions savings would total 22 MMT. GHG emissions from passenger vehicles in 2035 are estimated assuming current vehicle performance. The uptake of newer, more energy-efficient vehicle technologies into the future would lower emissions even further.

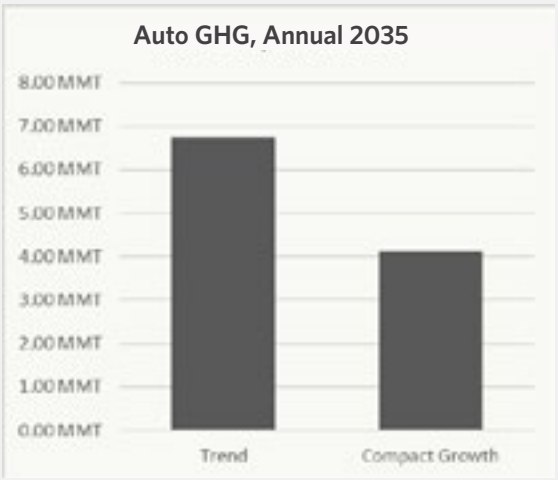

Figure 3-11: Greenhouse Gas Emissions from Autos, Annual 2035

AIR POLLUTANT EMISSIONS

Air pollutant emissions from transportation also decrease along with VKT. The Compact Growth scenario emits 293,000 MT, or 39 percent less in total NOx, CO, THC, PM, black carbon, and SO2 emissions annually in 2035 as compared to the Trend.

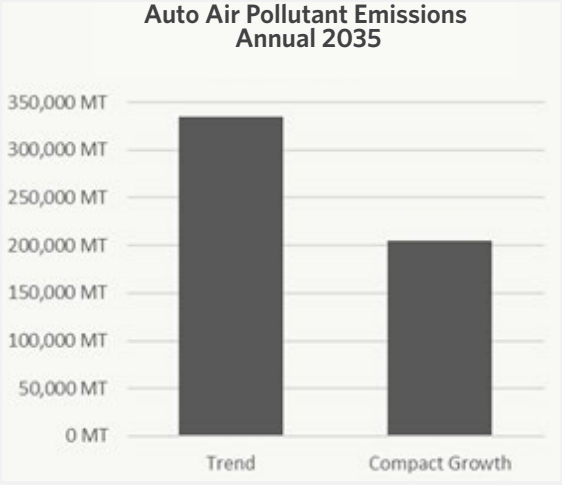

Figure 3-12: Total air polluant emissiona from passenger vehicles, annual 2035

HOUSEHOLD COSTS

Development patterns affect how much households spend on transportation and home energy use. The Compact Growth scenario saves the average household over 5,100 renminbi (RMB) annually (in 2018 RMB). Cumulatively to 2035, this savings would total 229 billion RMB—money that could otherwise be applied to housing or other costs.

Figure 3-13: Average household costs, annual 2035

INFRASTRUCTURE COSTS

The lower road, water, and sewer infrastructure required for the Compact Growth scenario saves ¥34 billion cumulatively to 2035 as compared to the Trend scenario. Ongoing operations and maintenance costs would compound this difference.

Figure 3-14: Cumulative infrastructure costs to 2035

CASE STUDY

The Liangjiang Growth Area

Within the overall Chongqing planning area is 37,000 hectares of core-adjacent land to the north of the historic city center and east of the airport. This massive area had 13,000 hectares of existing developed lands and another 11,000 hectares committed to industrial development. The existing plan, along with the out-scaled industrial lands, resulted in a significant imbalance between jobs and housing with a total of over two million projected jobs. In addition, the development pattern was structured around standard superblocks and isolated land-use zones. An alternate plan for this prime development area was created following the sustainable design standards. Significant elements of the alternate focused on environmental preservation, walkable mixed-use transit oriented districts and a jobs/housing balance for the area.

The first step of the plan was to map all the significant environmental assets and constraints in the area. The area was rich in waterways, ridges and steep slopes. Rather than proposing mass grading and riverbank development, the alternate preserved all the significant riparian corridors, steep slopes and ecologically sensitive areas. Next, the primary highway systems and the waterways were used to define transit districts in which pedestrian and bike connections could be easily maintained. (see layers diagram) Finally, the extensive new Metro lines committed to the area defined a hierarchy of walkable mixed-use station areas each with differing land-use makeups and densities. The rational planning was based on the notion that the level of transit accessibility should define the intensity and the degree of commercial development.

There are four "center" types. A "primary" center is a station area that has two Metro lines and a hub for local and semi-regional buses. A "transit" center is either a station with two Metro lines or a single Metro line combined with a bus hub. A "secondary" center is a station area with a single Metro line. The 'remaining area' is land within a transit district but beyond the 600-meter radius of a major transit station. These areas are served by feeder buses and are designed to be walkable and mixed-use.

Design standards for each of the 20 transit districts set regulations for the local street network, bus system, auto-free streets, block size, and regular zoning criteria. The fine grained, human-scaled and diverse street network facilitated a mix of uses at the neighborhood and center level.

The resulting plan reinforced transit and walking as the primary modes of mobility at the same time it preserved the unique landscape and balanced jobs and housing. The Alternate Plan's jobs-to-population balance and transit-oriented density distributions would result in shorter commutes, less energy consumption, less air pollution, less congestion on regional roads and bridges, and less cost to individual households. In addition, the redistribution of densities to transit station areas would increase transit use and walking, while reducing auto use and costs.

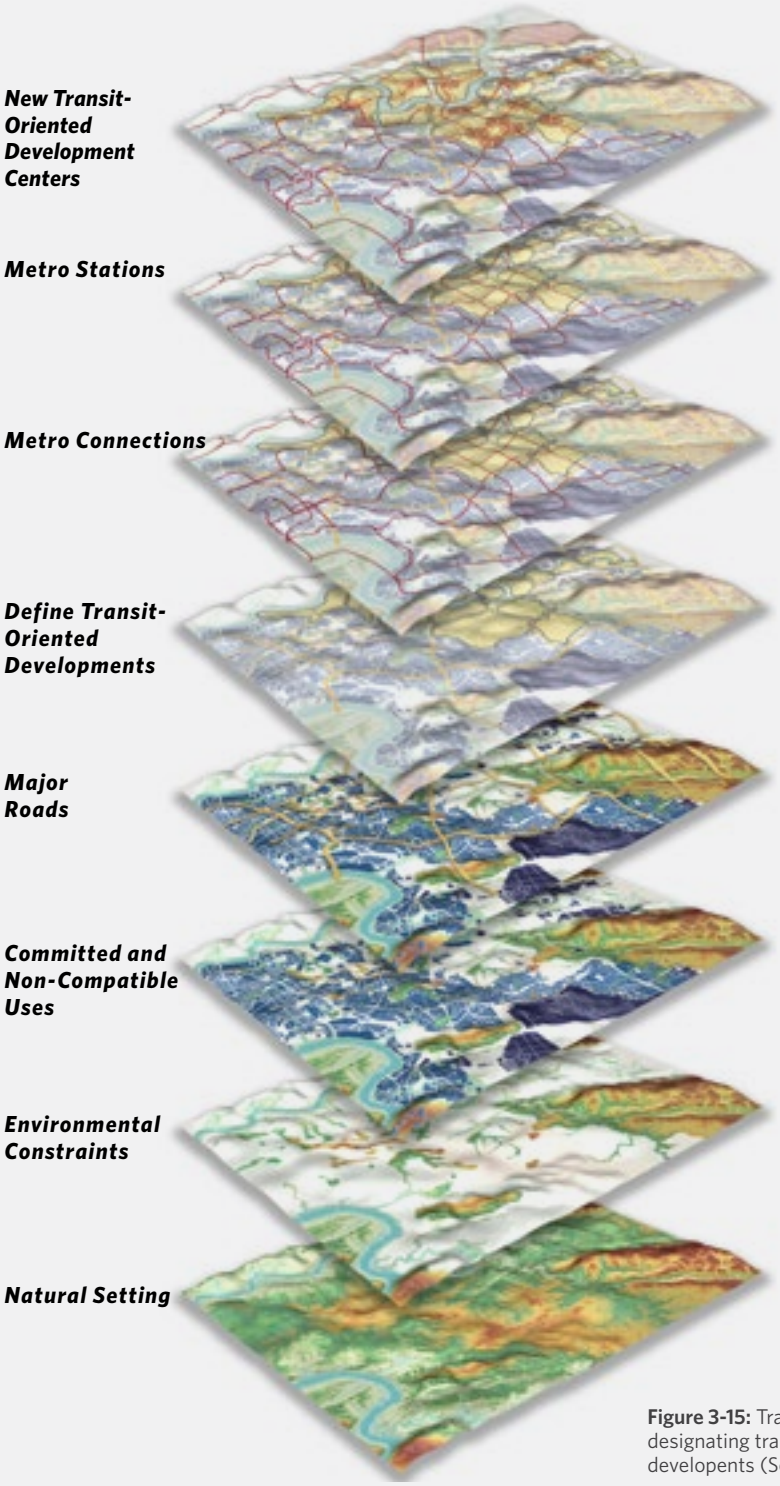

Figure 3-15: Transformation of designating transit-oriented developents (Source: HDR | Calthorpe)

Figure 3-16: Detailed views of the transformation of designating transit-oriented developments (Source: HDR | Calthorpe)

NATURAL SETTING

ENVIRONMENTAL CONSTRAINTS

COMMITTED AND NON-COMPATIBLE USES

MAJOR ROADS

DEFINE TRANSIT-ORIENTED DISTRICTS

METRO CONNECTIONS

METRO STATIONS

NEW TRANSIT-ORIENTED DEVELOPMENT CENTERS

CASE STUDY

Yuelai Eco City

Within the Liangjiang area, a new community along the Jialing river called Yuelai Eco City is planned with two Metro stations within the TOD framework of the Chongqing Northwest master plan. The previous plan for Yuelai suffered from many typical high-density sprawl planning problems: large single-use areas, pedestrian-unfriendly superblocks, and a lack of coordination with Metro stations. In this plan, a major low-density industrial area is currently operating at a key Metro station, forfeiting the opportunity for higher densities and a mix of uses. The future plan envisions a complete redevelopment of this industrial area into a high-density, mixed-use area with smaller blocks and linear parks, along with auto-free streets leading to the Metro station area.

The plan re-organizes the site into walkable neighborhoods, mixed-use transit centers in and among the rolling topography. A dedicated electric bus system operating along auto-free streets will transport people longer distances between the two Metro stations, and ultimately feed a network of neighborhood parks and civic facilities. Local bus lines will connect neighborhoods that are not serviced by the metro system, thereby providing a continuous system of transit connectivity. Hillside escalators will facilitate steep connections between neighborhoods and open space amenities, and a robust system of bikeways will be dedicated within major streets. Finally an extensive trail system will connect the hillside community parks, riparian areas, and the waterfront. The waterfront area, most of which resides in the floodplain, will be developed as a system of linear parks. Some of the larger open spaces will contain regional sports fields, and other smaller areas will be for strolling along the river.

The Yuelai site is unique in its local character and challenging topography. The urban design is closely fitted to its terrain, culture and history. Therefore, the proposed plan for Yuelai Eco-City is designed to several specific design themes.

WORK WITH THE SITE'S NATURAL FEATURES

The topography of this site typically would have been mass graded into a series of relatively flat, buildable sites. Instead the plan was approached with a sensitivity to the challenging topography by configuring the roads and buildings closely to the natural landscape. Streets will curve to follow the terrain and the traditional hillside architecture of the area will be used in steep areas. Open spaces, trails, and parks will preserve the land in areas of extreme slopes and around ecological areas such as the low-lying riverfront zone and riparian corridors. Overall, the site plan concept will achieve multiple connections between the riverfront open space and the community through a series of creek tributaries and linear parks.

CREATE A WALKABLE COMMUNITY

Within this steep terrain, creating walkable streets and small blocks presents a tough design challenge. Flatter areas contain the traditional grid of smaller blocks and narrower streets with bike lanes, but areas too steep for roads will feature hillside escalators much like those used in Hong Kong. Mixed-use shops will step down alongside the escalators, providing a unique pedestrian, hillside experience. Auto-free streets with a mix of pedestrians, bikes and transit systems will play a special role in connecting key community destinations. Public trails will also provide linkages to the natural, hillside areas and the low-lying Jialing riverfront parks, completing the ambitious task of community walkability.

