RapidFire & UrbanFootprint
Two Tools for Urban Growth Scenario Modeling

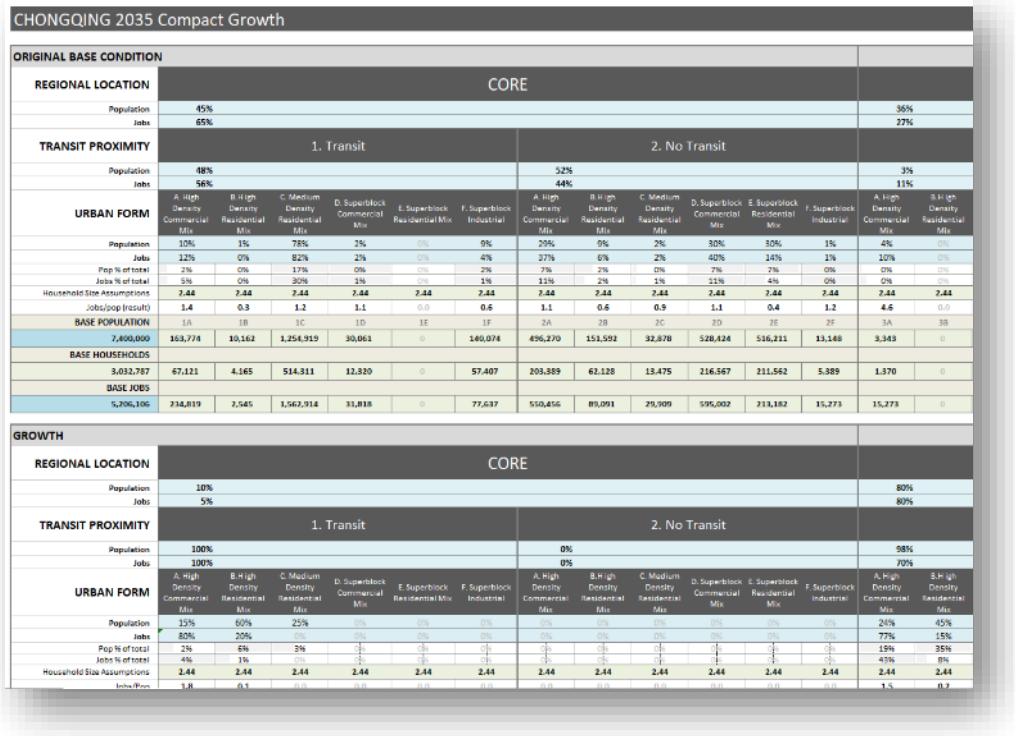
World Bank Global Platform for Sustainable Cities (GPSC) Expert Meeting
23-24 April 2018

Overview

- Introduction: RapidFire & UrbanFootprint
- Vision California and Beyond
  Planning and policy support at all scales
- Mexico City Regional Scenarios
  First international adaptation
- Chongqing 2035
  Planning for sustainable urban growth in China

Two tools built to examine the role of land use

RapidFire



CHONGQING 2035 Compact Growth

ORIGINAL BASE CONDITION

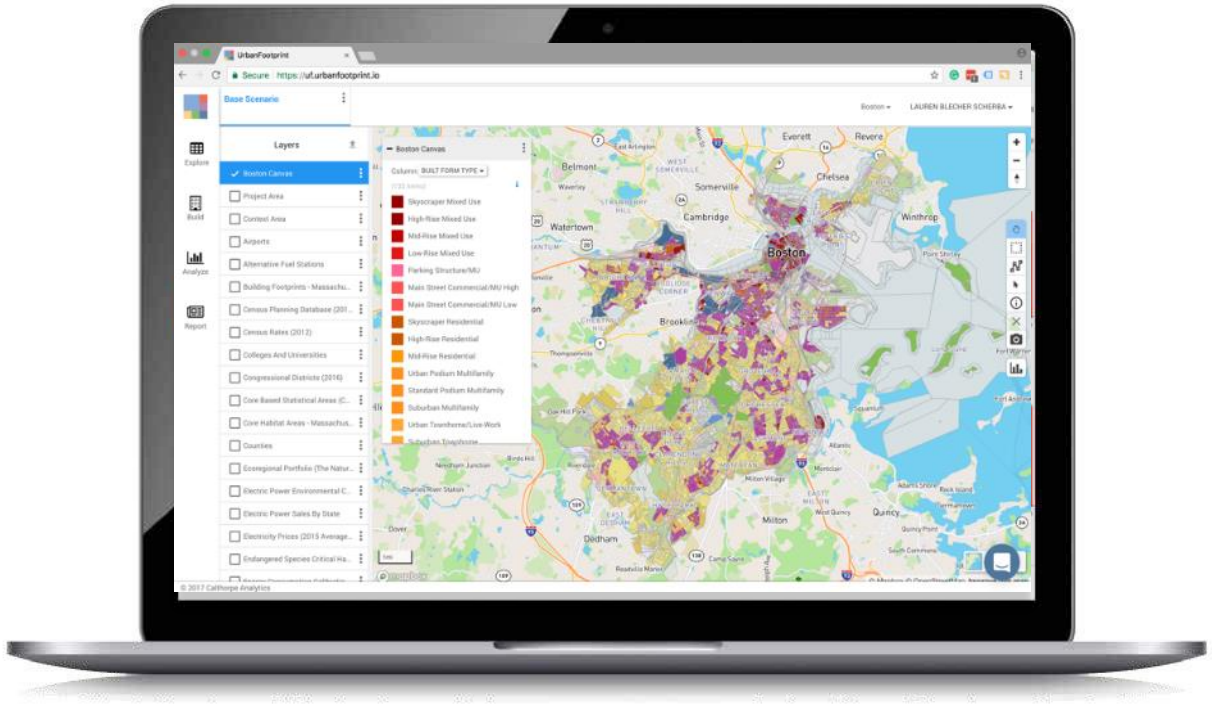
REGIONAL LOCATION	CORE												
Population	45%												36%
Jobs	65%												27%
TRANSIT PROXIMITY	1. Transit						2. No Transit						
Population	48%						52%						3%
Jobs	56%						44%						11%
URBAN FORM	A. High Density Commercial Mix	B. High Density Residential Mix	C. Medium Density Residential Mix	D. Superblock Commercial Mix	E. Superblock Residential Mix	F. Superblock Industrial	A. High Density Commercial Mix	B. High Density Residential Mix	C. Medium Density Residential Mix	D. Superblock Commercial Mix	E. Superblock Residential Mix	F. Superblock Industrial	A. High Density Commercial Mix	B. High Density Residential Mix
Population	10%	1%	78%	2%	0%	9%	29%	9%	2%	30%	30%	1%	4%	0%
Jobs	12%	0%	82%	2%	0%	4%	37%	6%	2%	40%	14%	1%	10%	0%
Pop % of total	2%	0%	17%	0%	0%	2%	7%	2%	0%	7%	7%	0%	0%	0%
Jobs % of total	5%	0%	30%	1%	0%	1%	11%	2%	1%	11%	4%	0%	0%	0%
Household Size Assumptions	2.44	2.44	2.44	2.44	2.44	2.44	2.44	2.44	2.44	2.44	2.44	2.44	2.44	2.44
Jobs/pop (result)	1.4	0.3	1.2	1.1	0.0	0.6	1.1	0.6	0.9	1.1	0.4	1.2	4.6	0.0
BASE POPULATION	1A	1B	1C	1D	1E	1F	2A	2B	2C	2D	2E	2F	3A	3B
7,400,000	163,774	10,162	1,254,919	30,061	0	140,074	496,270	151,592	32,878	528,424	516,211	13,148	3,343	0
BASE HOUSEHOLDS														
3,032,787	67,121	4,165	514,311	12,320	0	57,407	203,389	62,128	13,475	216,567	211,562	5,389	1,370	0
BASE JOBS														
5,206,106	234,819	7,545	1,562,914	31,818	0	77,637	550,456	89,091	29,909	595,002	213,182	15,273	15,273	0

GROWTH

REGIONAL LOCATION	CORE												
Population	10%												80%
Jobs	5%												80%
TRANSIT PROXIMITY	1. Transit						2. No Transit						
Population	100%						0%						98%
Jobs	100%						0%						70%
URBAN FORM	A. High Density Commercial Mix	B. High Density Residential Mix	C. Medium Density Residential Mix	D. Superblock Commercial Mix	E. Superblock Residential Mix	F. Superblock Industrial	A. High Density Commercial Mix	B. High Density Residential Mix	C. Medium Density Residential Mix	D. Superblock Commercial Mix	E. Superblock Residential Mix	F. Superblock Industrial	A. High Density Commercial Mix	B. High Density Residential Mix
Population	15%	60%	25%	0%	0%	0%	0%	0%	0%	0%	0%	0%	24%	45%
Jobs	80%	20%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	77%	15%
Pop % of total	2%	6%	3%	0%	0%	0%	0%	0%	0%	0%	0%	0%	19%	35%
Jobs % of total	4%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	43%	8%
Household Size Assumptions	2.44	2.44	2.44	2.44	2.44	2.44	2.44	2.44	2.44	2.44	2.44	2.44	2.44	2.44
Jobs/Pop	1.8	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.2

Excel-based
Top-down

URBAN FOOTPRINT



Geospatial
Bottom-up

RapidFire

- Represents land use in terms of broad, easily legible Place Types
- Transparent assumptions and calculations
- Adaptable for different contexts
- Can be used to represent, model, and analyze scenarios or plans from other sources
- Receptive to research-based inputs
- Links performance to place types to produce a range of metrics

URBAN FOOTPRINT

- Web-based SaaS
- Pre-loaded with a growing library of US datasets
- Users can upload local data
- Uses a detailed schema of building and place types
- Supports exploration of existing conditions and streamlines scenario development and analysis
- Performs geospatial analysis of a range of metrics, with more capabilities being added

When it comes to urban planning, the stakes are high

Foster Clear Communication with Comprehensive Reporting

Land Consumption

Energy Use

Transportation

Emissions

Public Health

Fiscal Impacts

Household Costs

Water Use

Walk Accessibility

Transit Accessibility

Conservation

Vision California and beyond

Planning and policy support at multiple scales

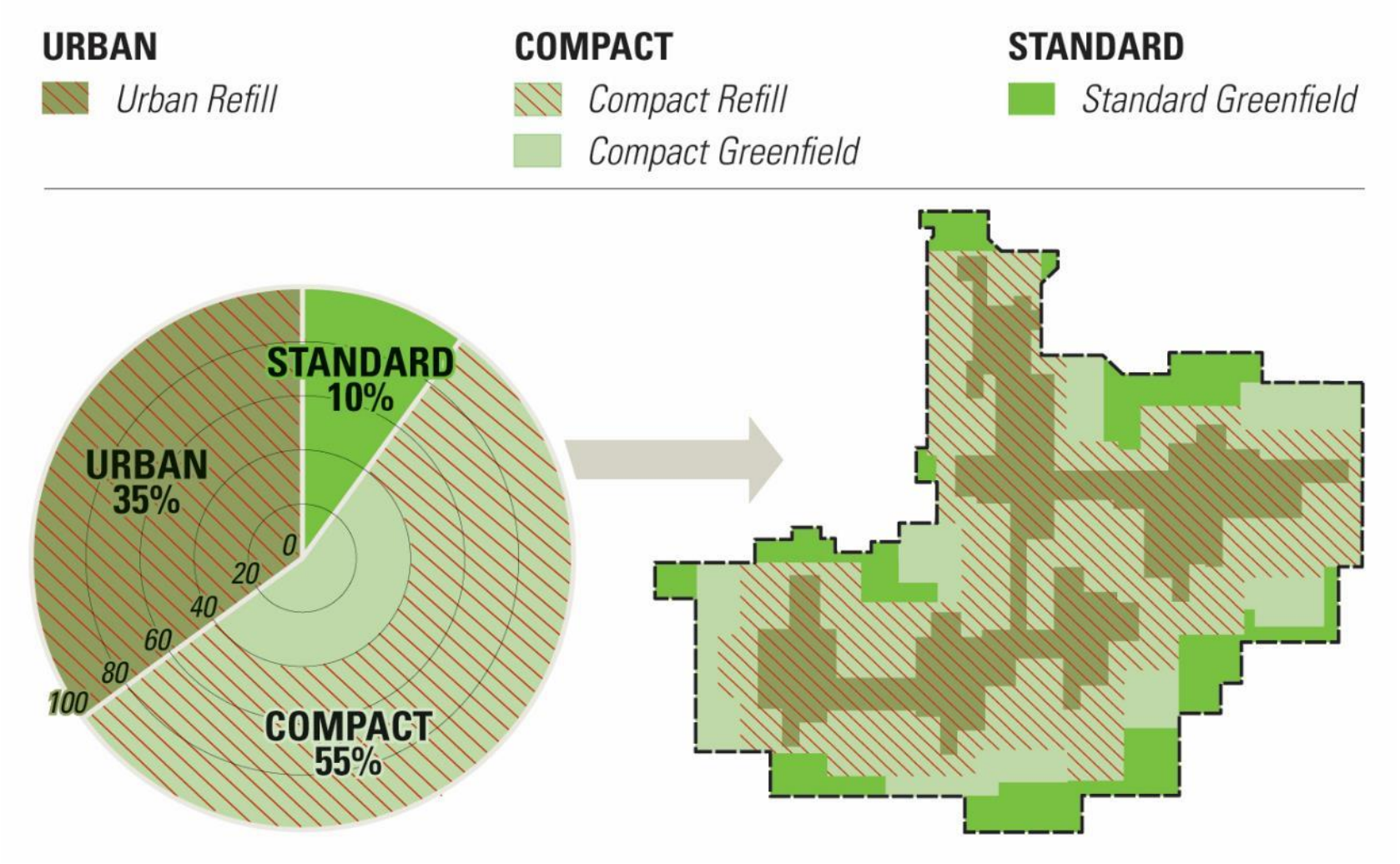
What role can land use play in climate policy?