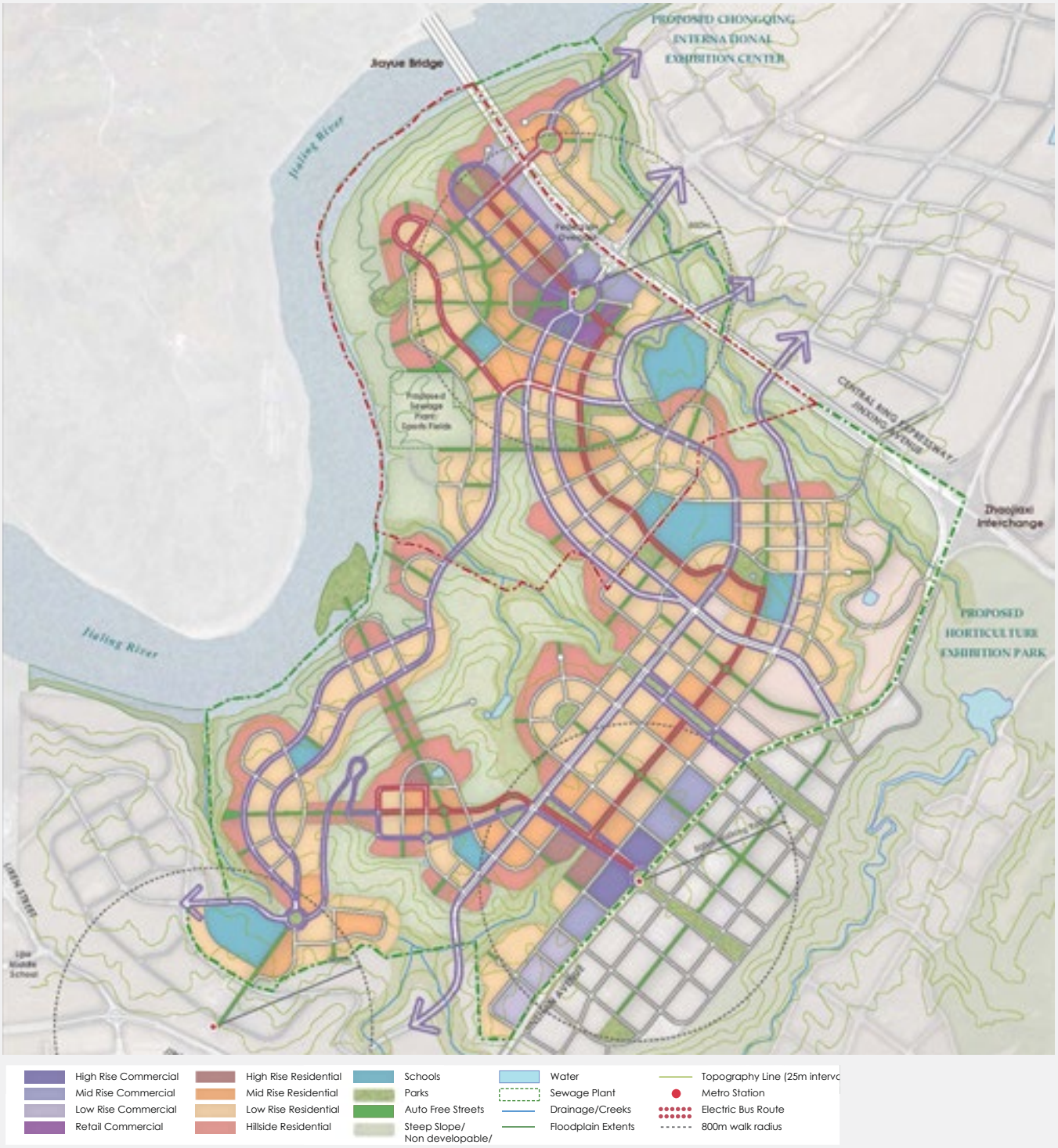

Figure 3-17: The design of Yuelai Eco-city is closely fitted to its terrain and organizes the site into walkable neighborhoods and mixed-use transit centers. (Source: HDR | Calthorpe)

ORIENT DEVELOPMENT TO TRANSIT FACILITIES

The two Metro stations in Yuelai Eco-City will become the focus of high-density jobs, services, retail, and residential development. At the Ellipse Gateway plaza (the gateway for most visitors), the traveler will emerge from the Metro station below into an expansive park framed by mixed-use commercial towers and several main street retail centers. At the Jinshan Metro station, the industrial area will be converted over time into a mixed-use district with higher density commercial. An electric bus running along an auto-free street will connect the two Metro stations. This bus will pass through the heart of the residential neighborhoods with stops at most of the local schools and neighborhood parks.

DEVELOP ACCESSIBLE PARKS AND TRAILS

The success of Yuelai Eco-City will hinge on the ability to implement an extensive public parks system with approximately 340 ha of parks and open space. Active and natural parklands will be developed continuously along the riverfront, with trails and walkways along its 4.6 kilometer frontage. A major recreational area will be developed along with amphitheaters, community gardens, and farmer's markets. A series of trails will follow streams up to interior valleys then on to the hillside developed areas and auto-free streets. These interior parklands will preserve the natural ecology of watersheds and hillsides, and within the residential areas a network of active parks, schools and open space.

Figure 3-18: Visualization of Yuelai Eco-City: the plan works with the natural terrain to create walkable streets and small blocks. (Source: HDR | Calthorpe)

Figure 3-19: Detailed view of bus and transit lines
(Source: HDR | Calthorpe)

Figure 3-20: Detailed view of trails, greenways and auto-free streets
(Source: HDR | Calthorpe)

DEPLOY STATE-OF-THE-ART ECOLOGICAL SYSTEMS

Climate-responsive building design will reduce energy and electrical demands as it makes the architecture more appropriate to this region. Engineers will investigate the potential for the sewage treatment plant to become a model of waste-to-energy systems by using its methane production in a state-of-the-art electric generation facility. In addition, the waste heat from this plant can be used in a district cooling plant to provide for building needs.

Figure 3-21: In this visualization of Yuelai Eco-City, the design responds to the site's challenging topography, climatic considerations as well as traditional hillside architecture of the region. (Source: HDR | Calthorpe)

Figure 3-22: In this visualization of Yuelai Eco-City, the Ellipse Gateway is the central focus. From this node, streets and pedestrian connections radiate out to connect to other parts of the community. (Source: HDR | Calthorpe)

Figure 3-23: A visualization of Yuelai Eco-City as viewed from Jialing River. (Source: HDR | Calthorpe)

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04 Low-Income Sprawl

04
Low-Income Sprawl

Most of the developing world is on a different trajectory than China and suffering from a different type of sprawl. Rather that government-controlled rural migration to new urban districts of high-rise apartments, the majority of low-income people around the world accesses cities through informal settlements: slums, favelas, barrios, katchi abadis, or shantytowns. Rather than oversized streets and new Metro lines, their streets are undersized, discontinuous, and uncontrolled—and overwhelmed by cars, trucks, jitneys, rickshaws, tuk-tuks, or tricycles, not to mention carts, stalls, pedestrians, playing children and domestic animals. Rather than coordinated public bus systems, there are the jitneys, colectivos and other forms of privately operated mini buses that too often run dirty engines on chaotic routes with irregular schedules and cause congestion with their ad hoc stops. Rather that state-of-the-art infrastructure, state-sponsored schools and health services, chronic shortfalls exist in all municipal services.

Much of this difference is the product of very low per capita incomes and weak or corrupt government. It is estimated that 1 billion people today live in urban slums in developing countries and that this number could grow to 3 billion by 2050 if current trends are not curbed. This leads to a different set of priorities than those in the Global North or China: poverty and slum revitalization, economic integration, basic public services, and environmental cleanup are all urgent needs. These priorities affect the whole city. Until the urban poor and their communities become more secure and integrated into the life of the city, the city's economy and livability for all will suffer.

Much of mankind's urban expansion is taking place in the Global South, and the rate of low-income sprawl is accelerating. Of the 187,066 new dwellers added to cities every day between 2012 and 2015, 91 percent, or 171,213, were born in the Global South.[1] One of every 10 children will grow up in slum conditions. The planet's informal settlement

population grew on average by six million a year since 2000. This means an increase of 16,500 people to informal settlements daily. The UN estimates that by 2050, nearly 90 percent of urban growth will have been in Asia and Africa.[2]

This massive population growth is having a profound impact on the form of cities in the developing world. In *Planet of Cities*, author Shlomo Angel and a group of researchers used refined satellite imagery to examine dynamics of urban population growth and urban land cover growth in a global sample of 120 cities between 1990 to 2000. The study showed that land cover of cities grew more than twice as fast as their population growth. If the pace of urban expansion over the last decade of the twentieth century persists, the world's urban land cover will double by 2030. Driving much of this physical expansion, fragmentation and low-income sprawl are the informal settlements of migrants seeking the economic opportunities, safety and the social life that cities offer.

A decrease from 39 percent to 30 percent of urban population living in such slums in developing countries between 2000 and 2014 was a positive sign. However, with intensifying urban migration and natural growth, absolute numbers of informal settlement dwellers continue to grow.[3] The urban development pressures are immense: UN-Habitat estimates that by the year 2030, an additional three billion more people, about 40 percent of the world's population, will need access to adequate housing. This means 96,150 homes every day and 4,000 every hour.[4]

Improving life opportunities for newcomers to cities is a big part of the sustainable development challenge of the coming decades. This requires strategic planning at the regional scale, as well as local methods of upgrading existing neighborhoods in ways that would support people's livelihoods, promote healthy governance and reduce impact on the surrounding environment. The sustainable design principles presented in this book set best practice goals and metrics at both the regional and local scale, but each city needs unique specific planning, financing and policies.

Physical planning can be facilitated by software such as UrbanFootprint, which identifies local conditions using multiple databases, provides tools to study future scenarios, and analyzes a range of important social, environmental, and economic outcomes. The Mexico City case study described later in this chapter is a demonstration of such a regional planning process. Its Vision Scenario revealed major improvements where possible in all key indicators—from average commute time and air quality impacts to household costs and water consumption.

At the local scale, rehabilitating existing slums and planning for new low-income settlements is the challenge. It is well known that improving informal settlements involves resolving multiple needs: security, safe and available utilities, a range of social services, and efficient transportation. Revitalization initiatives have only been effective when they integrate social, economic, and infrastructure programs. In Jamaica and Brazil, several successful programs combined microfinance, land tenure, crime and violence prevention, investments in day care, youth training, and health care along with the physical upgrades. But such efforts take a lot of money, consistent governance and good urban design. In Bogota, Colombia[5] and Brazil,[6] the cost of such upgrade programs were 2.8 to 3.0 times more expensive than developing new serviced land.

While many have to make do without government support, the long-run costs for inhabitants are debilitating. For example, the lack of infrastructure in Monte Olivos, Guatemala became a long-term economic burden to residents as water truck delivery is up to seven times the cost of piped water.[7] Energy is often produced ad hoc with polluting diesel, coal, dung or drawn along dangerous improvised lines, causing multiple health costs. Waste accumulates in water bodies and raw sewage flows in the streets. Houses

often lack proper ventilation and light. The list of challenges is staggering and the deferred costs always fall to the inhabitants with big multipliers.