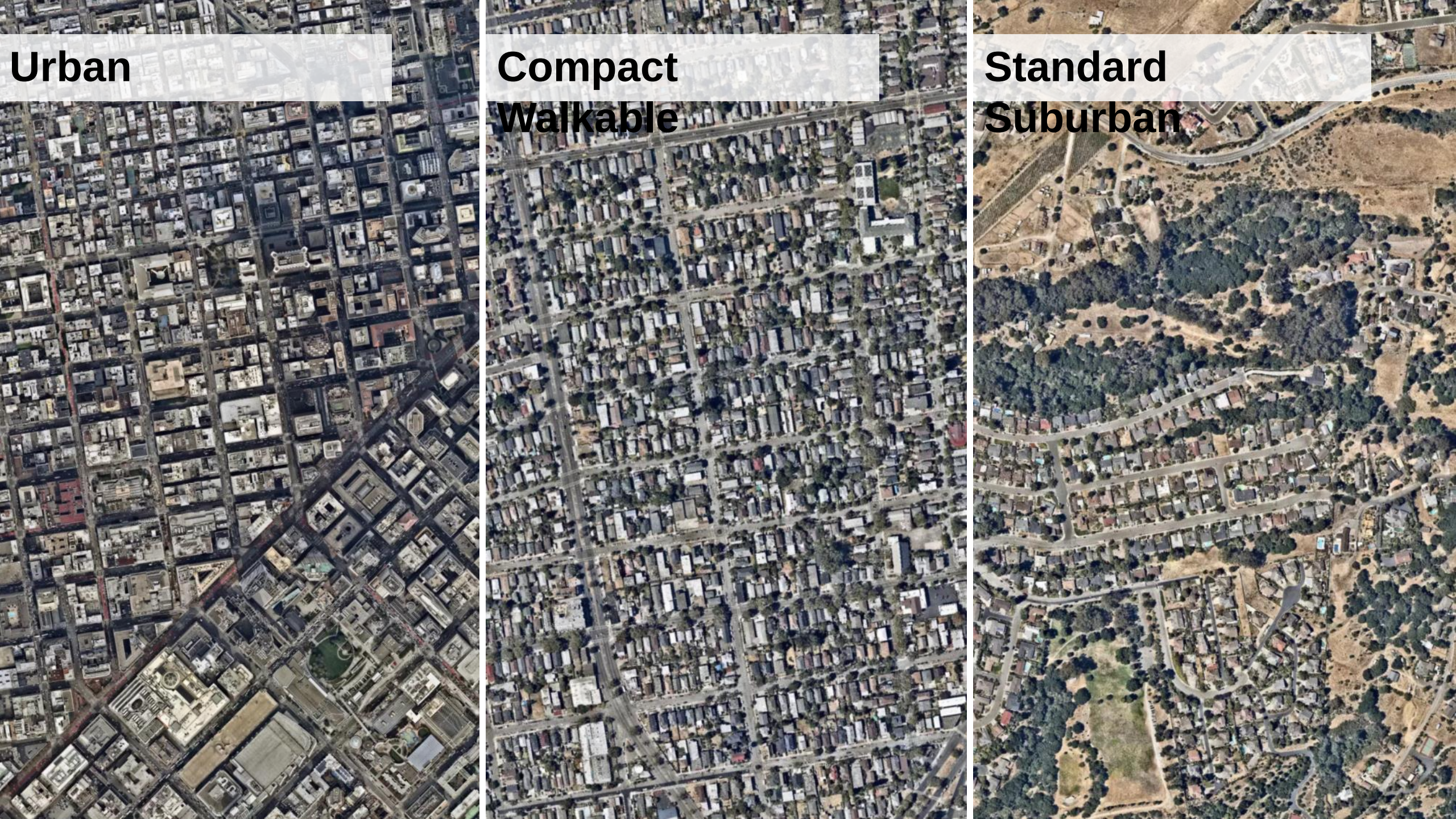
- California AB 32 – Actions across all sectors to achieve 80% below 1990 emissions by 2050
- SB 375 – Regional targets for land use/transportation plans to reduce vehicle miles traveled (VMT) and GHG
- GHG reductions + co-benefits

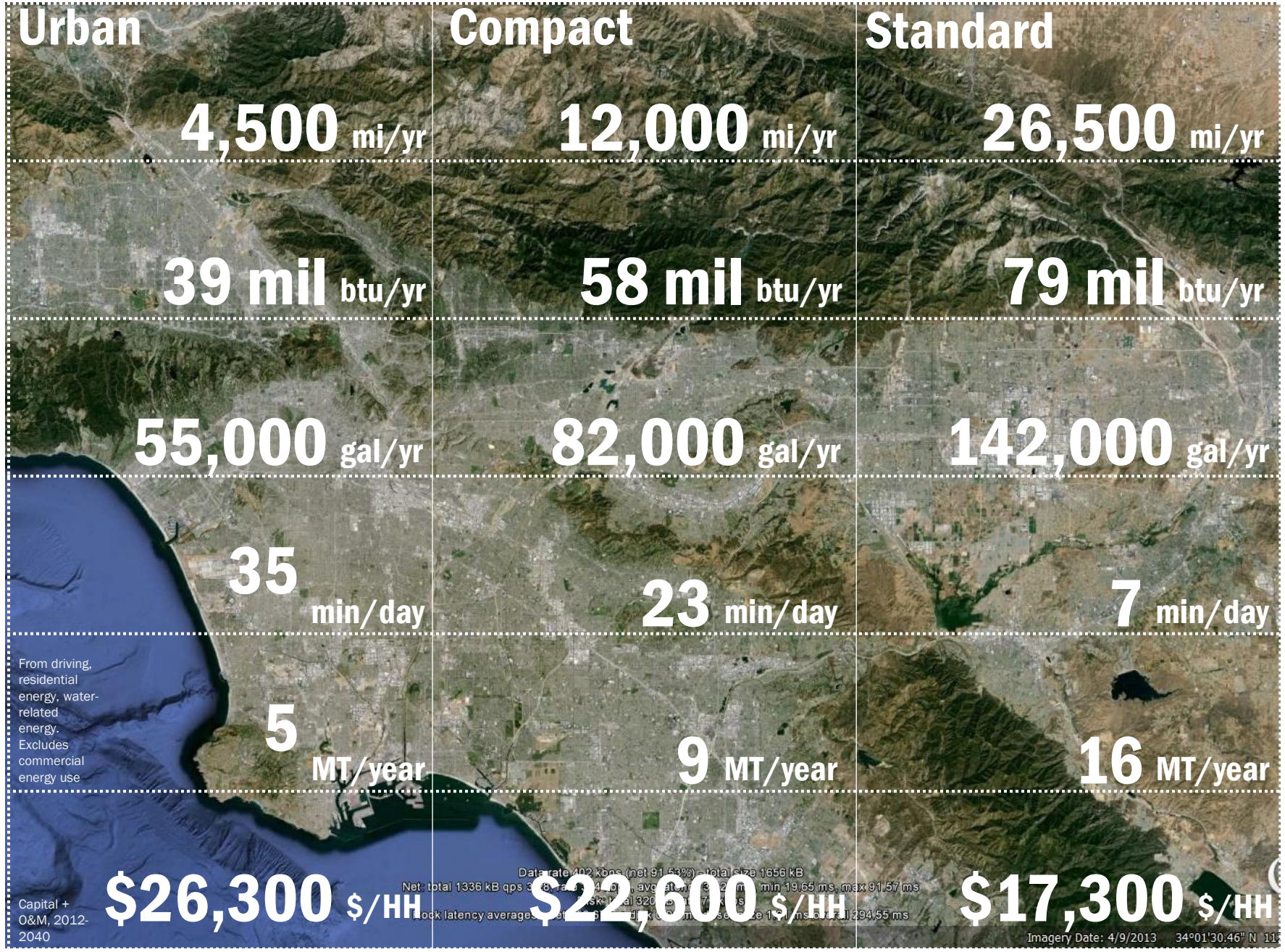
Vision California

- State-sponsored model and scenario development
- 50 million people by 2050
- Explored GHG emissions and co-benefits of “Business-as-Usual” vs. “Growing Smart”
- Land use options modeled with alternative policy-based technical assumption sets

RapidFire California Place Types




Urban
Compact Walkable
Standard Suburban



Comparison for Typical Southern California Household, 2012

Household VMT

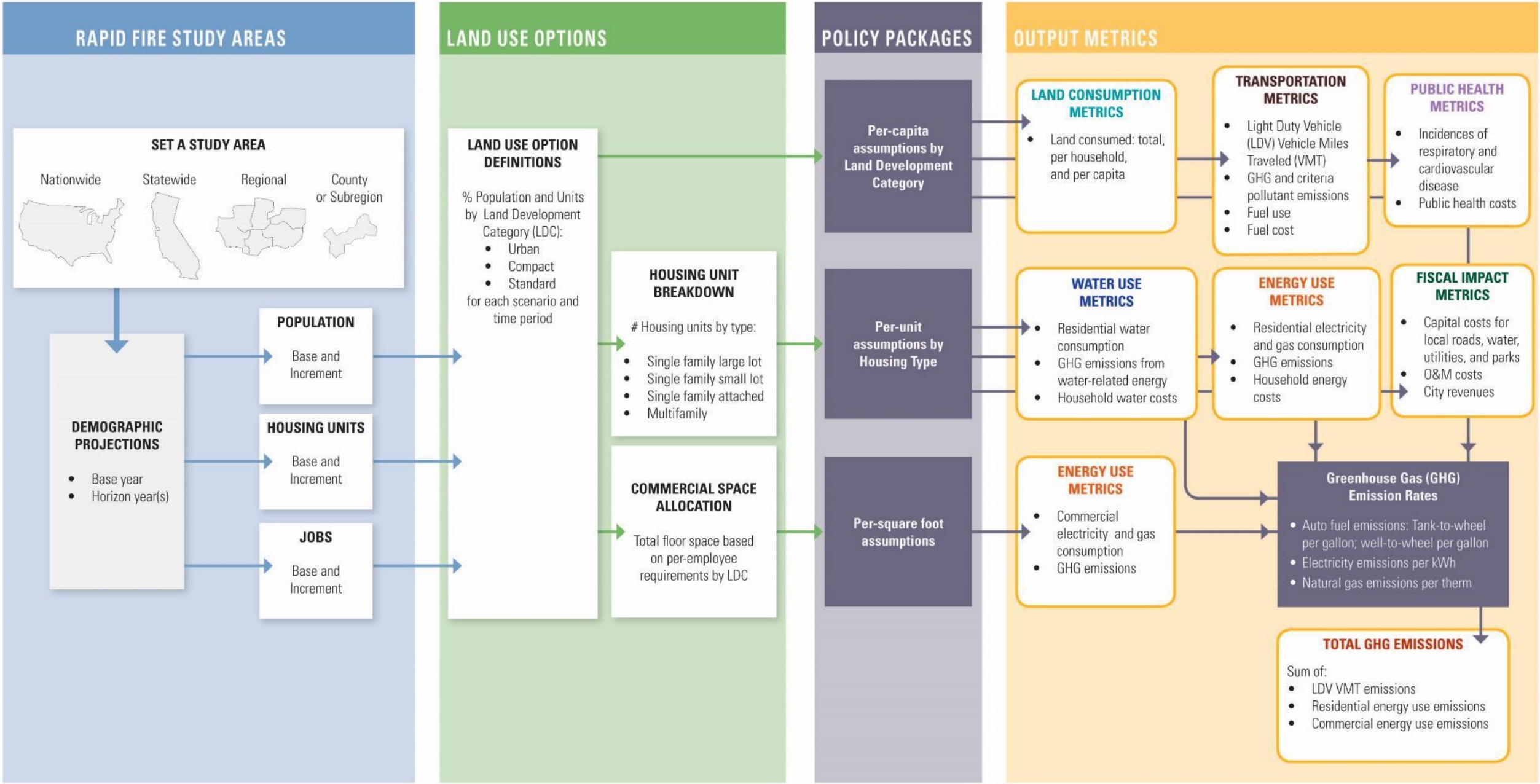
Residential Energy Use

Residential Water Use

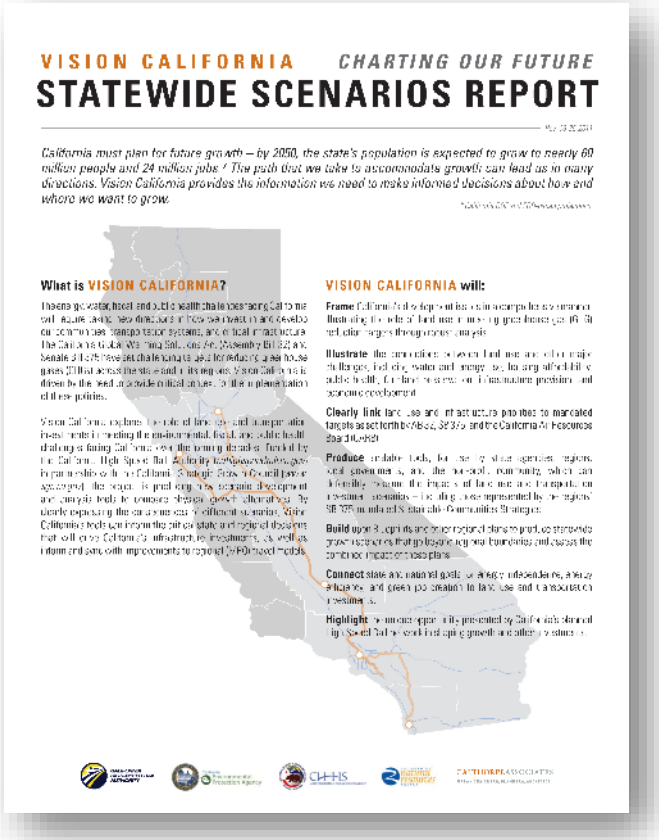
Walking

Carbon Emissions

Local Infrastructure Cost


RAPID FIRE STUDY AREAS
SET A STUDY AREA
Nationwide
Statewide
Regional
County or Subregion
DEMOGRAPHIC PROJECTIONS
Base year
Horizon year(s)
POPULATION
Base and Increment
HOUSING UNITS
Base and Increment
JOBS
Base and Increment
LAND USE OPTIONS
LAND USE OPTION DEFINITIONS
% Population and Units by Land Development Category (LDC):
Urban
Compact
Standard
for each scenario and time period
HOUSING UNIT BREAKDOWN
Housing units by type:
Single family large lot
Single family small lot
Single family attached
Multifamily
COMMERCIAL SPACE ALLOCATION
Total floor space based on per-employee requirements by LDC
POLICY PACKAGES
Per-capita assumptions by Land Development Category
Per-unit assumptions by Housing Type
Per-square foot assumptions
OUTPUT METRICS
LAND CONSUMPTION METRICS
Land consumed: total, per household, and per capita
TRANSPORTATION METRICS
Light Duty Vehicle (LDV) Vehicle Miles Traveled (VMT)
GHG and criteria pollutant emissions
Fuel use
Fuel cost
PUBLIC HEALTH METRICS
Incidences of respiratory and cardiovascular disease
Public health costs
WATER USE METRICS
Residential water consumption
GHG emissions from water-related energy
Household water costs
ENERGY USE METRICS
Residential electricity and gas consumption
GHG emissions
Household energy costs
FISCAL IMPACT METRICS
Capital costs for local roads, water, utilities, and parks
O&M costs
City revenues
ENERGY USE METRICS
Commercial electricity and gas consumption
GHG emissions
Greenhouse Gas (GHG) Emission Rates
Auto fuel emissions: Tank-to-wheel per gallon; well-to-wheel per gallon
Electricity emissions per kWh
Natural gas emissions per therm
TOTAL GHG EMISSIONS
Sum of:
LDV VMT emissions
Residential energy use emissions
Commercial energy use emissions

Vision California

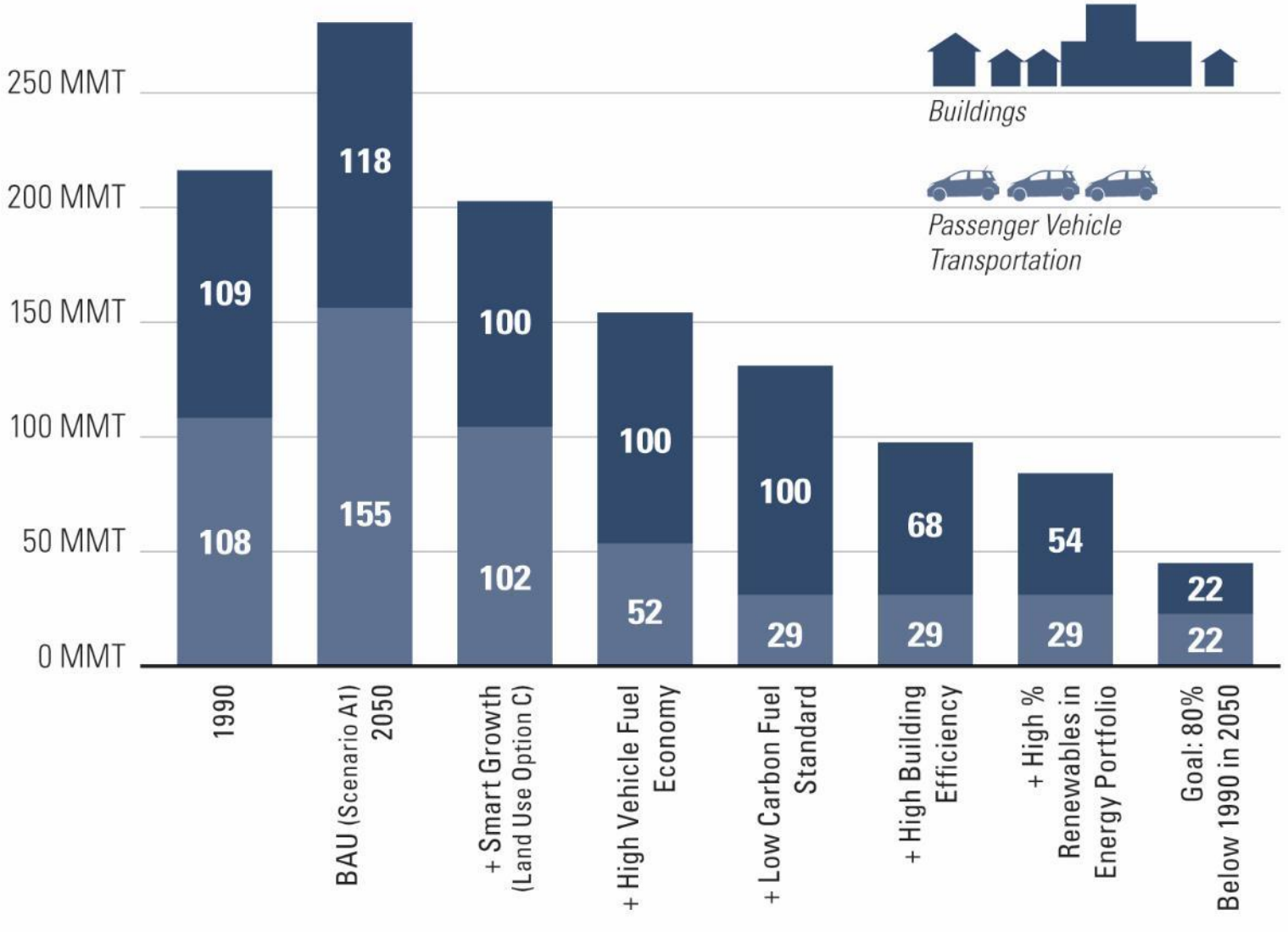

VISION CALIFORNIA *CHARTING OUR FUTURE*

STATEWIDE SCENARIOS REPORT

California must plan for future growth – by 2050, the state's population is expected to grow to nearly 60 million people and 24 million jobs. The path that we take to accommodate growth can lead us in many directions. Vision California provides the information we need to make informed decisions about how and where we want to grow.

What is VISION CALIFORNIA?

VISION CALIFORNIA will:

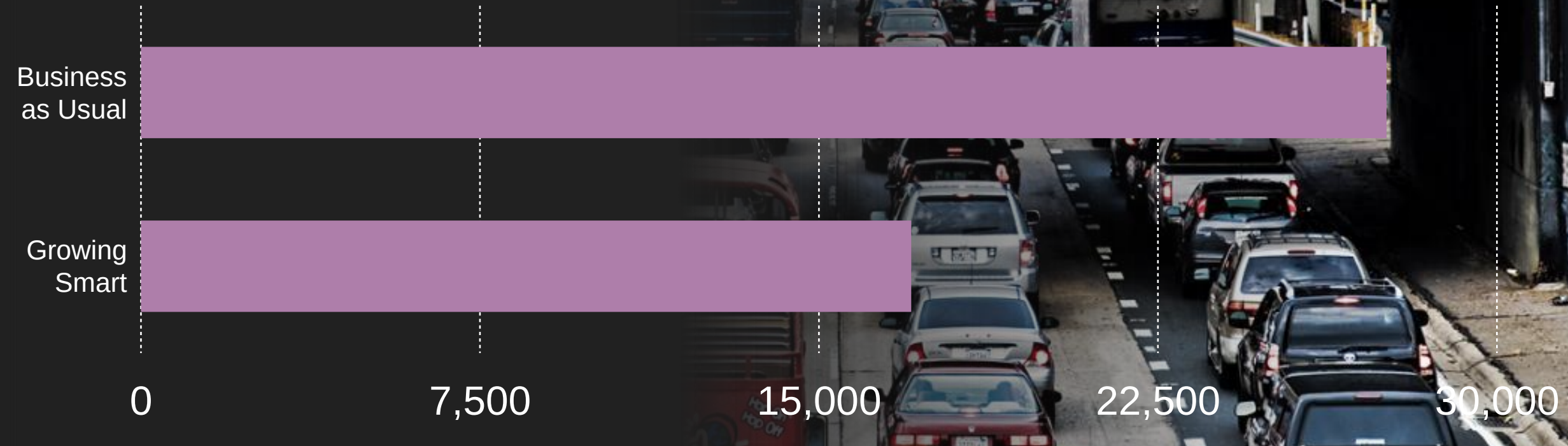


Vision California: Land Consumed

More land than Delaware
and Rhode Island combined

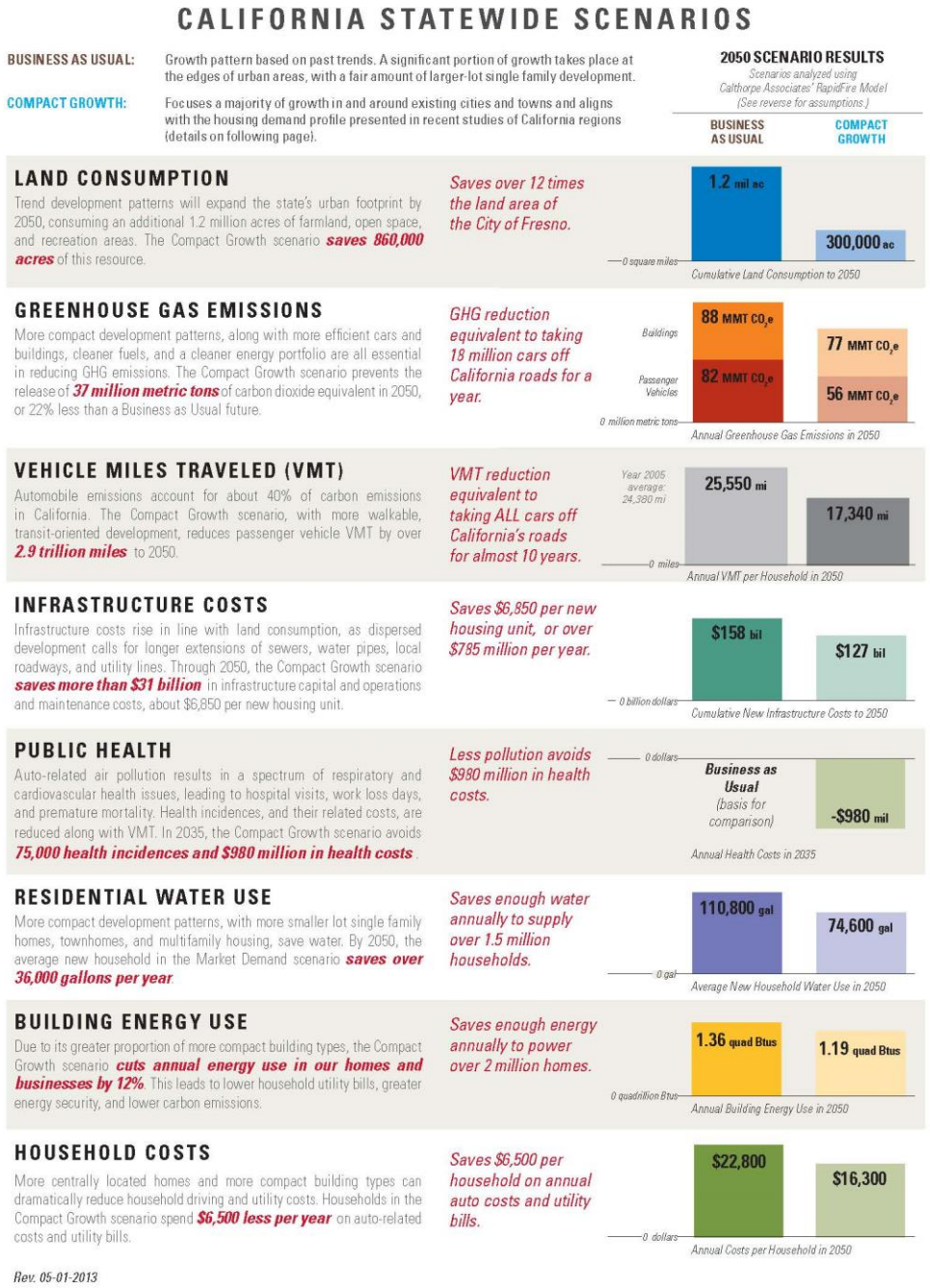
Vision California: Vehicle Miles Traveled

10,500 Fewer Miles
Per Household



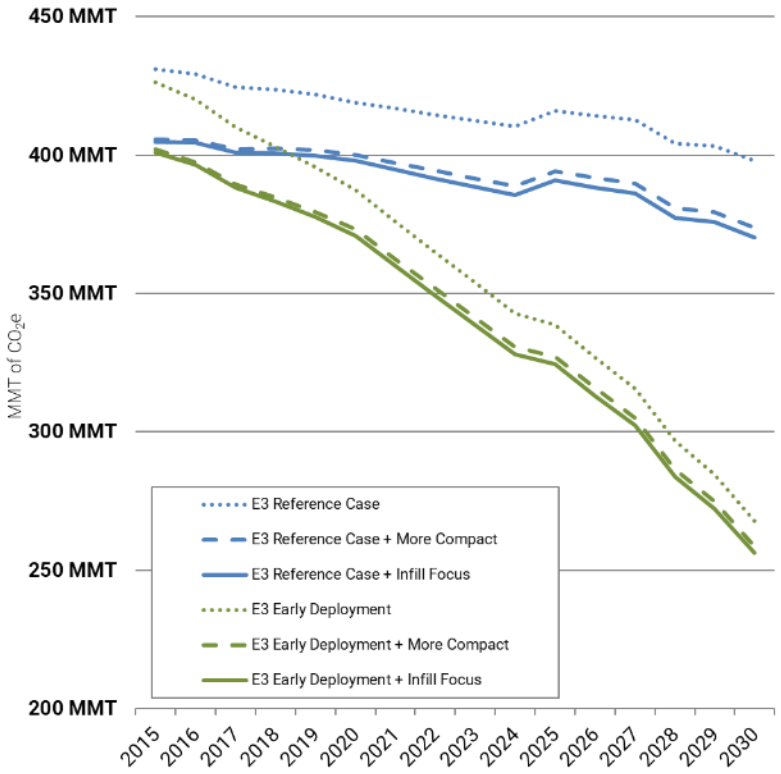
Compelling co-benefits: SB 375 Target Setting

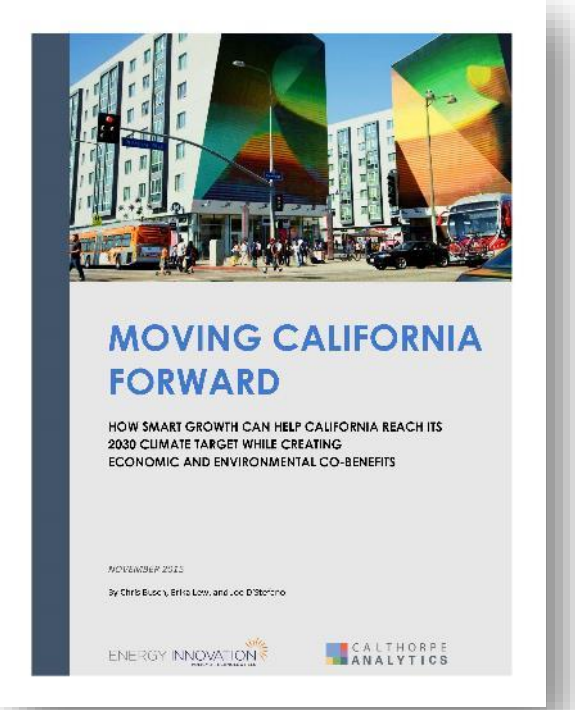
- Scenarios for all major regions in California showed potential reductions in VMT attributable to land use
- Advocates used co-benefit results – for better health outcomes, natural and agricultural land preservation, and energy, water, and fiscal savings – to push for more aggressive targets



Energy policy connection: Moving California Forward

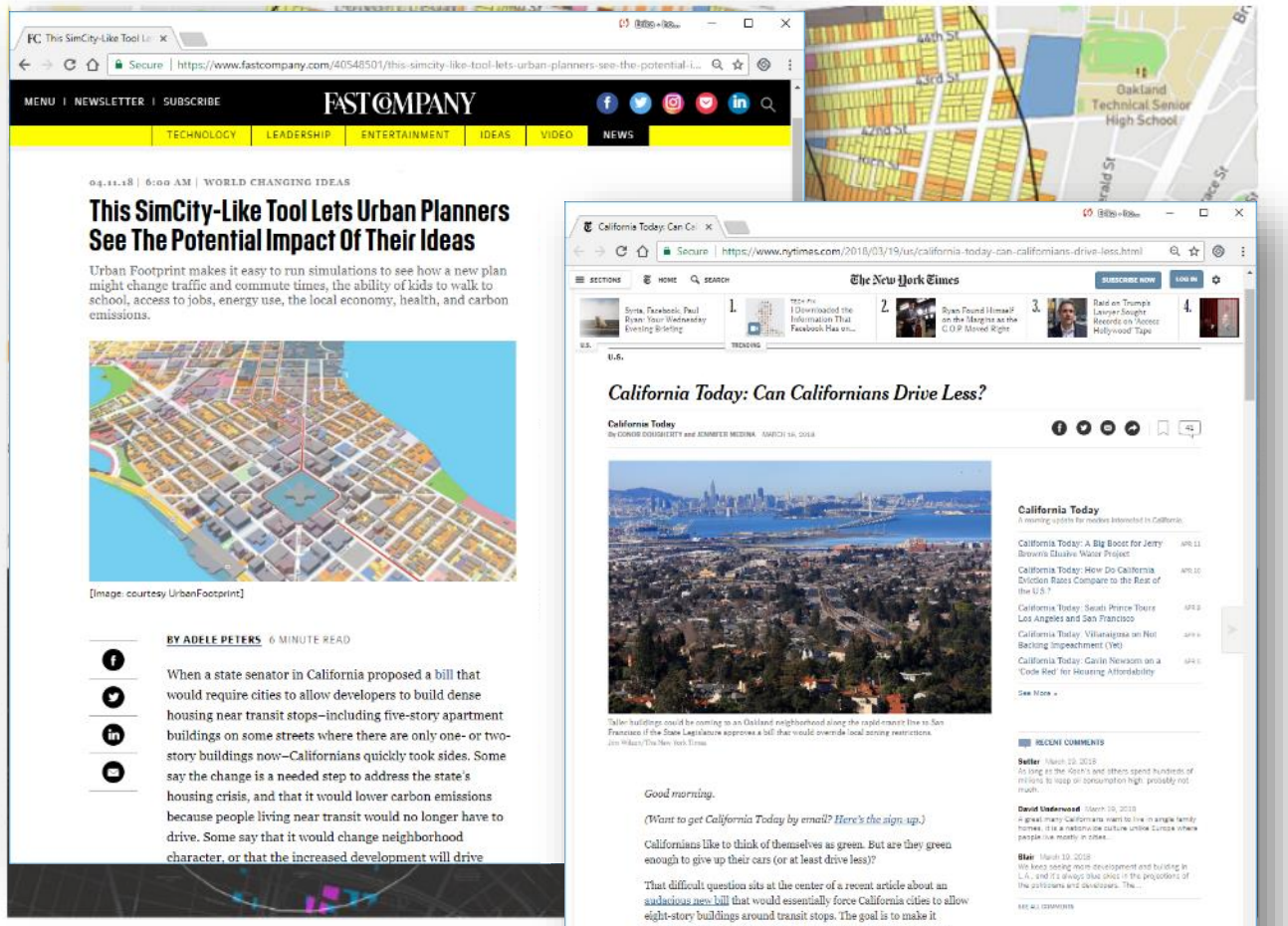
Paired e3 energy policy assumptions with land use scenarios to demonstrate the necessity of **compact land use + energy and vehicle policies** to meet accelerated GHG reduction targets





Timely analysis: SB 827 zoning policy

- Controversial proposal to dramatically up-zone near transit stations
- UrbanFootprint scenarios were quickly developed to estimate new housing capacity under varying conditions
- Results entered the debate and were covered by the NY Times, Fast Company, and other media



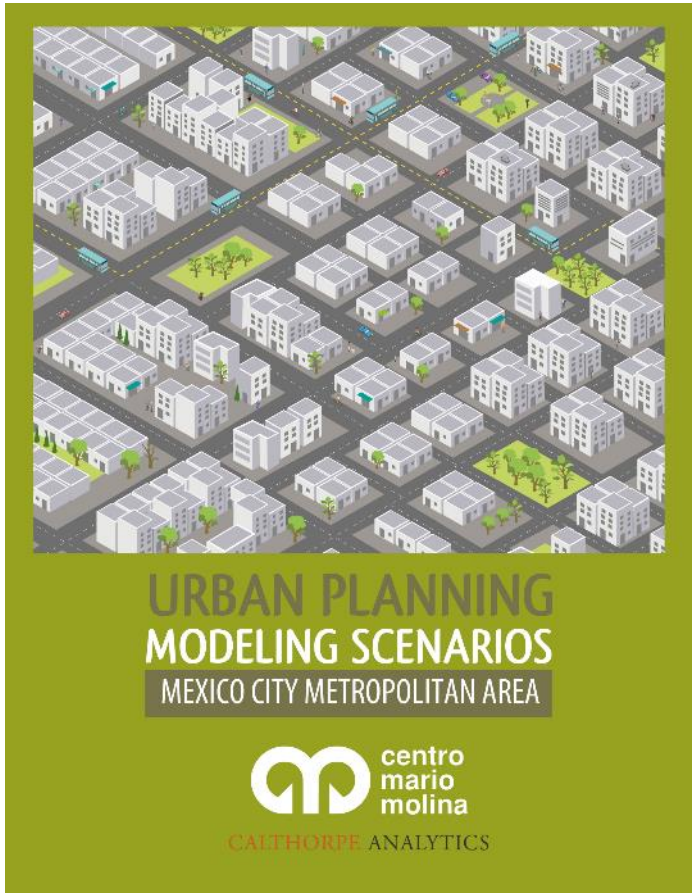
MacArthur BART Study Area with quarter and half mile buffers
SB 827 Upzone scenario at right. Yellow represents ~8 story (8
buildings up to 4 stories (45').