The magnitude of health costs related to life in slum conditions is vast and evident in much lower life expectancy. The World Health Organization lists multiple infectious diseases related to poor housing conditions, as well as many chronic diseases that are often undiagnosed. Poor sanitation and lack of access to safe food and water contribute to high prevalence of disease and higher cotangents[8] such as the spreading of Ebola virus in Liberia and Sierra Leon.[9]

Tragically, the children and women who spend the most time at home are more vulnerable to the health risks. The slum health crisis is exasperated in times of emergencies and extreme weather conditions.[10] And there is much more amiss; informal housing and its lack of land title or an address affects civic participation, access to the credit, loss of civil rights, and constant risk of eviction. One study indicates that between 2004 and 2006, nearly 150,000 people were evicted in 15 Latin American countries,[11] while in Nairobi, a single demolition sweep in 2018 is estimated to have affected 30,000 people in the Kibera settlement, leaving 2,000 children without schooling.[12]

ACCESS AND THE CHALLENGE OF LOW-INCOME SPRAWL

Two fundamental challenges exist for low-income populations in developing cities. The first is the rehabilitation of existing informal settlements; second is planning for new communities to accommodate growing rural migration. Many programs and policies have demonstrated that informal settlements can be pre-planned, or later transformed into vibrant and well-integrated parts of a city. But one key challenge stands out: Many of today's urban poor live in remote locations due to the high cost of housing in the city core and because affordable housing policies push them toward remote land. Living in peripheral urban locations, particularly without adequate access to efficient transport services, can mean exclusion from a range of urban facilities, services, and jobs—and very long commutes for those lucky enough to have a job.

The sustainable development standards provide a design framework at the regional and local scale for new affordable communities, but they do not provide solutions to the economic, political, and institutional implementation struggles. Getting out of a slum is not only a matter of standards of housing, it is about access to opportunity. Available financing options, private sector capacity, and strength of local governance differ from city to city. Among different geographies, no one-size-fits-all solution for low-income development will work. Nonetheless, implementng the basic urban design principles detailed in this book can help prevent the formation of slums in urban expansions and increase success rates when investing in informal settlement upgrades.

As Angel points out in his book, a necessary step to ensure healthy urban development is securing a network of publicly owned roads and open spaces prior to development. Manhattan's 1811 Commissioner's Plan, laying out 200- by 600-foot blocks, avenues, and streets well in advance of building, was foundational for New York's population and economic boom in the early twentieth century. While Angel recommends reserving only major roads at one kilometer spacing, a more finely grained circulation system that can support mixed-use, walkable communities with decentralized parks and services is desirable.

A bottom-up example of both reserving critical circulation and providing services is Villa El Salvador in Lima, Peru. The neighborhood grid was laid out in 1970 with 16-block modules surrounded by 50- to 70-meter arterial roads and 10- to 14-meter inner streets; space for a park, schools and

public amenities was designated in the center of each module. Industrial and agricultural land were reserved and commerce was allowed to form spontaneously. The non-residential land uses prevented the formation of an economically isolated commuter town. Rural migrants could more readily build a home and find a job close to home while avoiding new burdens on municipal infrastructure. Just a few years after settling the land, representatives from each module formed an autonomous governance structure, accountable for a rapid integration of electricity and water. Community organizing also proved to be an early example of collaborative production of infrastructure, a method later endorsed by UN-Habitat in its participatory projects. The community received World Bank Sites and Services funding for public lighting in 1975.

Community representatives successfully negotiated for an underground installation of the electric lines. Since funds were limited, each resident dug a trench in front of their own lot, and the public authority laid the pipes.[13] Today, Villa El Salvador is a well-integrated mixed-use and mixed-income district of Lima, with nearly 400,000 people and a strong local identity.

Figure 4-1: Overview of the Villa El Salvador slum, 1975. (Source: Institute for Housing and Urban Development Studies[22])

A more elaborate scheme for accommodating urban expansion in cities is the provision of serviced land, with water, sewage, and electricity as well as roads and public facilities included. In some cases, each lot came with a service wall or construction frame as a first step for incremental housing. In this approach, basic utilities are provided as well as parcel ownership.

These kinds of "sites and services" programs have been carried out since the 1970s with varying levels of success. Successful projects included mixed-use land uses to enable local employment, such as retail, light industry or agriculture, as well as serviced residential parcels of various sizes, including very small ones. One project in Chennai, India offered lot sizes ranging from 33m^2 to 223m^2, while in denser Mumbai, lots ranged from 21 m^2 to 100m^2 [14]. Another key aspect for success was a balanced ratio of open spaces and roads. Less successful projects included allocation of land in distant locations where it was cheaper, isolating low-income people from opportunities. In other cases, uptake was low due to incorrect targeting; the high cost of serviced land kept low-income people away, and they went elsewhere to form new slums.

Proactive preparation of an urban expansion plan guided by sustainable development standards can be seen as a preventive health measure, or a contingency plan for emergencies. Urbanization happens in leapfrog steps during economic shifts, climate-related disaster, or political change. A future of uncertainty exacerbated by the changing climate awaits us, and cities with an urban expansion plan in place will be equipped with a resilient response. In times of stability, compact development should be prioritized within an urban growth boundary (UGB) to avoid fragmentation and sprawl. Such growth boundaries and green belts should be re-examined periodically and monitored for their impact on housing affordability and densities. UGBs should be used to direct growth into the most logical locations and should always be updated to contain enough developable land to handle the demands.

Cities with an urban expansion plan in place will be well equipped with a resilient response to the challenges of climate change and economic stress. Those without will be overrun with unplanned communities that will ultimately be more expensive to repair and move harmful to their inhabitants.

UPGRADING EXISTING INFORMAL SETTLEMENTS

Government strategies for upgrading informal settlements in the Global South has changed and evolved in the past decades, with lessons on design, finance, and process multiplying. Over the past two decades, in-situ upgrade projects are garnering success. Under the current UN-Habitat Participatory Slum Upgrade Programme (PSUP), integrated projects combine infrastructure upgrades with participatory economic and social empowerment programs. Informal settlement upgrades helped a total 227 million people to rise out of slum conditions between the years 2000 and 2010, primarily in Asia, according to UN-Habitat estimates.[15]

In many cases where costs for upgrades exceed available financing, innovative co-production and shared land titling arrangements are emerging as methods to introduce basic services with sweat equity. Decentralized infrastructure, such as solar power micro-grids, reduce utility investment costs while creating low-carbon communities with low ongoing expenses. In other cases, solid waste treatment facilities provide jobs in environmental services while creating fertilizers for growing local food. Orangi Pilot Project in Karachi, Pakistan enabled each resident to pay for the installation of water tap and drainage system to their property line. The city then provided sewage trunks to a water treatment plant, affordable credit to residents, and financial aid to vulnerable populations. Since 1980, this strategy enabled introduction of sanitation systems for 1.2 million people at 25 percent of the cost compared to a typical centralized government sanitation project.[16]

As a result, roads were cleared of harmful waste, small businesses opened, children and women could move freely, and the infant mortality rate fell from 130 per 1,000 in 1982 to 37 per 1,000 in 1991.[17]

Both planned expansions and informal settlement upgrade projects will result in economic and social gains by implementing the sustainable development design principles. Land use policies that promote mixed uses, coupled with frequent, reliable transit, will provide the tools for residents of informal settlements to transform their neighborhoods into lively, self-sufficient places, on a path towards dignified life.

The good news is that solving the cluster of issues surrounding urban poverty—air quality, congestion, water pollution, health, employment and affordable housing—can lead to an economically vital, low-carbon city. As is in the developed world, smart urban design strategies solve a range of social, economic, and environmental ills simultaneously. A new regional study for Mexico City by Centro Mario Molino and HDR | Calthorpe Associates connects the dots and demonstrates that planning at the regional scale can address the challenge of the poverty crisis in the Global South.

CASE STUDY

Mexico City and Low-income Sprawl

Mexico City is not a poor region by global standards; its average per capita GDP is above $7,000. As noted earlier, about half the globe subsists on less than $4,000 a year. It is the upper half—the emerging middle class and isolated wealthy—that generate the environmental impacts we all must cope with, most notably carbon emissions and climate change. Even though Mexico is wealthier than many, it still struggles with all-too-familiar urban challenges: barrios, informal housing, disastrous air quality, grid lock, social stratification, and chronic water shortages to name a few. Perhaps more important, it represents a metropolis in transition to a more middle-class economy and as such could be a model for urban forms that are critical to the climate change imperative and this list of local challenges. While the poorest cities of the world should focus on basic health, wellbeing, and equity, emerging economies like Mexico must find a path to living well while living lightly on the land and air. As its population gains in wealth and consumption, must the global pattern of higher carbon emissions lock in?

During the past half-century, the Mexico City region has become less centralized and ever more expansive. Currently, more than half of its 20 million population lives outside of the Federal District, the historic core of the city. The poor have generally moved to unstable and flood-prone areas with limited infrastructure, particularly the eastern and northeastern periphery—Iztapaluca, Chalco, and Valle de Chalco-Solidaridad. Meanwhile, the middle class and wealthier residents occupied areas with stable soils and gentle slopes in the southern and western areas of the city—closer to the job centers.[18] While the poor and rich have never lived side by side in the Mexico City region, recent growth and expansion have magnified the scale of segregation.[19]

As Mexico City spreads outward and trends toward lower densities at the periphery, the global pattern of low-income sprawl is manifest. Physical expansion has outpaced population growth (from 2005 to 2010 the average annual growth rate of the region's population was 0.9 percent, while that of the built surface was 1.2 percent) while economic activities have remained far more centralized.

In 2015, the city's four central districts with 19 percent of the population generated 53 percent of the jobs. Incomes in central districts, home of the city's wealthiest, reached up to five times higher than the incomes in the periphery.[20].

Figure 4-2: View of Mexico City region where physical expansion has outpaced populatin growth (Source: George Miquilena, CC BY 2.0)

Mexico's urban geography parallels many economically emerging metro regions. Lower income residents are isolated in informal developments or social housing projects. In 1980, 65 percent of the population lived in informal private developments. More often than not these are remote locations, creating a debilitating disconnect between the poor and the economic opportunities, social capital, and social services that the central city enjoys. Compounding the physical isolation, the lack of dependable, efficient transit makes commutes an extreme penalty for the poor. It is estimated that an average person spends 3.5 hours per day in transportation,[21] with some cases reaching up to six hours per day. This is the plight of the autoless population that dominates those at the urban edge.

Like many cities in China, Mexico is yet to fully invest in cars. Auto ownership is about 170 per thousand population compared to over 530 in Los Angeles or 320 in London; like most emerging economies, the urban poor cannot afford cars. Nonetheless, Mexico City is headed in the wrong direction—from 1980 to 2010, the size of the light-duty vehicle fleet grew from 1.8 to 5.4 million cars and its mode share to driving jumped from 20 percent in 1995 to 28 percent in 2005, and continues to climb. Even at less than one-third of all trips, private cars emitted more than half of all road-based greenhouse gas emissions, including from freight vehicles and public transportation.

Mexico's congestion and deadly air quality are legendary even though most do not own cars because Mexico is largely dependent on ad-hoc colectivo buses and combi minivans rather than public bus routes or high quality express transit systems. Trips are slow, indirect, and more often than not in polluting vehicles. In addition, a massive taxi fleet, augmenting the fragmented informal transit routes, produced 1.75 times more greenhouse gas emissions than the notably inefficient transit system. In combination, this transportation system drives up congestion, emissions, energy consumption, and poor air quality while providing very low average travel speeds and long commutes for the poor. As the city geography has expanded overall, door-to-door transit and auto travel speeds are dropping and air quality (even with new emissions controls) remains toxic. And this air pollution disproportionately harms poorer residents, since they are more likely to live in neighborhoods with higher levels of pollution—particularly near highways—and have a more frequent direct exposure to fumes from low-quality transit.

The poor, less able to move to central locations or afford cars, bear the major burden of congestion and extraordinary commute times. In 2007, the average commute to work by car for someone in the urban center was less than two-thirds of the average public transit commute by someone in the suburbs (47 minutes compared to 73 minutes).

MEXICO'S FUTURES

Mexico City has all the typical challenges of most emerging cities: lack of affordable housing, social stratification, economic isolation, gridlock, poor air quality, flooding, limited water supply, and poor transit. While all certainly need individual attention and progressive technologies, they are all driven by urban form—the DNA of the city. Where development happens, what form it takes, and what kind of transit is available is fundamental to meeting each challenge.

In 2015, a scenario process similar to that used in Vision California was conducted for Mexico City. Its goal was to reveal the impacts and trade-offs of differing urban growth strategies through the year 2050. The process was the same: study the region and its challenges, develop differing future growth scenarios, and analyze those scenarios across a range of metrics. But the challenges, issues, and

social structure was very different from those in the north. Rather than the amount of private auto use, the key mobility question was the quality of transit and travel times. Rather than middle class and wealthy leaving the city, the equity challenge was the remote location of most low-income and affordable housing. Rather than low densities and unwalkable neighborhoods, the urban design imperative was connecting traditionally pedestrian-friendly neighborhoods to jobs and regional assets.