Mexico City Metropolitan Area

Model adaptation and scenario development

Mexico City RapidFire Model & Scenarios

- First adaptation outside US
- Worked with Centro Mario Molina (CMM), CTS Embarq, Fehr & Peers, the Institute for Transportation and Development Policy (ITDP) + local partners
- Supported by CONACyT: Consejo Nacional de Ciencia y Tecnología
  (Mexico National Council of Science and Technology)



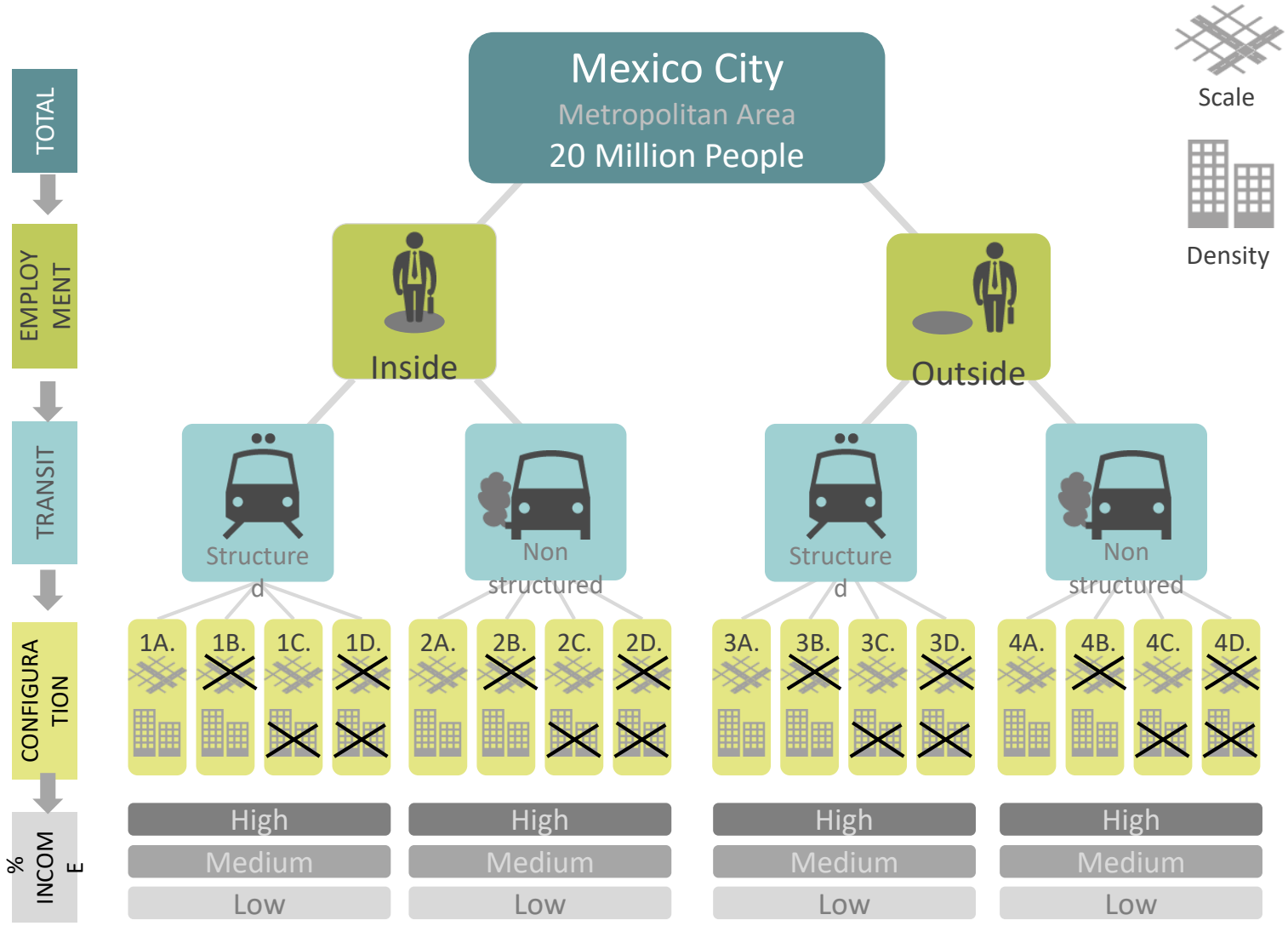
Regional Challenges

- Growth to 25 million people and 8.7 million jobs
- Vast growth in dispersed, disconnected development patterns
- High traffic congestion and pollution
- Livability issues

Modeling Context

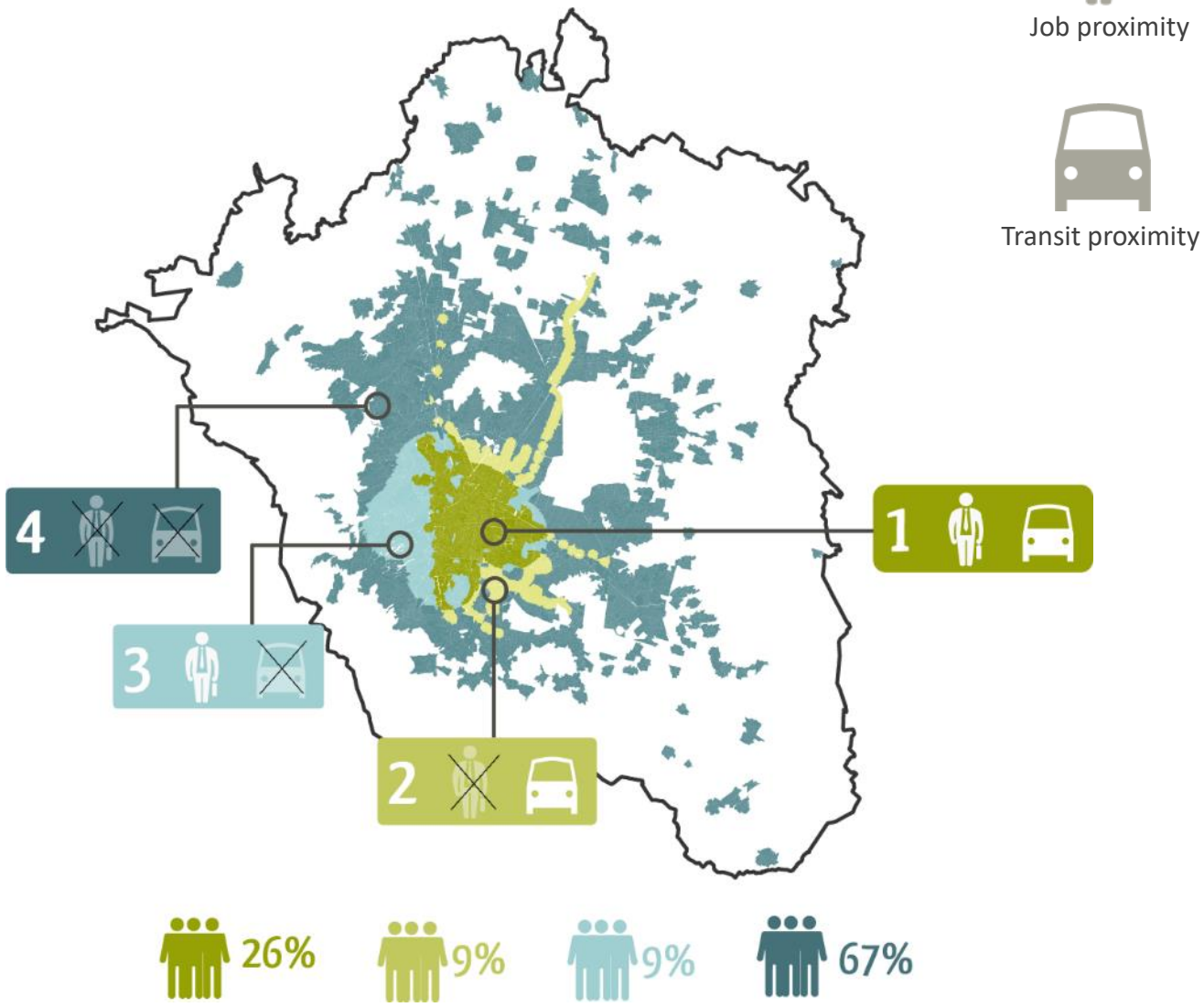
- Expertise and strong technical capacity of local team and partners
- Good data availability