Adapting urban form to this new set of challenges and urban geography involved creating a different mapping of the region and a new set of 'place types' to build futures with. The way we mentally and actually map a city deeply affects the way we understand it. Typical maps show streets, parcels, parks, and other public features. It is a narrow understanding blind to history, ecology, economic activity, geology, topography, or community structure. One map cannot capture all the dimensions of a city, but with the wealth of data now available and the capacity of geographic information system (GIS), most physical, social, and environmental layers can be illustrated. Mapping Mexico's history of growth, its economic structure, its job distribution, and its environmental infrastructure clearly revealed the challenges facing the region.

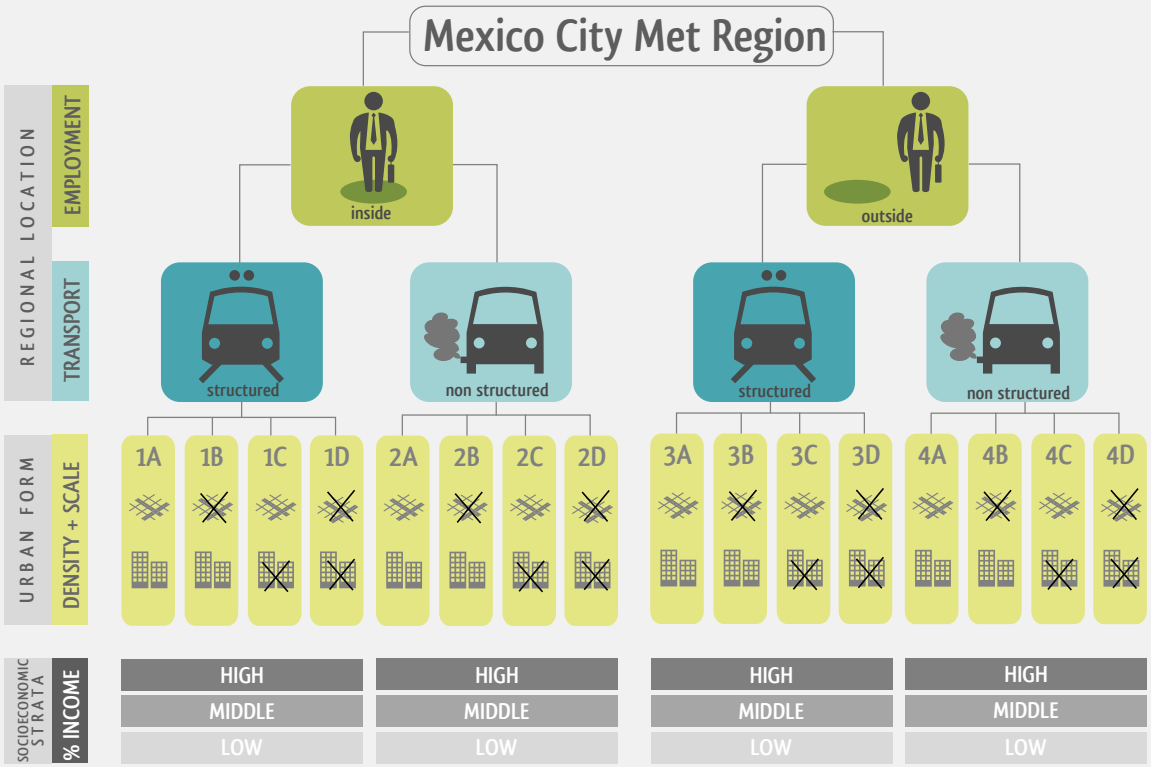

Figure 4-3: Characterization of the region (Source: HDR | Calthorpe)

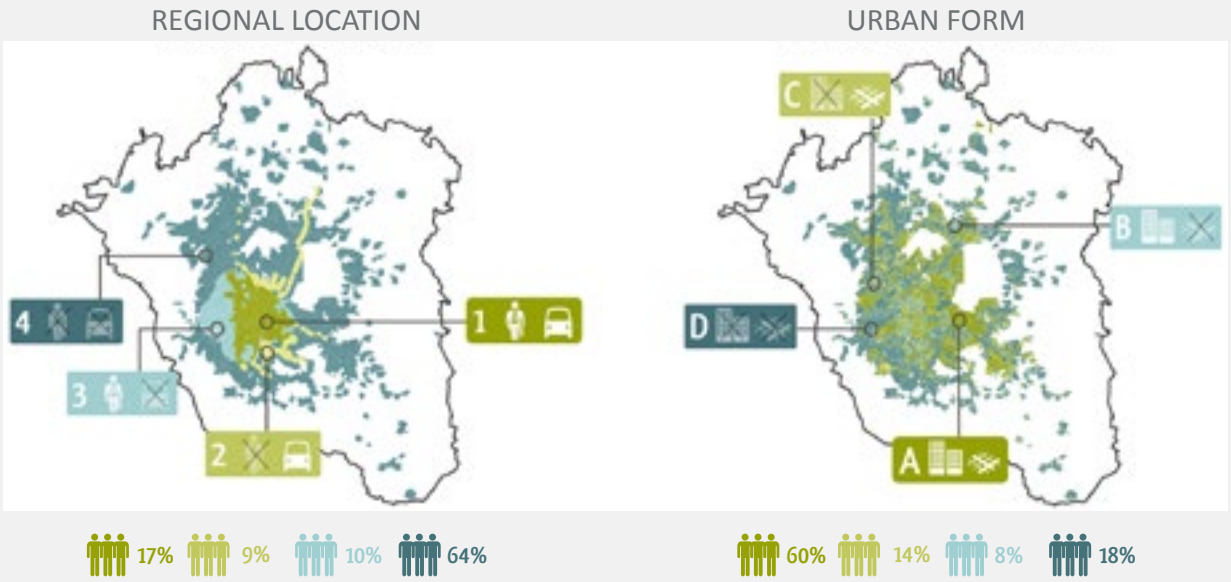

Figure 4-4: The territory was characterized based on the regional location (left) and the urban form (right). The percentages show the population living in areas with access to employment and structured public transportation (left), as well as proper density and block scale (right). (Source: HDR | Calthorpe)

In order to better understand the social, economic, and urban form of the region, a new type of mapping was developed. It crossed three factors: accessibility, urban form, and income to produce 48 place types. Four types of accessibility were defined by proximity to the major job centers of the region and access to formal transit. Urban form was defined by combining two housing density and walkability factors as identified by the quality of the street network. Finally three levels of income was combined with the 16 proximity and urban place types. For example, one of the 48 place types could be defined as middle income, with decent proximity to the regional job center but no formal transit, with a low-density but walkable physical form. This mapping of income, regional location, transportation facilities, density and urban form created a unique and revealing picture of the city.

Individually each factor told a story. Only 26 percent of the population live within five kilometers of a regional center, the study's definition of "good" proximity. Only 29 percent of households live close to transit defined as high-capacity bus or trains on fixed schedules with high quality service—effectively the city's Metro and BRT lines. Sadly, over two-thirds of the population were neither close to the job center or to structured, high quality transit. The existing conditions were much better for urban form. Seventy-four percent of the population live in areas of over 50 dwellings/hectare (not unlike densities of London's townhouse neighborhoods) and 68 percent live in areas with human-scale streets and block sizes under 1.2 hectare (a traditional size in most walkable districts). In fact, the city is dominated by good urban form: 60 percent live in walkable areas with appropriate densities and only 18 percent live in what is generally considered sprawl—lower density areas without a walkable street grid.

The mapping highlighted the need for more high quality transit, new job center locations that could reduce commute distances as well as with more compact and walkable new development and more affordable housing infill close to the economic center of the region. The future growth scenarios for 2050 were based on these four variables: percent of housing infill, location of new job centers, level of transit service, and urban form. In all scenarios, 2.7 million new housing units of varying types were accommodated, but some scenarios used higher density types. In all cases there are new jobs, but the location, regional proximity to housing, access to transit, and location within mixed-use areas of

those jobs varied. Transportation varied largely by the quantity of new structured mass transit constructed, but all scenarios used well studied and proposed alignments. Three scenarios were created from these four variables: Trend, Moderate, and Vision Growth.

The Trend scenario explores extending the current urban development's direction, characterized by the inefficient land-use policies that encourage urban sprawl. In terms of employment accessibility, it still has an unbalanced trend between the areas that concentrate housing and those that concentrate employment. Regarding access to transport, a moderate expansion of transit based on the proposals adopted in the Second Government Report 2013–2014 was used. Finally, for urban configuration, as housing continues to spread at the edge, a significant percentage of new communities will lack the desired scale, density and walkability of typical infill projects.

For the Moderate scenario, modest infill within existing urban areas is studied—however, sprawl to the periphery does keep increasing. A large investment in structured public transport is modeled, increasing its coverage by 50 percent through new BRT lines. There will be a better balance between areas with walkable urban forms and areas lacking human-scale or urban density. This scenario can be seen as a transition between the baseline and the vision.

Finally, the Vision scenario focuses on infill development by strengthening and decentralizing centers of employment. It seeks a balance between the number of jobs and housing units on a sub regional basis, effectively creating a polycentric metropolis of 25 million linked by high quality transit. In terms of public transport, there is an increase in the service capacity, mainly focused on promoting regional connectivity. Final this scenario assumes that most of the new development will be mixed-use, human-scaled, and walkable—a city of TODs.

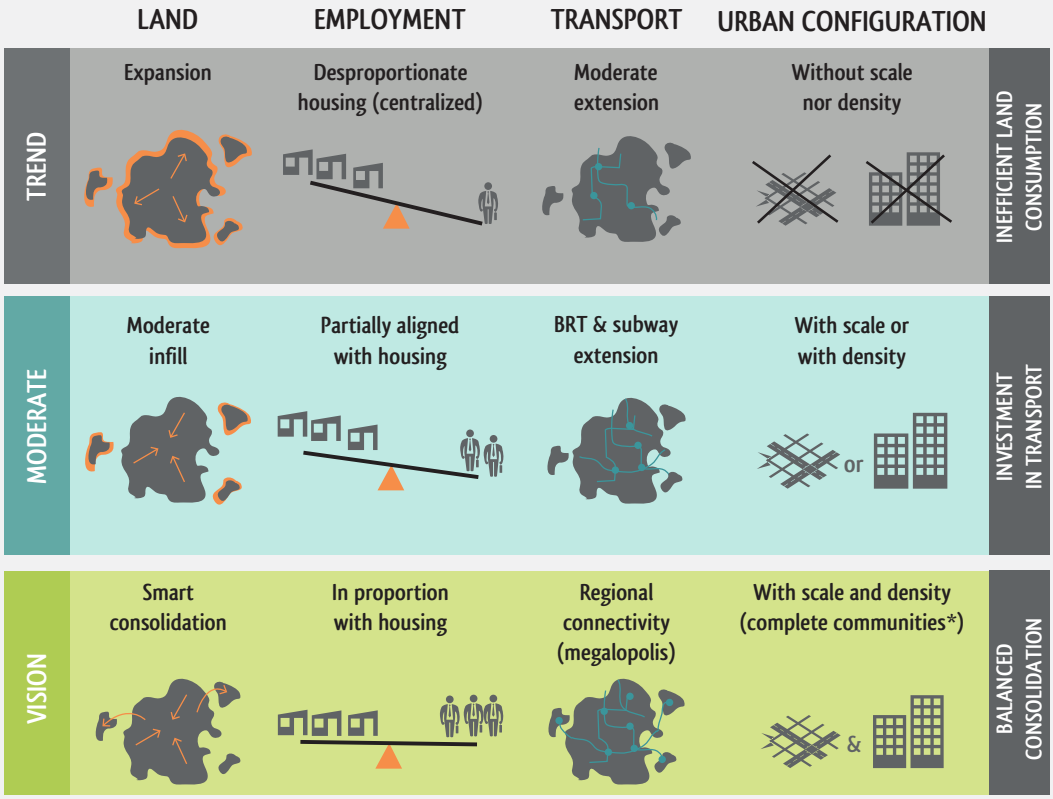

Figure 4-5: Conceptual definition of scenarios (Source: HDR | Calthorpe)

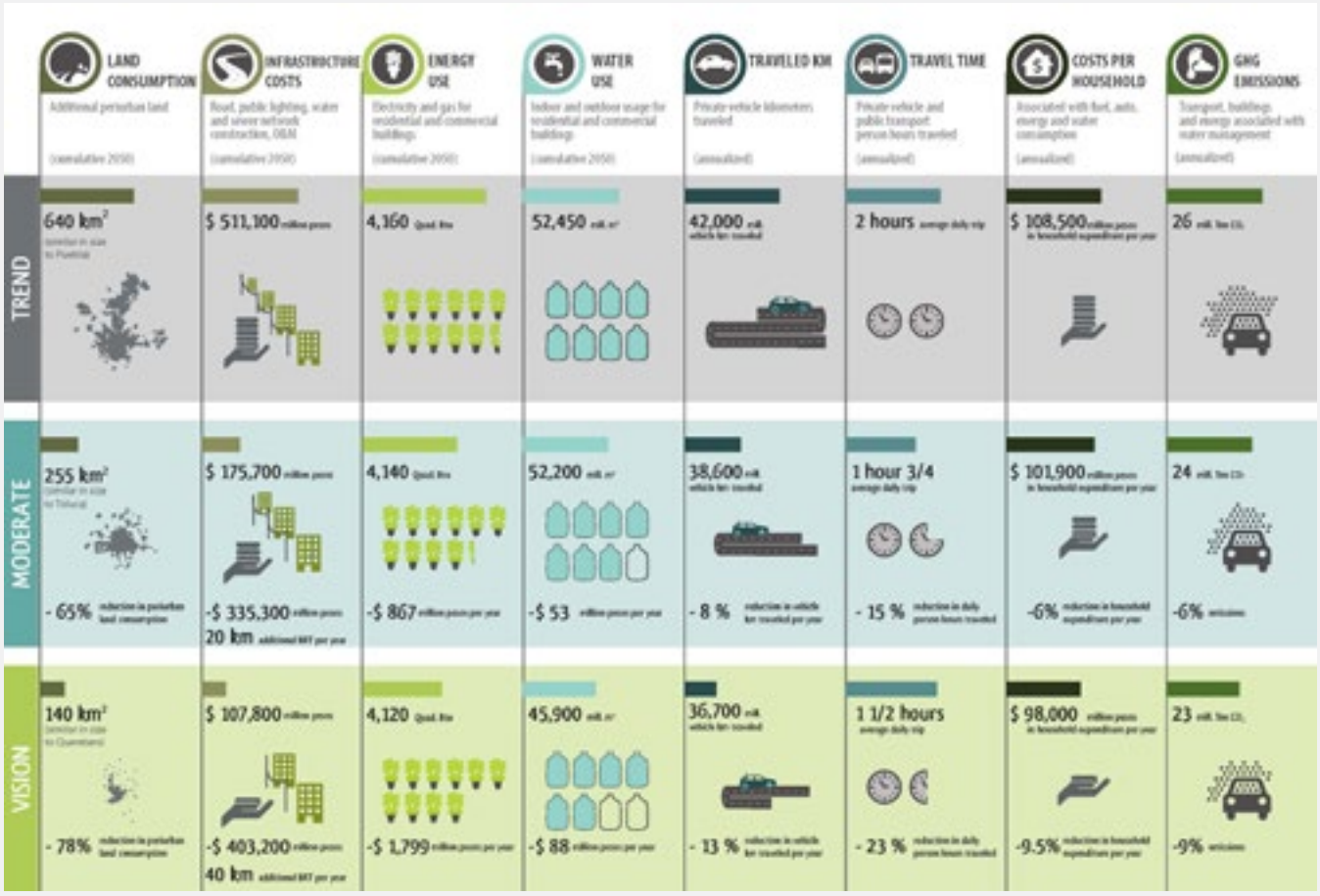

Figure 4-6: The figure displays a summary of the results, showing variations between Trend, Moderate and Vision scenarios (Source: HDR | Calthorpe)

The result can be read through differing lenses: per capita overall, per capita for the new population or per capita for low-income population. The overall metrics blend the new with the old both in terms of land use and infrastructure—diluting the impact of new development. Nonetheless, these results highlight consistent improvement in all metrics as the scenarios progress from Trend to Vision. (See Figure 4-6.) While the interconnected nature of the co-benefits are clearly quantified, some of the factors show more dramatic effects. Land consumption is cut by 78 percent with many tertiary implications, including reducing infrastructure costs cumulatively by a similar amount even while producing 40 kilometers of new BRT line per year. Water consumption is down 13 percent overall and household costs and carbon emissions are both down nine percent. One key metric—average travel time per day, which drives congestion and air quality—is down 23 percent for all auto and transit riders.

CASE STUDY

Sustainable and Resilient Futures for Ho Chi Minh City

Ho Chi Minh City is a thriving, fast-growing city in Vietnam whose future depends on resilient and sustainable development. Given its location in a low-lying delta vulnerable to typhoons, sea level rise, and upland flooding, the viability of its future economy, safety of its people, and health of its environment are contingent on transitioning to new forms and locations for sustainable urban growth. There are two critical factors for growth in any city: the location of new development and the standards for ecological and urban design. This study of Ho Chi Minh City for the World Bank frames its recommendations around these 'where' and 'what' questions into four key strategies, each with specific recommendations.

According to a recent McKinsey study, without climate adaptation measures, the costs associated with flooding events in Ho Chi Minh City will grow faster than its GDP (McKinsey Global Institute, 2020). Increasing average global temperatures are also concerning because of related heat island effects in the urban environment. The temperature in the city is up to 10 degrees Fahrenheit hotter than the surrounding rural area. Intense urbanization in flood-prone areas and the related loss of natural areas are likely to worsen existing conditions.

While existing and "in progress" development in low-lying areas must be protected with planned ring dike infrastructure, new development can and should be directed toward safer high-ground sites no less than 1.5 meters above sea level. Once appropriate high ground areas are identified, a series of resilient development practices can be applied to enhance the long-term value, social cohesion, and ecological viability of new communities.

These practices involve approaches to low-carbon transportation, mixed-use neighborhood development patterns, and best practices for blue/green infrastructure. In the area of transportation, this means transitioning to electric motorcycles and providing dedicated rights-of-way for this dominant mode of transport, along with designating adequate road widths in all new growth areas. It means building mixed-use walkable neighborhoods, including transit-oriented

Figure 4-7: The city is regularly affected by flooding caused by high tides, heavy rainfall and storm surges. (Source: iStock)

development (TOD), and integrating sufficient affordable housing and local services to meet the community's future needs. Regarding ecology and preservation, it means building state-of-the-art blue/green infrastructure while preserving and enhancing drainageways and the Can Gio Mangrove, expanding tree canopies, and protecting critical agricultural lands that can provide bypasses for peak stormwater events.

The following four strategies can achieve a sustainable and resilient future for Ho Chi Minh City.

DEVELOP SAFE AND RESILIENT SITES

- **Finding**: Based on current zoning, the city has 382 square kilometers (km^2) of developed lands in flood-vulnerable areas and is allowing another 199km^2 of future development in low-lying areas. A recent McKinsey study finds direct infrastructure damage from a 100-year flood today would be $500 million, and $1 billion by 2050.
- **Recommendations**: This study locates areas appropriate for safe high ground urban expansion totaling 320km^2, an area easily capable of accommodating the four million population increase projected through 2040. One site of 40km^2 close to the urban center could accommodate close to one million in new population

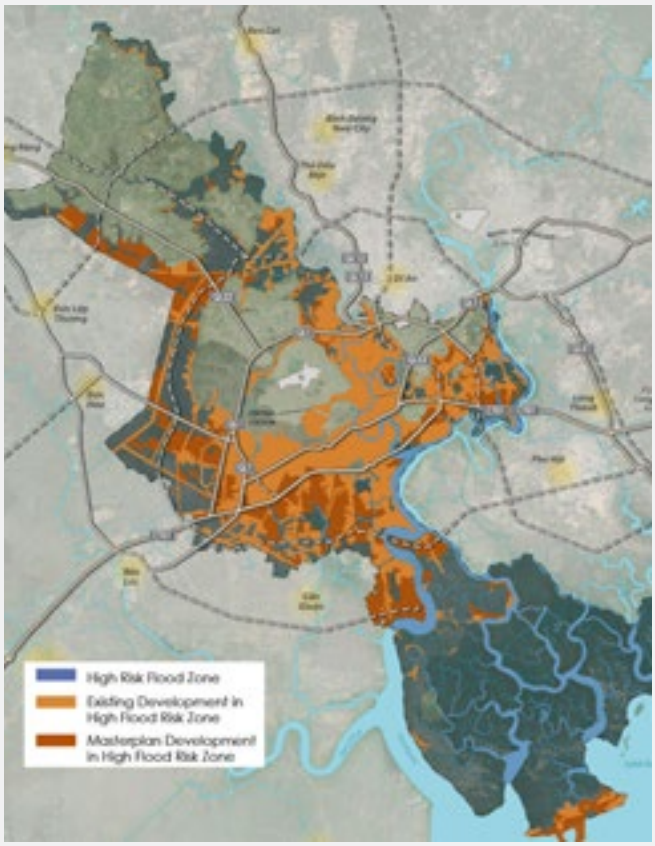

Figure 4-8: Growth continues to occur in flood prone areas that have limited drainage and flood infrastructure (Source: HDR | Calthorpe)

Figure 4-9: Identifying and allocating new growth areas on high ground (Source: HDR | Calthorpe)

DESIGN FOR A LOW-CARBON TRANSPORT NETWORK

- **Finding**: The city has developed a robust transit plan which comprises six Metro lines, two monorail lines, a tramway, and six BRT lines. Motorcycles are the main and possibly the best means of transportation, providing cheap and flexible transport, accounting for 90 percent of vehicle trips (World Bank, 2015). However, when mixed with cars, trucks, and buses, they result in congestion and smog.
- **Recommendations**: This study's analysis shows that dedicated e-motorcycle lanes can provide three times the capacity at one-half the cost of some at-grade transit systems. Therefore, a mix of traditional transit systems with an e-motorcyle street network would be cost effective while supporting local travel behavior. Converting the existing motorcycle fleet to electric would reduce carbon emissions by 55 percent.

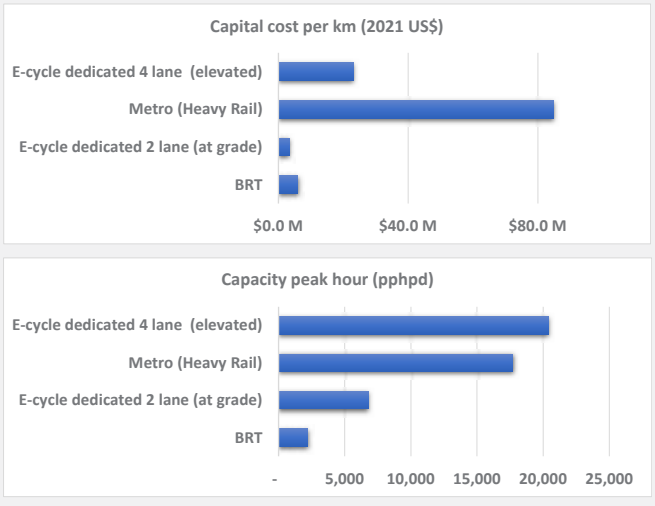

Figure 4-10: BRT, Metro, and e-motorcycle comparison (Source: HDR | Calthorpe)

CREATE COMPLETE COMMUNITIES WITH DIVERSE HOUSING AND SERVICES

- **Finding**: Lack of affordable housing and local community services has created informal settlements of substandard construction with inadequate infrastructure and services. In 2010, 62 percent of migrants were living in spaces less than seven m^2 per person, and one-third were living in spaces less than four m^2/person (UN-Habitat, 2014).
- **Recommendations**: In new growth areas, the city's Masterplan 2040 should plan for 'complete neighborhoods' that combine adequate affordable housing and sites and services parcels with a range of market-rate housing. These should be located with local civic and commercial destinations within walking distance to reduce trip lengths and auto use.