Mexico City Place Type Framework



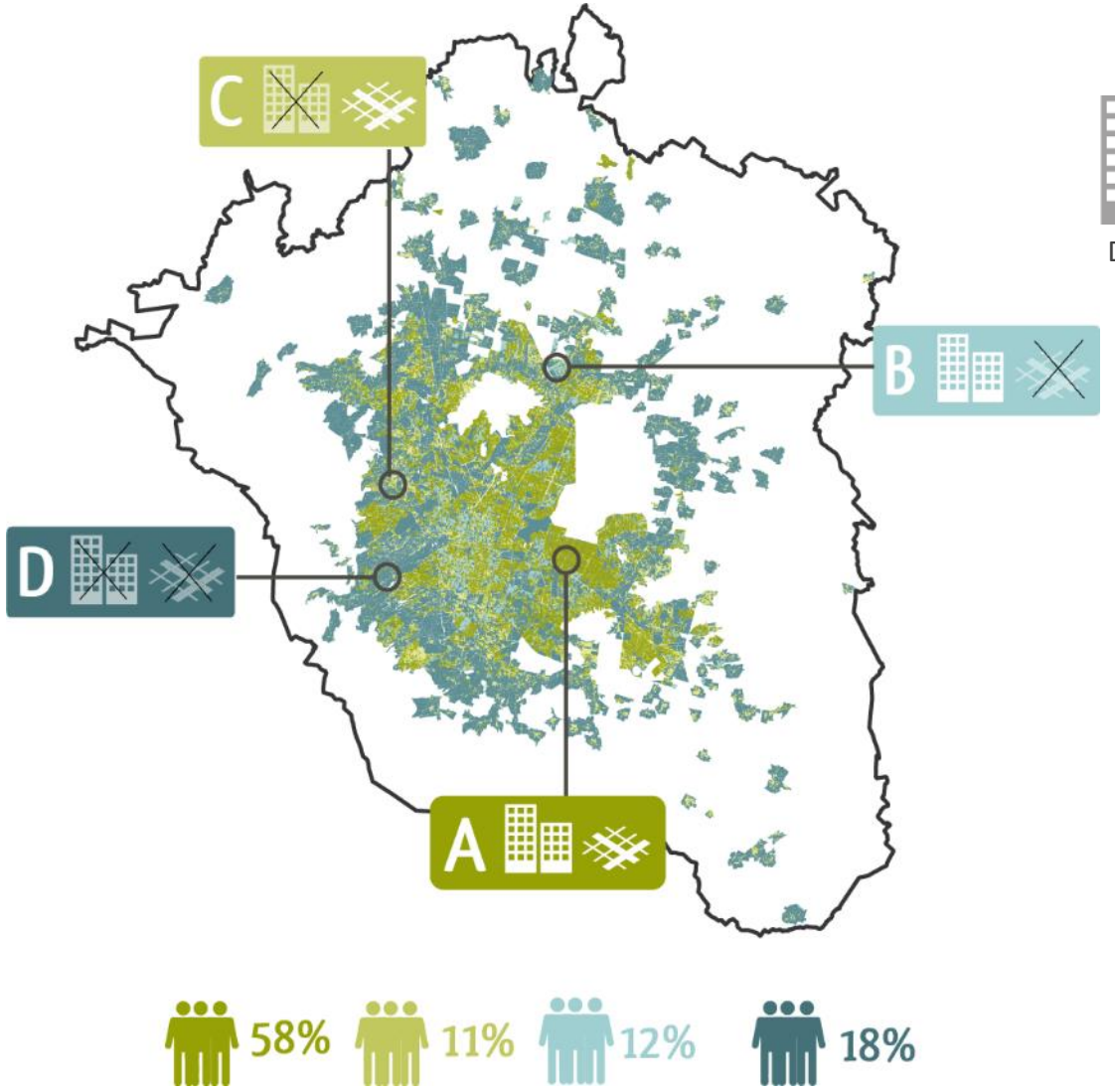
Mexico City Place Types

Regional location



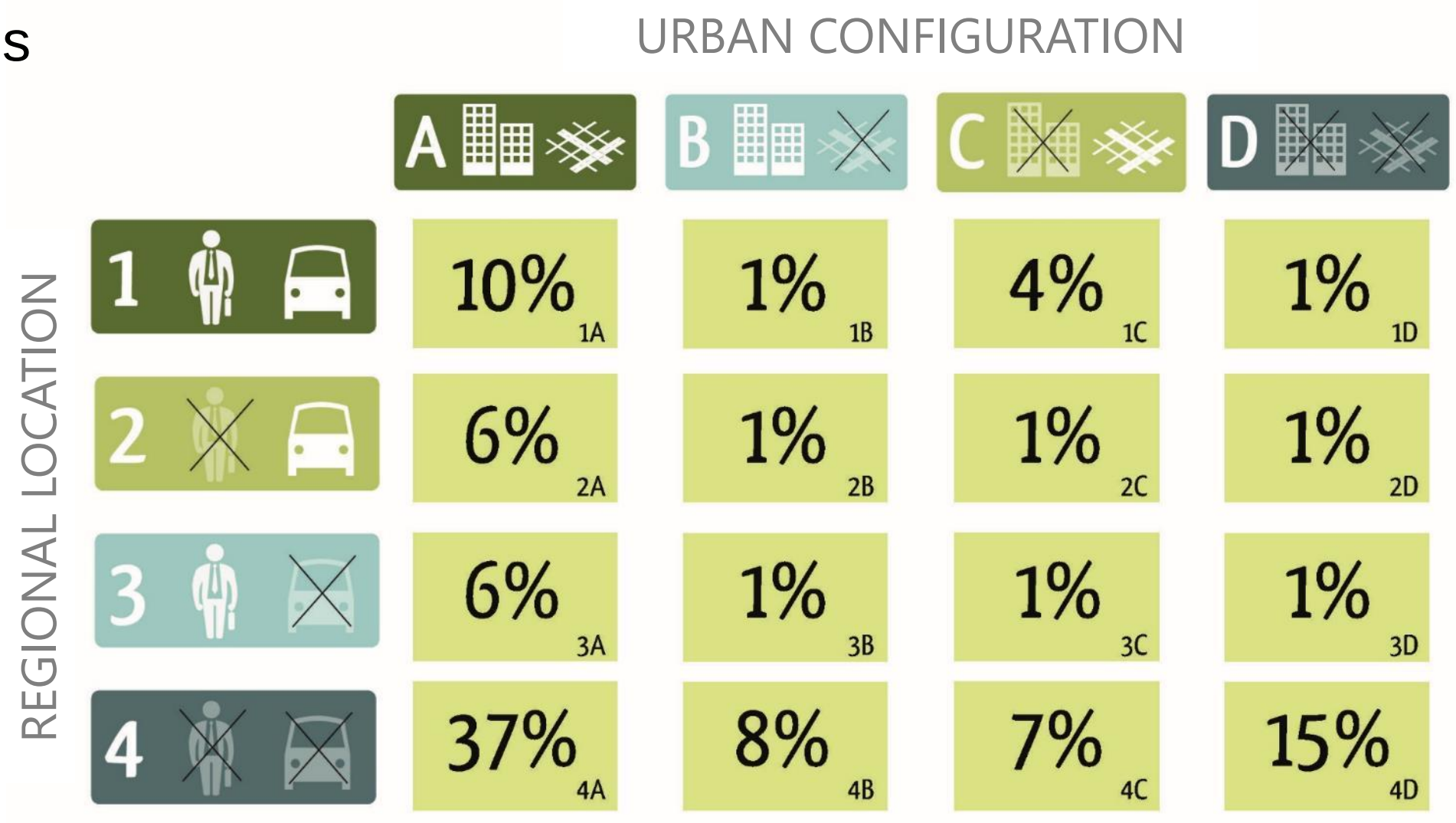
Mexico City Place Types

Urban form



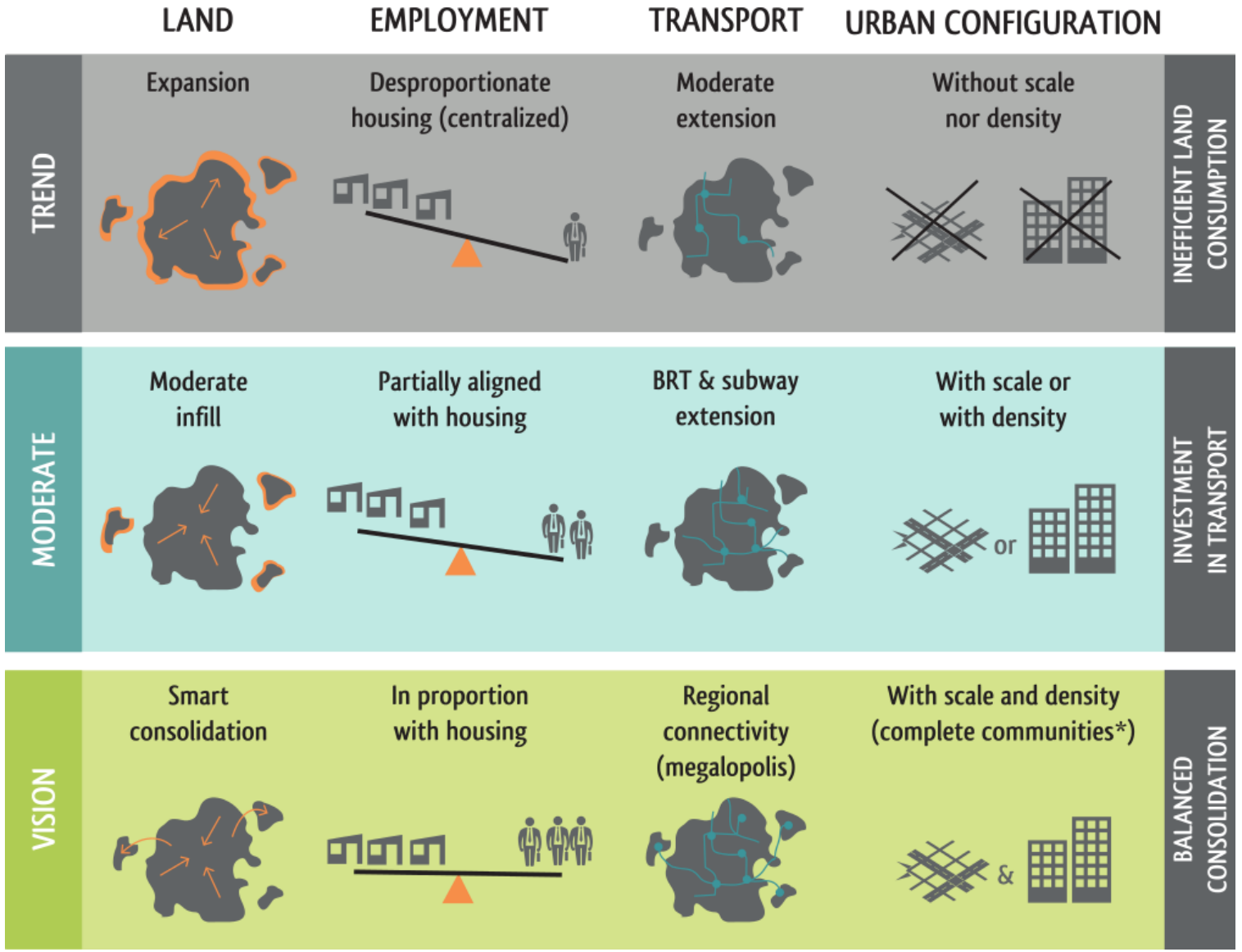
Mexico City Place Types

16 combinations

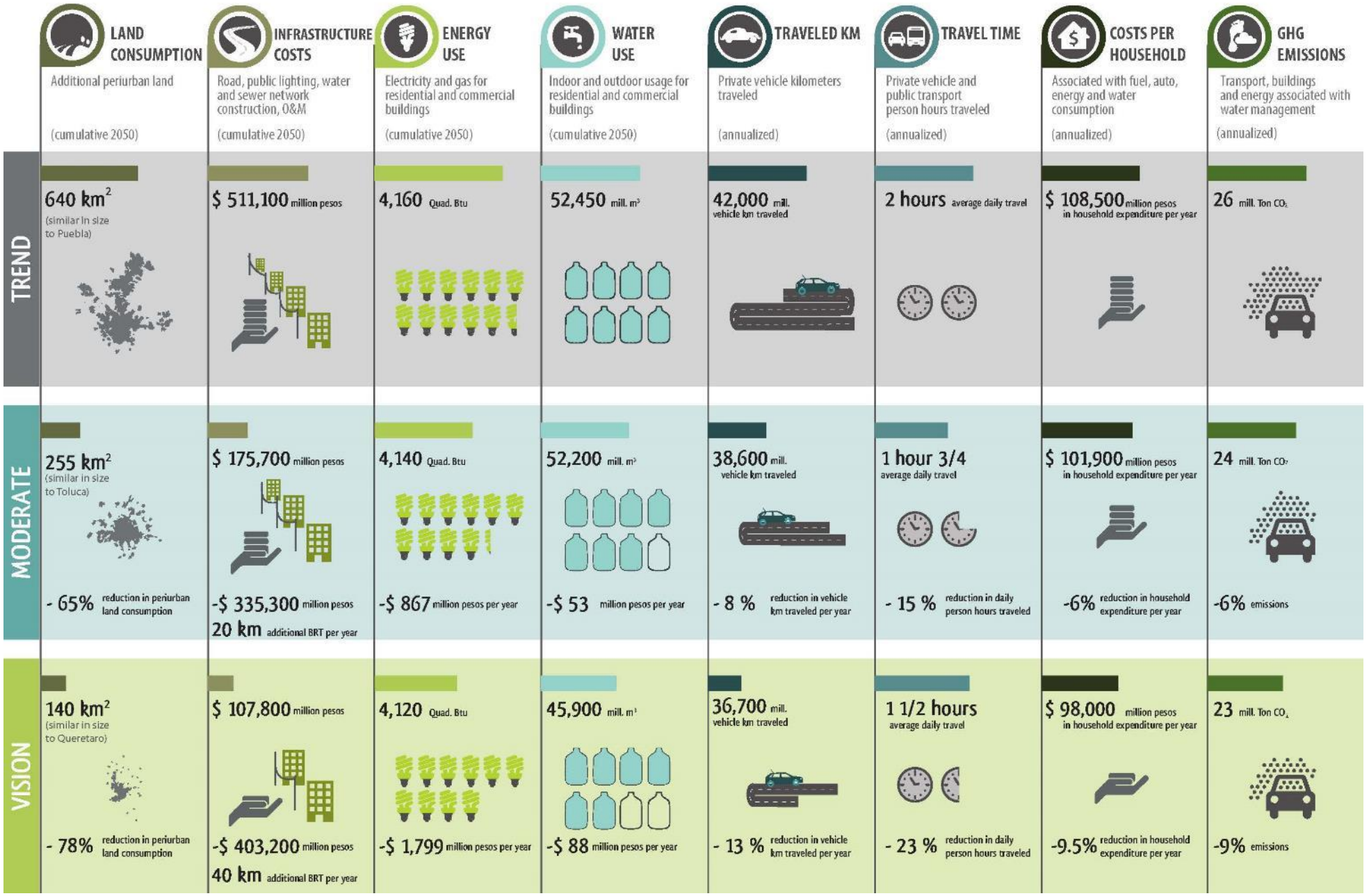


X 3 socioeconomic strata= 48 typologies

Scenario Definition



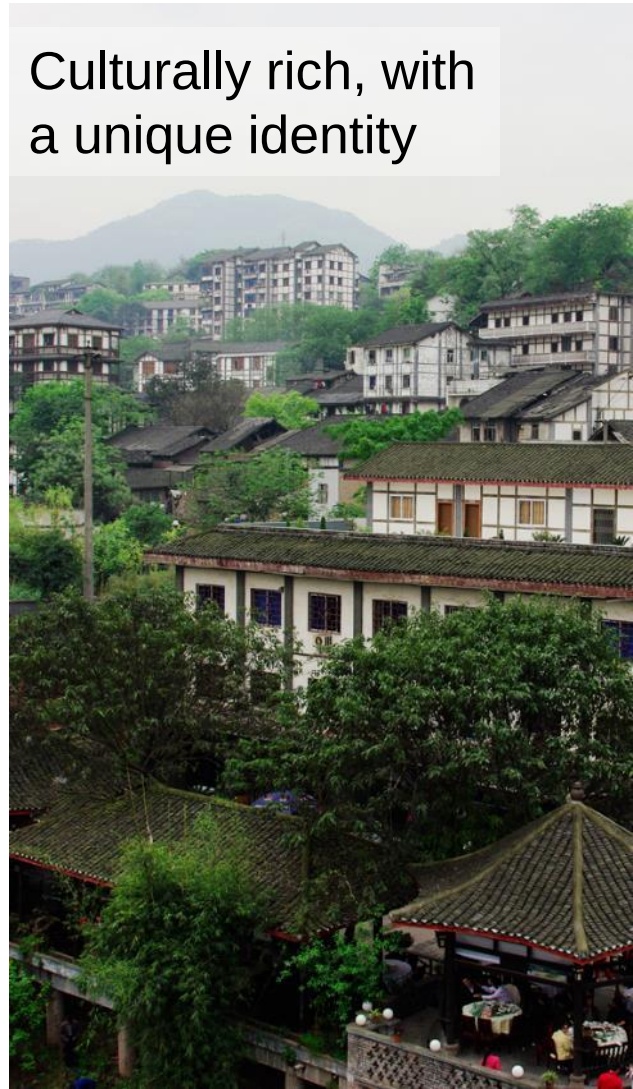
Metrics


LAND CONSUMPTION
Additional periurban land
(cumulative 2050)
INFRASTRUCTURE COSTS
Road, public lighting, water and sewer network construction, O&M
(cumulative 2050)
ENERGY USE
Electricity and gas for residential and commercial buildings
(cumulative 2050)
WATER USE
Indoor and outdoor usage for residential and commercial buildings
(cumulative 2050)
TRAVELED KM
Private vehicle kilometers traveled
(annualized)
TRAVEL TIME
Private vehicle and public transport person hours traveled
(annualized)
COSTS PER HOUSEHOLD
Associated with fuel, auto, energy and water consumption
(annualized)
GHG EMISSIONS
Transport, buildings and energy associated with water management
(annualized)
TREND
640 km2 (similar in size to Puebla)
$ 511,100 million pesos
4,160 Quad. Btu
52,450 mill. m3
42,000 mill. vehicle km traveled
2 hours average daily travel
$ 108,500 million pesos in household expenditure per year
26 mill. Ton CO2
MODERATE
255 km2 (similar in size to Toluca)
- 65% reduction in periurban land consumption
$ 175,700 million pesos
-$ 335,300 million pesos
20 km additional BRT per year
4,140 Quad. Btu
-$ 867 million pesos per year
52,200 mill. m3
-$ 53 million pesos per year
38,600 mill. vehicle km traveled
- 8 % reduction in vehicle km traveled per year
1 hour 3/4 average daily travel