Figure 4-11: Complete neighborhoods include a range of housing types, income levels, civic and commercial amenities, and open space. (Source: HDR | Calthorpe)

SUPPORT LOCAL AND REGIONAL ECOLOGICAL SYSTEMS

- **Finding**: Urban displacement of the city's open space and green system has compromised critical drainage, infiltration, and evaporation, and increased flooding related to runoff. Between 1998 and 2018, the area of land devoted to public parks was cut in half, 20 percent of canals and lakes were filled, and 95 percent of rivers and canals were encroached upon.
- **Recommendations**: In new growth areas, provide parks, greenways, open spaces, and regional parks that total a minimum of 25 percent of gross site area. Restore and preserve 90 percent of compromised streams and drainageways. And within existing urban zones, tree canopy areas should provide 30 percent coverage.

Figure 4-12: Proposed open space network (Source: HDR | Calthorpe)

Figure 4-13: Detailed illustration of greenways, parks, and blueways (Source: HDR | Calthorpe)

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PART II

05 Design Principles for Sustainable Urbanism

05
Design Principles of Sustainable Urbanism

As cities expand throughout the world, the problem is not only that suburbs and cities are sprawling, but that, since World War II, they have been developed according to an outdated urban design paradigm. Specifically, communities have been designed according to modernist design principles and implemented largely by specialists. The core modernist design principles of specialization, standardization, and mass production were drawn from an industrial paradigm. When taken to scale, they had a devastating effect on the character and sustainability of historic neighborhoods, cities, and regions. These modernist principles displaced generations of urban design wisdom with a radical experiment that reshaped cities and towns as "machines for living" rather than civic frameworks for community and commerce. The modernist canon quickly came to dominate the world of planning, architecture, and industrial design—and the world we now live in.

Against this modernist alliance of specialization, standardization, and mass production stands a set of principles rooted more in biology than in physics, more in ecology than in mechanics. These are the universal ecological imperatives of diversity, conservation, and human-scale. Diversity is at the core of any robust, rich ecology. Conservation means that nothing is ever lost in natural systems and that there is no such thing as waste. Human-scale is nature's tendency toward detail and complexity. In urban design, diversity implies more mixed, inclusive, and integrated communities. Conservation implies the care for and recycling of existing resources—whether natural, social, architectural, or institutional. The principle of human-scale brings the individual back into a built environment that has been increasingly shaped by remote and mechanistic concerns.

UNIVERSAL URBAN DESIGN IMPERATIVES

Moreover, these urban imperatives apply equally to the social, economic, and physical dimensions of communities. For example, the social implications of human-scale may mean police officers walking a beat rather than hovering overhead in a helicopter. The economic implications of human-scale may imply development policies that support small local business rather than national industries and corporations. And the physical implications of human-scale may be realized in the form and detail of buildings as they relate to the street and the pedestrian. Unlike the isolated governmental categories of economic development, housing, education, and social services, each of these design imperatives brings together physical design, social programs, and economic strategies. These imperatives, then, are the foundation for the sustainable development principles that follow.

Human-scale

Human-scale is a design principle that responds simultaneously to simple human desires and the emerging ethos of decentralized economies. The focus on human-scale represents a shift away from top-down social programs, from command-and-control organizations, from uniform housing projects, and from bureaucratic and remote institutions. Human-scale in economics means supporting individual entrepreneurs and local businesses. Human-scale in community design means a walkable neighborhood and an environment that encourages everyday face-to-face interaction. In its most concrete expression, human-scale is the stoop of a townhouse or the front porch of a home rather than the stairwell of an apartment or the garage door of a tract home. It is a walkable city block rather than an auto-dominated superblock; it is local and decentralized services and nearby destinations rather than remote public and private institutions. It is the fine grain of great urban places.

For several generations, the design of buildings, the planning of communities, and the growth of our institutions has exemplified the view that "bigger is better." Efficiency was correlated with large, hierarchical organizations and processes. Now, the idea of decentralized networks of small entrepreneurial groups and more personalized institutions is gaining currency in both government and business—"small is beautiful" is popular again. Efficiency is correlated with nimble, small working groups, not large institutions. The same is true for the urban environment.

Certainly, today's reality is a complex mix of both of these trends—human-scale and "bigger is better." For example, we have ever-larger big box retail outlets at the same time that main streets are making a comeback. Some businesses are growing larger and more centralized while the "new economy" is bursting with small-scale start-ups, intimate working groups, and virtual firms. The range of housing types is diversifying at the same time that production is consolidating into larger, more homogenous financing packages. Both trends are evolving at the same time, and the shape of our communities will have to accommodate this complex reality.

Yet people react negatively to the current imbalance between these two forces. The building blocks of our communities—schools, local shopping areas, housing subdivisions, apartment complexes, and office parks—have in the developed world grown into forms that defy human-scale. And we are witnessing a reaction to this lack of scale in many ways. People long for an architecture that puts detail and identity back into what have too often become generic and mundane buildings. They desire the character and scale of a walkable street, complete with shade trees and buildings that orient frequent windows and entries their way. They enjoy, even idealize, main street shopping areas and historic urban districts.

Ironically, the quality of a street, even when lined by high-rises, can be human-scaled if its storefronts are varied and interesting, if its entries are frequent and rich in detail, and if its edges are filled with human activity. Small local parks may

not be efficient to maintain, but they support community and walkability in ways that are essential to healthy neighborhoods. Likewise, small schools, especially for elementary and preschoolers, are scaled to the emotional and social needs of children and fit into communities in ways that larger institutions cannot. Community-scaled technology, such as small, dispersed electric power plants coupled with district heating systems, can be thought of as a human-scale alternative to large centralized power plants. Finally, the small human-scaled buildings that accommodate start-ups and local businesses are often at the heart of a vibrant, creative and local economy.

Diversity

Diversity has multiple meanings and profound implications. In nature, diversity is the key to resilience and adaptive capacities within any ecosystem. In community design, diversity has overlapping layers of physical, economic, and social meanings. Physical diversity results in maximizing the mix of activities, building types, and civic places within a community. Economic diversity tends toward places that support a broad range of businesses at differing scales. Social diversity produces places that are integrated and inclusive. As a planning axiom, diversity calls for a return to mixed-use neighborhoods that contain a rich range of uses as well as a wide choice of housing types for all economic, ethnic, and age groups.

The four fundamental components of any community—civic places, commercial uses, housing opportunities, and natural systems—define the physical dimensions of diversity at any scale. As a physical principle, diversity in neighborhoods ensures that destinations are close at hand and that the shared institutions of community are closely integrated. It also implies a varied architecture rich in local character and streetscapes that change with place and use. It is the antithesis of the "one size fits all" approach to housing, workplaces, and public buildings.

As a social principle, diversity is controversial and challenging. It implies creating neighborhoods that provide for a large range in age-groups, household type, income, and race. Commonalities have always defined neighborhoods, even if they are energized by differences. But today we have reached an extreme: age, income, family size, and race are all divided into discrete market segments and constructed in separate locations. Complete housing integration may be a distant goal, but inclusive neighborhoods that broaden the economic range, expand the mix of age and household types, and open the door to racial integration are feasible and desirable. The success of the HOPE VI program in the United States, designed to replace single-income federal housing projects with mixed-income communities, is a dramatic demonstration that this principle can be realized even at our social extremes.

Diversity is a principle with significant economic implications. Gone are the days when economic revitalization efforts focused on a single industry or a major governmental program. A more ecological understanding of industry clusters has emerged. This sensibility validates the notion that a range of complementary but differing enterprises (large and small; local, regional, and global) are important to maintaining a robust and sustainable economy, and that now more than ever, quality of life and urbanism play a significant role in the emerging economy.

Finally, diversity is a principle that can help guide the preservation of local and regional natural resources. Clearly, understanding the complex nature of stressed habitats, ecologies, and watersheds mandates a different approach to open space planning. Active recreation, agriculture, and habitat preservation are often at odds. Just as in the built environment, diversity in the range and type of natural areas within a metropolitan area is essential. A broad range of open space types, from the most active to the most protected, must be integrated in community and regional designs. Diversity in use, diversity in population, diversity in enterprise, and diversity in natural systems are fundamental to a sustainable future.

Conservation

Conservation implies many things in community design in addition to husbanding resources and protecting natural systems; it implies preserving and restoring the cultural, historic, and architectural assets of a place as well. Conservation certainly calls for designing communities and buildings that require fewer resources—less energy, less land, less waste, and fewer materials—but it also implies caring for what we have and developing an ethic of reuse and repair, in our physical and social realms as well as natural landscapes. Restoration and conservation are more than environmental themes, they are an approach to the way that we think about community at both the regional and local levels.

Conserving resources has many obvious implications in community planning. Foremost is the opportunity to save the farmlands and natural systems displaced by sprawling development and the voluminous auto travel it requires. Even within more compact, walkable communities, conservation of resources can lead to new design strategies. The preservation of waterways and on-site water treatment systems can add identity and natural amenities at the same time that they improve water quality. Energy conservation strategies in buildings leads to designs that are climate-responsive while reinforcing a unique identity of place.

Conserving the historic buildings and institutions of a neighborhood helps to preserve the icons of community identity. Restoring and enhancing vernacular strategies in buildings leads to designs that are climate-responsive while reinforcing a unique identity of place. Although the preservation movement has made great strides with landmark buildings, they are now wise in extending their agenda beyond building façades to the social fabric of neighborhoods and the economic ecology of the communities that are the lifeblood of any historic district.

Conserving human resources is another implication of this principle. In too many of our communities, poverty, lack of education, and declining job opportunities lead to a tragic waste of human potential. As we have seen, communities are not viable when concentrations of poverty turn them into a wasteland of despair and crime. In this context, the term conservation takes on a larger meaning: the stewardship, restoration, and rehabilitation of human potential wherever it is being squandered and overlooked. There should be no natural or cultural environments that are disposable or marginalized. Conservation and restoration are practical undertakings that can be economically empowering and socially enriching.

These three principles—human-scale, diversity, and conservation—set the foundation for a new direction in community design. The three global sprawls and their regional structures are a manifestation of an older and markedly different paradigm: the industrial qualities of mass production, standardization, and specialization. As a counterpoint, the principles and concurrences of human-scale, diversity, and conservation define a new paradigm for the next generation of growth, one that leads from sprawl to sustainable communities. These principles need to be expressed at the scale of local community and the regional metropolis. As regional design is beginning to emerge as a key to our economic, social, and environmental health—and it can be guided by the same urban design principles that work for neighborhoods and towns.

REGIONAL BUILDING BLOCKS

Translating the design imperatives of urbanism into practical development involves rethinking the basic building blocks of the region and its jurisdictions—creating a new armature of circulation along with a new language for zoning and planning. In the end, the transportation system will shift from auto-centric roads and highways to finer-grained, more connected networks that provide for the pedestrian, bikes, and transit as well as autos—what are now called "complete streets." Likewise, the approach to planning will shift from segregated

single-use zones to a rich, finer-grained lexicon of mixed-use places and communities. Rather than the simplistic land-use designations found on most zoning maps today, diverse "place types" are needed to design complete regions, cities, and towns. There are five basic categories of such a place-based approach to community design: neighborhoods, centers, districts, corridors, and preserves.

Neighborhoods are the most basic building block of community. They are, by definition, walkable areas that integrate a range of housing types with parks, schools, and local services. Centers are the mixed-use destinations of a group of neighborhoods; they include jobs and housing as well as services and significant retail. Districts are special-use areas typically dominated by a primary land use, such as a university, a cultural center, industrial zones, or an airport. Corridors are the edges and connectors of the region's centers, neighborhoods, and districts. They come in many forms, from roads and highways to rail lines and bikeways, from power-line easements to streams and rivers. Preserves are the open space elements of the region, be they productive agriculture, parklands, significant geographies or natural habitat. Maps that use variations on these five simple elements can help to reconceive and redirect planning at the regional and local levels.