- 15 % reduction in daily person hours traveled
$ 101,900 million pesos in household expenditure per year
-6% reduction in household expenditure per year
24 mill. Ton CO2
-6% emissions
VISION
140 km2 (similar in size to Queretaro)
- 78% reduction in periurban land consumption
$ 107,800 million pesos
-$ 403,200 million pesos
40 km additional BRT per year
4,120 Quad. Btu
-$ 1,799 million pesos per year
45,900 mill. m3
-$ 88 million pesos per year
36,700 mill. vehicle km traveled
- 13 % reduction in vehicle km traveled per year
1 1/2 hours average daily travel
- 23 % reduction in daily person hours traveled
$ 98,000 million pesos in household expenditure per year
-9.5% reduction in household expenditure per year
23 mill. Ton CO2
-9% emissions

Chongqing 2035 Scenarios

Planning for sustainable growth in China

Guided by goals to grow sustainably as a global city



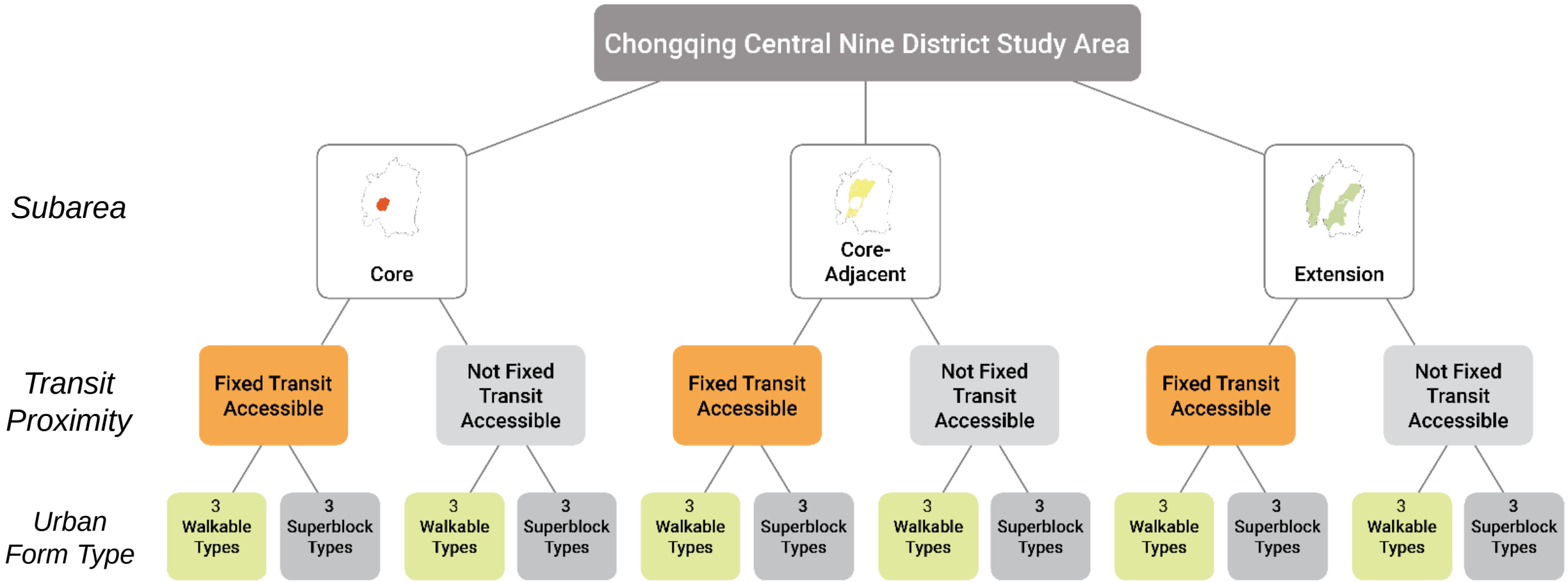
Challenges

- High growth projection
  - +5.8 million urban population
  - +4.6 million jobs
- Fragmented urban growth and monocentric employment concentration
- Superblock development paradigm
- High levels of congestion and air pollution

Modeling Context

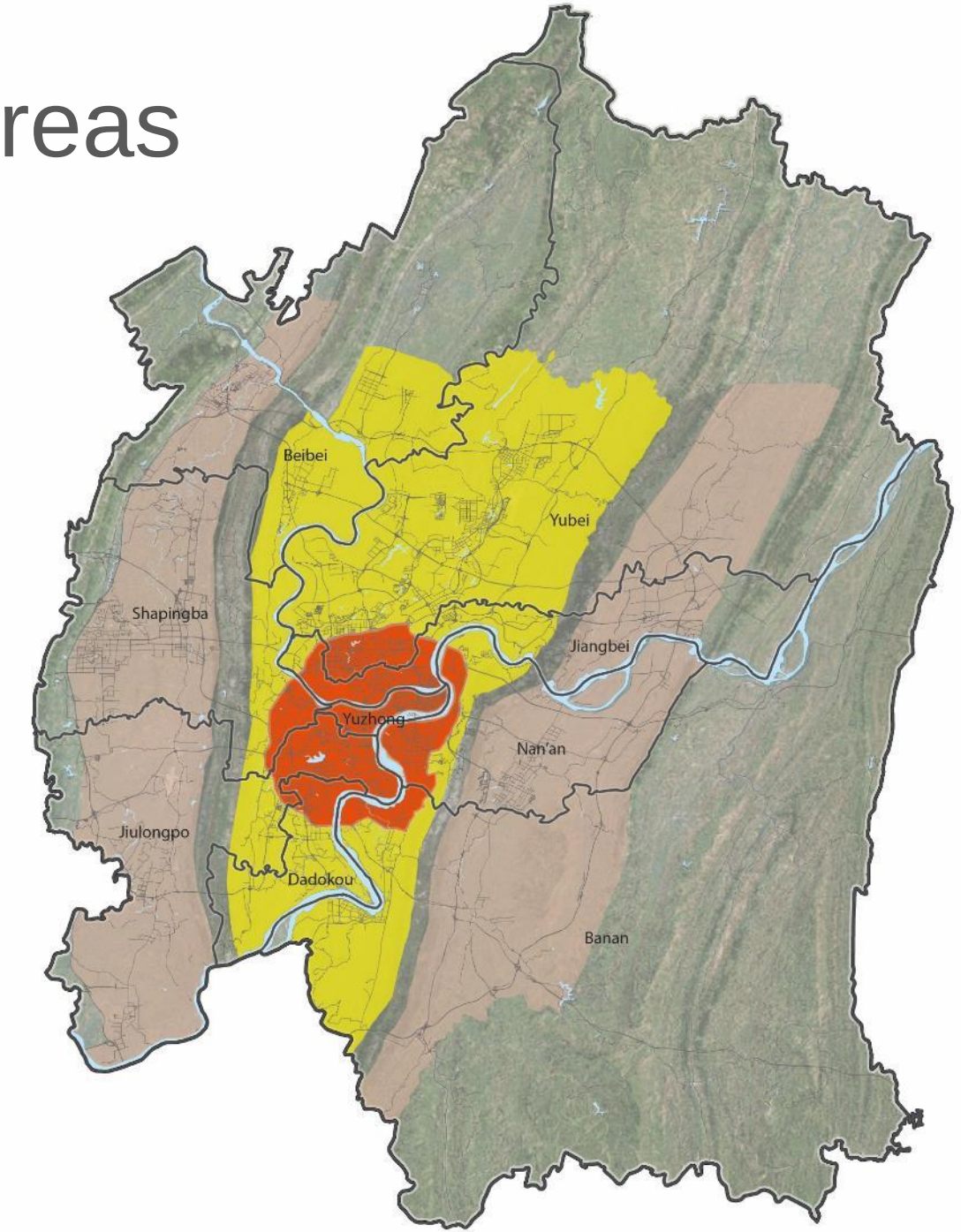
- Data availability/sharing limitations
- Challenge of a limited regional transportation model

Chongqing Place Types



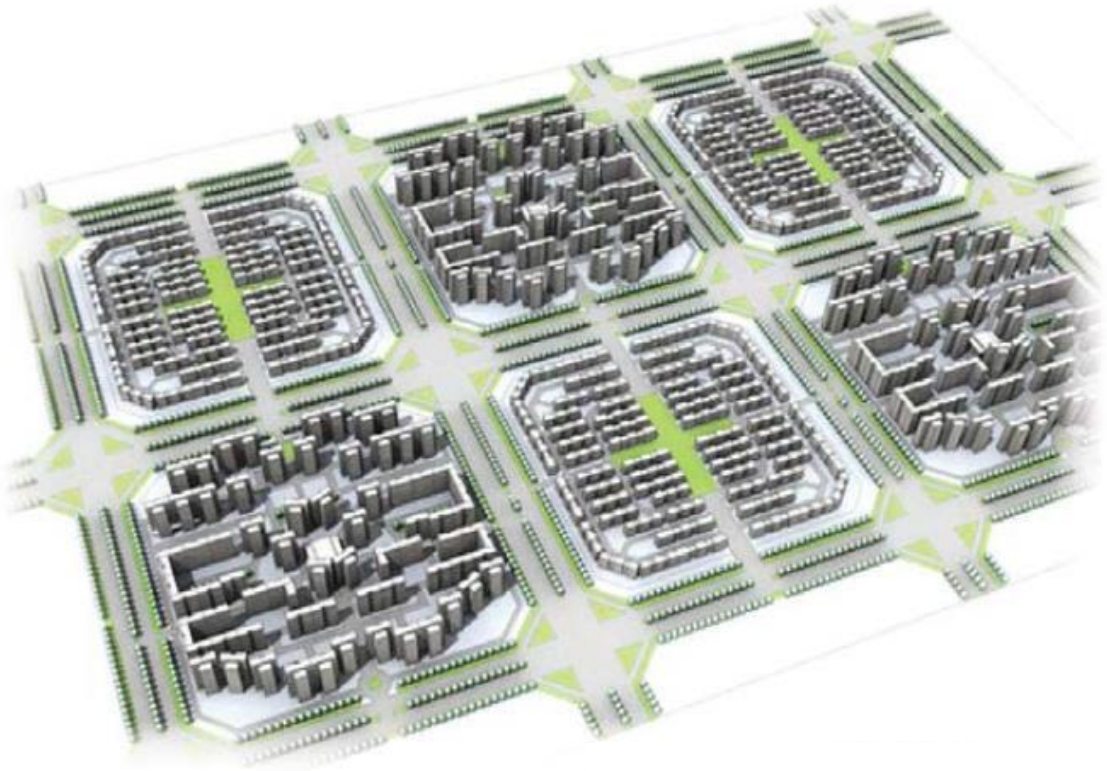
Central City Study Subareas

- **Core**
- **Core-Adjacent**
- **Extension**



Urban Form: Superblock Development

- Single-use zoning separates residential and commercial areas
- Large blocks served by wide arterial streets are oriented to autos rather than pedestrians and bicyclists
- May be transit *adjacent*, yet not transit *oriented*