Neighborhoods

The subdivision is the most ubiquitous element in the urban landscape, whether comprising lots for single or multifamily houses. In the case of low-income sprawl and informal settlements, proper legal ownership designations and reasonable infrastructure are missing and thereby create major social and economic challenges. Too often, more formal subdivisions become isolated by arterials and often unified by income, age, and building type: a community of likenesses rather than a community of diversity. A healthy neighborhood is much more complex and can take a wide range of forms, densities, and scales. In its simple physical ideal, a neighborhood is a walkable place with shared parks and an identifiable center of local services and schools. It includes a variety of people, offering housing opportunities for rich and poor, large family and small, young and old. Its diversity and human-scale breed a kind of intensity and sociability that creates a resilient identity and a strong sense of community.

Many types of neighborhoods do not meet this ideal yet still sustain healthy communities. Some residential areas, for example, have several overlapping centers that are shared among neighborhoods—it is less like a self-contained cell with its own nucleus and more like a network of overlapping places and shared uses. It does not necessarily have a simple boundary or a single center. In fact, we now live in digital neighborhoods as much as physical neighborhoods, and the typical adult's social and economic lives are in most cases regional. Nonetheless, the idea of a local and physical neighborhood is essential for kids, seniors, and all of us. Local friends and acquaintances as well as familiar shopkeepers and services connect people in ways that still are intrinsically important. At their best, neighborhoods offer a way of knowing and connecting to people that are not just like us.

We live in nested communities that telescope in scale, the most local being a walking radius that cannot (at anything less than the highest densities) provide for all of our daily needs. In most cases, the sense of neighborhood extends beyond to other destinations necessarily shared by several neighborhoods. And, certainly, the identity and range of a neighborhood shifts for different people: seniors and kids may consider the neighborhood to be a sharply defined area that they sense as "theirs," mobile adults may gather a larger area into what they would call a neighborhood. Everyone's mental map differs and is not necessarily at the same scale.

Just as important as the physical context are the social, economic, and cultural networks that spring up in a neighborhood setting. These are the networks of daily life that produce what sociologists call "social capital." In the words of Harvard's Robert Putnam, who popularized the notion in the early 1990s, social capital consists of "civic engagement, healthy community institutions, norms of mutual reciprocity, and trust." Social capital broadens people's sense of self from "I" to "we" and encourages them to work together on community problems. Based on research, Putnam believes that community life—and even effective democracy—depends for its strength and vibrancy on the kind of informal networks that can be created only by a dense web of community organizations and neighborhood affiliations. With social capital, Putnam suggests, communities thrive; without it, they falter.

Sociologists such as Putnam have been at a loss to explain just exactly why the stock of social capital appears to be diminishing for many in the West. Indeed, some have argued that there is, in fact, no loss of social capital at all. Rather, people simply associate with one another in different ways. Instead of physical places, they create informal networks by engaging one another on the Internet. In other words, the argument goes, we don't need strong communities of place if we have strong communities of interest.

It is alluring to think that, thanks to the Internet and other virtual communication, there can be societies rich with social capital even if neighborhoods disintegrate—if "face to face" no longer matters and the chance encounters no longer happen. But no matter how strong and powerful chat rooms and Facebook networks become, it is hard to imagine that metropolitan regions can be strong and vibrant if neighborhoods continue to unravel. Putnam recognized this idea as counterintuitive: "My hunch is that meeting in an electronic forum is not the same as meeting in a bowling alley—or even in a saloon."[1]

Centers

Villages, towns, and city centers are the focal points, workplaces, and destinations of neighborhoods within the regional landscape. They gather together neighborhoods and local communities into the social and economic building blocks of the region. They are mixed-use, combining housing of different scales with businesses, retail, entertainment, and civic uses. Such centers form the key job centers of the region. In addition to employment, each typically includes civic uses and public spaces, such as greens, squares, churches, government institutions, recreation facilities, and day care. At their best they have a walkable network of streets, human-scaled and lined with accessible uses.

Centers are distinct from neighborhoods but may include neighborhoods. The distinction is that neighborhoods are primarily residential with some civic, recreational, and support uses mixed in. Centers, on the other hand, are primarily retail, civic, and workplace dominated with some residential uses mixed in. They are the destinations of several or many neighborhoods. Centers are also the appropriate location for major transit nodes and transfer points. They are, by definition, the TODs of the region.

A hierarchy of centers is essential, but there are no hard-and-fast distinctions among the types of centers, only general qualitative differences. In all cases, urban centers are qualitatively different than their modern disaggregated replacements: shopping centers, malls, office parks, and industrial zones. Although many of these commercial developments name themselves village or town centers, these names are often an empty illusion. True urban centers are profoundly different. In addition to being walkable and mixed-use, they are civic in ways that the parking lots and single-story boxes of our commercial environments can never be.

A village center is the most common and smallest of this type. Its retail component is defined by the inclusion of local stores, such as a grocery, wet or dry markets along with services, smaller shops and restaurants. A village center typically mixes second-floor uses—housing and small offices—with its commercial and retail. It adds recreation and civic uses and integrates all these activities within an accessible and walkable street system. It is typically a local destination for five to 10 neighborhoods accessed by foot, bike or bus.

A town center is larger and more commercial than a village center. It typically includes a large number of office and employment uses, along with nighttime facilities, such as cinemas, theaters, museums, and hotels. Its retail component is close to the scale of what the retail industry calls a "community center," anchored by several major stores that are accompanied by specialty shops and restaurants. Second-floor office and residential uses add to the intensity and urbanity of the area, and cinemas, bars, and restaurants maintain its nightlife.

The most important potential of the town center is as a sub-regional employment center and the potential for strong transit connections. Unlike the typical suburban format, its office buildings are not surrounded by parking lots and its uses are not separated by six-lane arterials. Parking restricted in ratio to the transit, structured and shared with nighttime and weekend uses. The addition of dense housing also transforms these areas into more complex urban neighborhoods as well as regional destinations. This mix of uses and intensities makes the town center a key station in any regional transit system.

Defining a city center is complex and elusive as it can come in so many forms, densities, and characters. City centers are the most compact and dense form of community with the greatest range of uses in the region. Even more than in a village or a town center, city centers must be mixed-use, walkable, dense, and transit served. They must also be more intense, more inclusive, more diverse, and more active than their smaller village and town counterparts. They hold the history, the color, the economics, and the cultural character of the region. As they become the cultural and economic focus of the region, they also become the transit vortex of the metropolitan circulation system.

Regions can and, in many cases, should have several city centers. For example, the San Francisco Bay Area has at least three: San Francisco, San Jose, and Oakland. Either multiple or singular, city centers form the primary focus of a region. They are the business, cultural, and civic centers that provide the global identity and international destination of a metropolitan area. Their differences, in turn, help to define the surrounding metropolis.

Districts

Not all places in the new lexicon are urban or mixed. Districts are areas that accommodate uses not appropriate for a mixed-use environment—those that cannot be of a scale, mix, and character that fit within a neighborhood or a city center. Examples of such uses are plentiful: light and heavy industrial areas, airports and major seaports, big box retail and distribution centers, military bases, and university campuses, to name a few. Districts are also the location for locally unacceptable land uses: the junkyards, abattoirs, auto repair shops, rail and truck depots, prisons, and so forth. These areas are critical to the economic and functional life of a region but must be separated from the fine grain of a neighborhood or the complex mix of a center.

Unfortunately, some uses that are often segregated as part of districts can be more closely integrated with centers—and should be. Office parks are a prime example. Under current planning practice, these primary work destinations are isolated and clustered into single-use districts near freeway interchanges. Through some misplaced identification

with factories, offices are too often seen as a poor fit with village, town, and city centers. To the contrary, they should be integrated into our mixed-use centers. Such integration adds strength to the retail, reinforces the transit system, and increases the value of any of the center's civic uses.

The challenge of integrating offices into urban centers is often their scale. The design challenge is to maintain human-scale and pedestrian connections with large buildings and large parking areas. In city centers, the solution is conventional and well established: the high-rise building wrapped with ground floor retail. In town centers, midrise buildings can be integrated into a block system that respects the pedestrian while allowing efficient building footprints. Shared parking, structured parking, and reduced parking (when transit is accessible) all can help mitigate the separations typically created by large surface lots. A hierarchy of streets can easily allow for a pedestrian-friendly side of the office development and a back service and parking side.

Other examples of important uses mistakenly isolated from centers are many cultural, religious, and civic facilities. The ubiquitous suburban civic center or entertainment zone is a lost opportunity to complete and reinforce town and village centers. Civic buildings, houses of worship, and cultural facilities can be integrated into the fabric of communities, mixed with employment, shopping, and some housing. The modern equivalent of the courthouse square can be a focal point of new main streets. Theater districts and movie complexes should also be an essential part of the centers that draw communities together.

Light industry and factories, on the other hand, should be segregated. The low intensity of jobs in these areas, the need for frequent truck access, and the scale of the buildings do not lend themselves to mixed-use areas. Warehouse facilities and businesses that use toxic materials also need separation into special districts. In a way, big box retailing is a kind of light industrial use. It is, in effect, a warehouse that sells merchandise directly. These uses are more appropriate in light industrial areas than in village or town centers, unless they take on a more urban form, as are just beginning to happen in some central city developments. But regardless of form, their economics are often destructive to the kind of local, small-scale retail businesses that support the urbanism and civic quality of most centers. They represent one of the most vexing quandaries of urbanism: while providing the affordability that so many households need, they are destructive to historic main streets, local shops, and local produce.

Some other uses, such as college or university campuses, become special districts because of their functional needs. Certainly, the edges of these institutions must be clear and identifiable, but the relation between such special districts and mixed-use centers is a rich opportunity. The "town and gown" tension adds interest and character to many cities and towns throughout the country.

Preserves

Preserves are perhaps the most complex and controversial building block of healthy regional planning: complex because they include so many very different landscapes, locations, and potential uses; controversial because the means of saving the land and the economic impacts are challenging. Identifying which landscapes are appropriate for preservation is a major component of a regional vision. Natural preserves and green belts at the edge of a region are almost universally desired, as are open space corridors within the region. But their delineation, financing and preservation can be a political and economic challenge.

Sometimes natural features give clear definition to the region; oceanfront and mountain ranges or waterfront and lakes are good examples. But preserving unbuildable areas—wetlands, riparian corridors, steep slopes, watersheds, forestlands, and

endangered habitat—will rarely define a complete regional boundary. Regions surrounded by prairies, agriculture, forests and pasture lands are examples of places without easily discernible natural edges. In most regions, simply preserving crucial environmental lands is not enough to contain sprawl. In all cases, a combination of rural preserves, grazing pastures, open-land preservation, infrastructure planning, and land use controls is necessary to direct the location and types of urban expansion areas.

There are two distinct types of regional preserves: community separators and regional boundaries. Community separators function to create open space breaks between individual communities within the region. They are a high priority for communities seeking to avoid the "wall-to-wall" quality of many massive metropolis. Lacking sufficient size for large-scale agriculture, community separators are often preserved for local farms, habitat, or recreation. They can be created by cluster development that dedicates open space in a coordinated way, by the creation of urban growth boundaries, by limits to infrastructure and services or by the outright purchase of development rights from property owners. Being closest to contiguous development and infrastructure, community separators are an expensive form of open space when not legally constrained.

Preserving farmlands as regional boundaries is often difficult as the land values are not high comparted to potential development. But preservation is critical because high-quality farmland is threatened in many areas of the world. In the United States, for example, American Farmland Trust reported a loss of approximately one and a half million acres per year of "prime farmland" from 1992 to 2012.[2] Prime farmland often coincides with development because major metropolitan areas tend to be located in river valleys and their typically rich soils. But the issue goes well beyond actual farmland developed to what is called the "zone of conflict" surrounding development, in which farming practices are compromised. For example, if one million acres of farmland are lost to urbanization in California's fertile Central Valley, as much as 2.5 million acres will fall into this constrained zone at the edge of development.[3]

It is an uphill fight to preserve greenbelts and contain sprawl in much of the world. This is largely because the urban land values that become available to farmers and ranchers overwhelm the tax incentives for preservation. So growth must be guided carefully by intelligent placement of infrastructure or, no matter how controversial, ultimately by growth boundaries and regional plans that specify specific preferred growth areas. Piecemeal preservation can support but not replace comprehensive green plans.

Beyond the need to preserve our agricultural capacities is a larger desire to preserve the rural heritage close to their urban areas, regardless of soil classification or ecological value. Whether for scenic value or the growing sense that local, fresh produce is healthy and ecological, this impulse has translated into efforts in many countries to finance open space acquisition and purchase development rights. A complete regional design must integrate protected habitat with significant farmland preservation and scenic corridors. The tools to do so are as varied as the types of land that need to be preserved.

Corridors

Although corridors come in many types and sizes, natural or human-made, they always constitute flow and movement. Waterways, traffic, freight, and habitat movements define the unique corridors of within each metropolitan region. Corridors become either the boundary of a community or one of its unifying bits of common ground—a main street or riverfront are simultaneously destinations and passageways. Corridors are the skeletal structure of regional form and its connections; they form the defining framework of its future.

Natural corridors can be defined by specific habitats, unique ecologies, or watersheds. In most cases, they are a combination of all three. The interconnected quality of natural corridors is essential to their viability and efficacy. The more disconnected the system, the less ecological value it has and therefore the less power it has in shaping the built environment. For this reason, a regional approach to open space corridors are essential, and preserving corridors rather than isolated parcels is critical.

Each region has a watershed structure that is fundamental to its natural form. Every watershed is made up of catchment areas (mountains and hillsides), drainage areas (streams, lakes, and rivers), wetlands (deltas and marshlands), and shorelines (beaches and cliffs). There may be other natural corridors worth preserving in the region—such as specific habitats of endangered species, unique ecosystems, or scenic corridors—but these four basic watershed domains are critical and contain many of the other types. Although many elements of a watershed (wetlands, riparian habitat, and shorelines) are protected by regulation, the results of the regulations are often piecemeal, emerging only as individual properties are developed and often in a disconnected form. Continuity is more important than quantity in natural corridors.

Using the region's waterways as a primary corridor system not only is ecologically wise but enhances the quality of life. The American River Parkway in Sacramento, California is a 23-mile park that not only preserves valuable wetlands, habitat, floodplain, and water quality, but also forms a major recreational asset for the entire region. It has become a kind of regional commons that everyone identities with and enjoys. In many areas, these waterways have been lost to private development, flood control projects, or channelization. The Los Angeles river in Southern California is a prime example. Restoring them after development is a massive challenge, as is preventing further loss. Re-establishing lost waterways is part of the ecological repair that each region needs to undertake as part of building its open space network.

A striking example of the intersection among habitat preservation, waterway protection, and regional land use patterns has been created by the recent placement of salmon on the endangered species list in the Pacific Northwest. The regional land use implications are immense. Not only do the waterways themselves have to be protected with significant buffers, but the water quality and water temperature must be controlled from increased stormwater runoff due to development throughout the watershed. Because of this, the quantity of impervious surfaces and the design of detention and water-quality treatment systems become central features of the region. These systems then become assets within neighborhoods, just as the larger watershed elements create invaluable open space elements within the region. Ecology and urban design become inseparable.

Ironically, utility corridors are perhaps as important in shaping a regional plan as are the open space corridors. Investments in water-delivery systems, sewers, drainage systems, freeways, and other utilities form the infrastructure backbone of development. If these investments push outward into areas appropriate for natural or farmland preservation, no amount of zoning and regional regulation will stop inevitable development. Designing these systems to be efficient, compact, and responsive to the land-use vision of the region is essential. The Urban Service Boundary in the Twin Cities of Minneapolis and St. Paul is a good example of using infrastructure planning as a powerful tool in regional design.

In the Global South, the problem is often the lack of utilities rather than their location. In all cases however, utility corridors must be coordinated with land use policy in both directions: they must be expanded and upgraded in areas targeted for urban expansion, infill and redevelopment, and they must be constrained in areas targeted for preservation.

This coordination can be accomplished only at the regional scale, inasmuch as local politics too often serve local development interests. Just as with highways, the bias of the past 40 years has been to subsidize infrastructure at the urban fringe—and this has been a catalyst for sprawl.

Reusing and repairing old, underutilized, and decaying corridors, either natural or human made, is an imperative for any regional strategy that includes significant infill and redevelopment. The strip commercial corridors of our older suburbs offer a chance, through redevelopment, to transform into mixed-use, walkable districts. In these areas, the roads need to be redesigned and enhanced for pedestrian, bike, and transit, and the infrastructure must be upgraded for higher densities and a mix of uses.

Natural and man-made corridors are the superstructure of the regional metropolis—they help to define its neighborhoods, centers, districts, and preserves. Their design can create healthy limits and appropriate opportunities for infill or can support scattered growth and community disinvestment. They can form rational boundaries and connectors for human-scale communities or they can fuel the next generation of sprawl.

A key element of vibrant cities and these principles are forms of access and mobility that are efficient, equitable and environmentally positive. The less dependent a region is on private vehicles, especially single-occupant cars, the less congestion, air quality impacts, and road accidents are likely. There is consensus within the transportation profession that the following metrics are key to a balanced and effective circulation system. In fact, most new traffic simulation models use these factors as key drivers. The following metrics for mobility are consonant with the principles.

SUSTAINABLE TRANSPORT

Density: Higher overall density of housing and jobs has long been correlated with lower auto use and more walking, biking and transit use. While areas dominated by middle income sprawl are deficient in this factor, the other two types of sprawl are dense in either population distribution if not building. The problem in these areas typically rests in the other factors.

Diversity: The more mixed-use an area the greater the opportunity for local trips on foot and the shorter the trip length. Many cities and historic districts where mixed and diverse, but recent development patterns have shifted to the international norm of isolated land-use zoning.

Design: Mix and density are not enough if the design of the streets and building frontages do not support easy and convenient pedestrian mobility. A walkable district has active and useful edges and short, safe street crossings. The design of many neighborhoods has grown increasingly inhospitable to pedestrians and bikes, as buildings and shops have retreated from what traditionally were public spaces designed for street life and activity. In low-income areas the infrastructure itself is insufficient.

Accessibility: The placement of regional destinations such as job centers and major institutions in areas well served by transit has a major impact on travel to work mode split, peak hour congestion, and overall auto use. Access to major job centers is becoming a crisis as commercial development is clustered in districts too large and isolated to be served by auto or transit.

Transit: The level of transit service, its headways, capacities, multimodal connections, and overall ease of use impact the key metric of mode split. If transit stops are too far from home, if the service is infrequent, if the travel time is slow, the use of transit will decline. Many large cities are aggressively investing in robust transit service, while small and medium cities often lack adequate service. Bus service on mixed streets is often slow and contributes to congestion.

Demand Management: The relative cost of different forms of mobility impacts transportation choices powerfully. Parking costs, road and bridge fees, and district access limits can all play a significant role in travel behavior. Few cities employ such demand management strategies, however they will become necessary as auto ownership grows while land use polices remain unchanged.

Demographics: The type of household, average age, and its income has a big impact on auto ownership rates and the average distance traveled per household. Providing affordable housing in areas well served by transit and local services allows lower cost transportation choices. As the Global South becomes wealthier and its urban middle class grows, its demographics will stress its transportation systems dramatically.

A NEW URBAN DESIGN PARADIGM

These universal urban design imperatives and regional building blocks provide a new way of thinking about community development and, effectively, a new system of planning. Putting these elements together into a self-reinforcing whole and implementing it at the regional scale is the challenge of the next generation of designers and planners. The taxonomy of neighborhoods, centers, districts, preserves, and corridors just described will eventually replace the old land-use language of single-use zones—neighborhoods replacing subdivisions, village centers replacing shopping centers, town centers replacing office parks and malls and city centers replacing single-use central business districts. In so doing, mixed-use urban places will become the new DNA of cities.

Endemic to our design problems is that land use, built form, environmental regulation, street design, civil engineering, and landscape standards are isolated disciplines controlled by independent public agencies, regulations, and approval processes. What's more, each profession—traffic, civil engineering, planning, landscape, and architecture—has its own codes, which rarely sync with one another or to the particular qualities of place.

For example, road design adheres to standards based largely on the desired speed and volume of vehicles rather than the type of community the roads are serving. When a highway comes into a town, it should change in character, design, and speed. Or, when an arterial comes into a village center, it should adapt to provide for bikes, pedestrians, and parking. Likewise, environmental standards often ignore place and impose formulaic regulations. A good example is the stormwater detention standards that require the same large ponding areas in both suburban and city center locations. While large retention areas are appropriate in low-density areas, open space in urban areas is precious and must be multipurpose.

The kind of transformation that the climate change challenge and the massive growth of cities over the next 50 years will require involves more than analysis, consensus building, and vision—it will require a new set of planning tools, methods, and standards for the design professions. This section outlines the land-use elements and design philosophy that can make up the planning and urban design documents for sustainable urban development. This new lexicon of land-use types will then need to be complemented by a new approach to transportation investments and street design. Together, these elements can define the physical dimensions of environmental, economic and social urban wellbeing.

The seven principles of city design presented in this book summarize the key urban design strategies for developing urban districts, cities, and metropolitan areas that can directly reduce carbon emissions, reduce infrastructure costs, consume less land, water and energy, and improve air quality. Indirectly they help to create more economically and socially vital cities. They are derived from international best practices. When applied together, they can help countries throughout the world create beautiful, thriving cities that will be models of smart urban development.

These principles depend upon and reinforce one another. Different cities can adopt differing mixes and priorities from the seven, but they are intended as pieces of a whole. They focus on the urban design, land-use, and transportation elements of a city master plan, not engineering, building design and infrastructure. While green building and sustainable infrastructure is critical to completing the picture, these are vast and varied areas of expertise and well covered in other documents.

They do not address implementation and financing. Each country and city have differing levels of economic resources, institutional capabilities, and political norms. In each context these economic, institutional and political realities will

shape the process and ultimate outcome. The principles are, therefore, a set of goals and urban forms that, while universal best practice, must be calibrated to the place and used to set policy direction and goals rather than means or process.

The strategies and standards introduced here represent what many of the worlds' leading experts believe to be best practices in urban design. Cities across the globe are gradually adopting these measures, and those that have embraced them are the most livable and economically secure cities in the world.

These principles support each other; they are, in some cases, circular. Blocks with mixed uses encourage walking, and walkable cities create customers for local businesses. Smaller block sizes encourage bike and pedestrian use, which cuts down on traffic, allowing public transit and automobile traffic to run better, and so on. Enacting all the principles is the powerful catalyst for a sustainable, livable city, but each alone is worthy.

The principles define a new direction at multiple scales—regional structures, city-wide planning, district design, project and building architecture, and the infrastructure systems that serve them. At the regional scale, one principle uses urban growth boundaries to direct city growth to preserve natural, agrarian, and historic resources while focusing on infill and redevelopment. Within these boundaries, another principle focuses on transit-oriented development to direct development and destinations in ways that offer convenient alternates to the car. At the district or neighborhood plan scale, mixed-use communities designed around human-scaled small blocks with accessible public space and parks support walking and biking. Alternate transportation systems from extensive and varied transit systems to auto-free streets and walk/bike policies reduce pressure on roads and increase low-cost mobility. To complement the urban design principles, green buildings, durable materials and environmentally sound landscaping create environments that are resource-efficient as well as more livable. In addition, a city's infrastructure plans can deploy state-of-the-art technology for sustainable infrastructure to advance renewable energy and efficient co-generation, as well as conserve and recycle waste and water. The integration of all of these strategies can build the next generation of cities—cities that can set global standards for livable, sustainable, low-carbon futures.

In the following seven chapters, we define each principle and its standards with a rationale, provide key metrics to ensure that they can be monitored, explain the key economic, environmental, and social benefits, describe brief case studies, and also list the best practices for optimal implementation.

Endnotes

1 Robert Putnam, "Bowling Alone: The Collapse and Revival of American Community." (New York: Simon & Schuster, 2000).

2 American Farmland Trust (AFT), "Farms Under Threat: The State of America's Farmland 1992 to 2012" (Washington, DC: AFT, 2012).

3 American Farmland Trust (AFT), "Alternative for Future Growth in California's Central Valley: The Bottom Line for Agriculture and Taxpayers" (Washington, DC: AFT, 1995).