Urban Form: Walkable Development

- People-oriented development (POD) or transit-oriented development (TOD)
- Mixed-use zoning creates a balance of housing and services to support active communities
- Small blocks are served by dense street networks that enhance walking, biking, and traffic flow
- Density and mix of housing, employment, and local activities and services are coordinated to transit capacity

Place Type Matrix

SUBAREA	TRANSIT PROXIMITY	PLACE TYPE CODE	URBAN FORM
Core *Infill/* *Redevelopment*	Transit Oriented	1A	Walkable Commercial Mix
		1B	Walkable Residential Mix
		1C	Walkable Medium Density Residential Mix
	Transit Adjacent	1D	Superblock Commercial Mix
		1E	Superblock Residential Mix
		1F	Superblock Industrial
	No transit	2A	Walkable Commercial Mix
		2B	Walkable Residential Mix
		2C	Walkable Medium Density Residential Mix
	No transit	2D	Superblock Commercial Mix
		2E	Superblock Residential Mix
		2F	Superblock Industrial
Core-Adjacent Greenfield	Transit Oriented	3A	Walkable Commercial Mix
		3B	Walkable Residential Mix
		3C	Walkable Medium Density Residential Mix
	Transit Adjacent	3D	Superblock Commercial Mix
		3E	Superblock Residential Mix
		3F	Superblock Industrial
	No transit	4A	Walkable Commercial Mix
		4B	Walkable Residential Mix
		4C	Walkable Medium Density Residential Mix
	No transit	4D	Superblock Commercial Mix
		4E	Superblock Residential Mix
		4F	Superblock Industrial
Extension Greenfield	Transit Oriented	5A	Walkable Commercial Mix
		5B	Walkable Residential Mix
		5C	Walkable Medium Density Residential Mix
	Transit Adjacent	5D	Superblock Commercial Mix
		5E	Superblock Residential Mix
		5F	Superblock Industrial
	No transit	6A	Walkable Commercial Mix
		6B	Walkable Residential Mix
		6C	Walkable Medium Density Residential Mix
	No transit	6D	Superblock Commercial Mix
		6E	Superblock Residential Mix
		6F	Superblock Industrial

Chongqing Place Types

Superblock Industrial *without Transit* (Place Types 2F, 4F, 6F)

Description
Industrial em
areas. Areas
other uses m
transit may b

Local exampl

Superblock Industrial *with Transit* (Place Types 1F, 3F, 5F)

Description
Industrial em
areas, with lo
employment
provided in s
pedestrian a

Local exampl

Superblock Residential *without Transit* (Place Types 2E, 4E, 6E)

Description
Primarily res
vary slightly
within reside
superblocks
longer travel

Local examp

Superblock Residential *with Transit* (Place Types 1E, 3E, 5E)

Description
Primarily res
though build
high-rise tow
Wide, auto o
parking in th

Local examp

Superblock Commercial *without Transit* (Place Types 2D, 4D, 6D)

Description
Primarily con
accommodat
interiors of l
foster pedes
undergrounc

Local examp

Superblock Commercial *with Transit* (Place Types 1D, 3D, 5D)

Description
Primarily con
densities in t
to the interio
not foster pe
and undergro

Local exampl

Medium-Density Walkable Residential Mix *without Transit* (Place Types 2C, 4C, 6C)

Description
Primarily res
neighborhoo
otherwise sn
nearby mixe

Local examp

Medium-Density Walkable Residential Mix *with Transit* (Place Types 1C, 3C, 5C)

Description
Primarily res
neighborhoo
otherwise sn
transit or nea

Local examp

Walkable Residential Mix *with Transit* (Place Types 1B, 3B, 5B)

Description
Primarily res
oriented to s
pattern. Park
and accessib

Local examp

Walkable Commercial Mix *with Transit* (Place Types 1A, 3A, 5A)

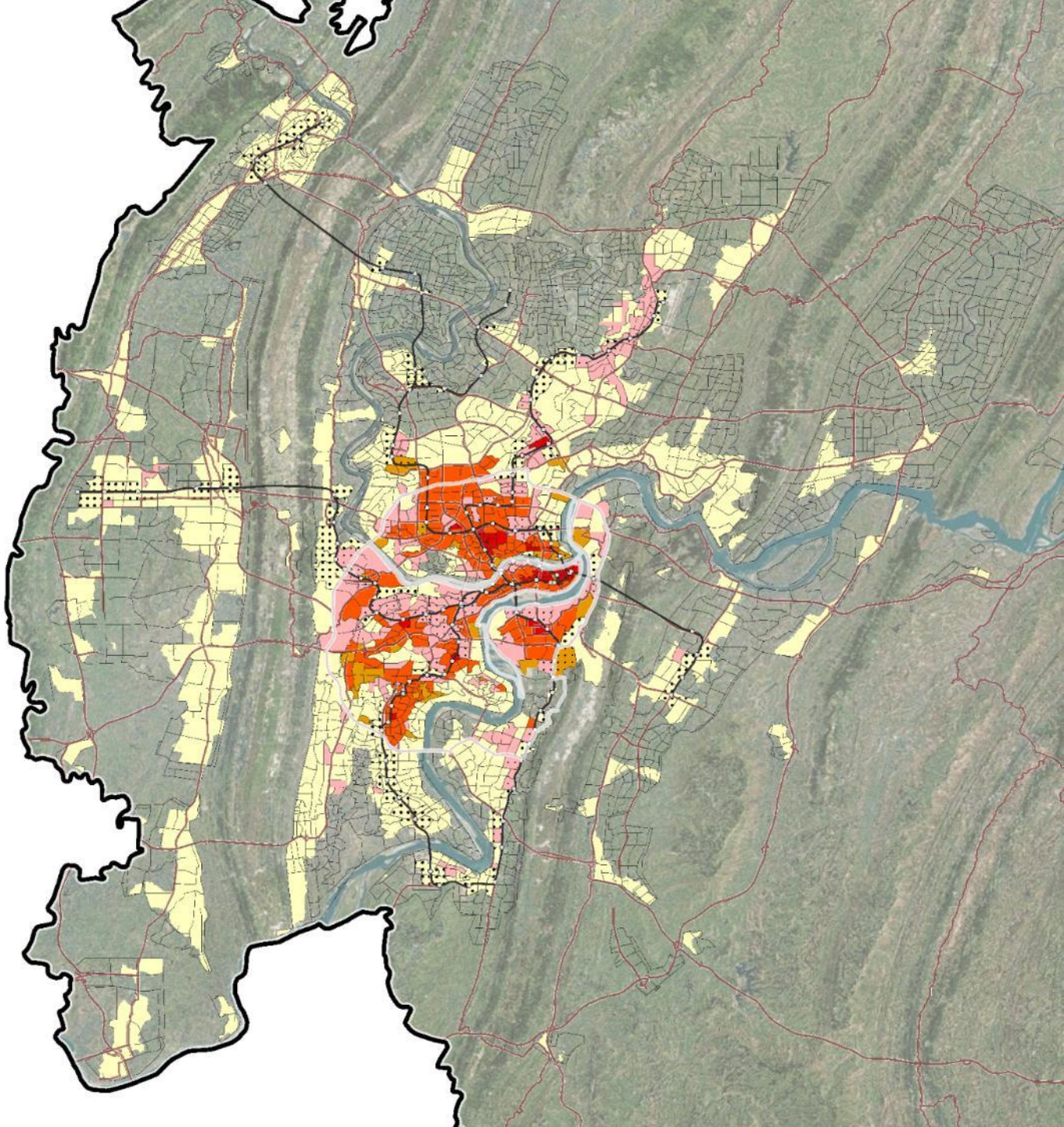
Floor Area Ratio (FAR)	Core	Core-Adjacent	Extension
Residential	2.0	1.5	1.5
Employment	5.0	4.0	2.5
Gross Density (per hectare)	Core	Core-Adjacent	Extension
Population	200	140	140
Employees	1,200	550	360
Employment Mix	Core	Core-Adjacent	Extension
Industrial	0%	0%	0%
Office, retail, civic, and other	100%	100%	100%

Description

Primarily commercial areas of urban mixed-use centers, with the highest densities in the Core, slightly lower densities in the Core-Adjacent, and lower densities in the Extension areas. High concentrations of office, retail, and civic employment. Mid- to high-rise buildings oriented to street, easily accessible and with minimal setbacks, create walkable environments. Grid or otherwise small-block street pattern. Parking limited to on-street supply, with some structured and underground parking. Accessible by regional metro transit, attracting commute and other trips from throughout the region.

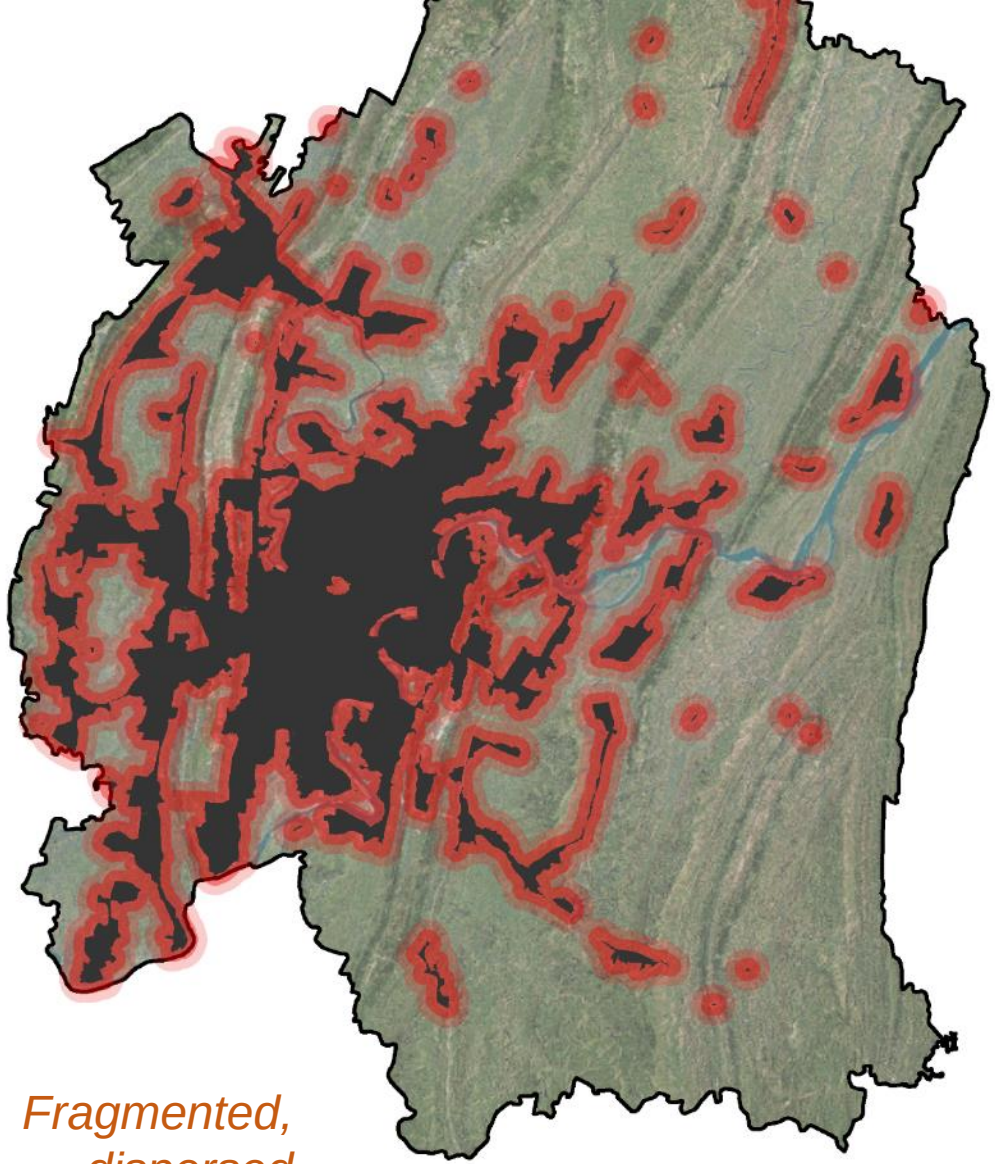
Local example: Guanyinqiao. Total FAR: 3.9 / Population density: 280 / Employment density: 1,710

Urban Form


Existing Builtup Area
Typed TAZs
Small Block Commercial Mix
Small Block Residential Mix
Small Block Medium Density Mix
Superblock Commercial Mix
Superblock Residential Mix

Trend Scenario

- Reflects development patterns over the past ~20 years
- Fragmented growth occurs throughout study area and built-up area density declines further
- Superblock pattern dominates despite investments made in transit
- Core area receives new commercial growth, necessitating further in-commuting
- Industrial growth dispersed throughout study area

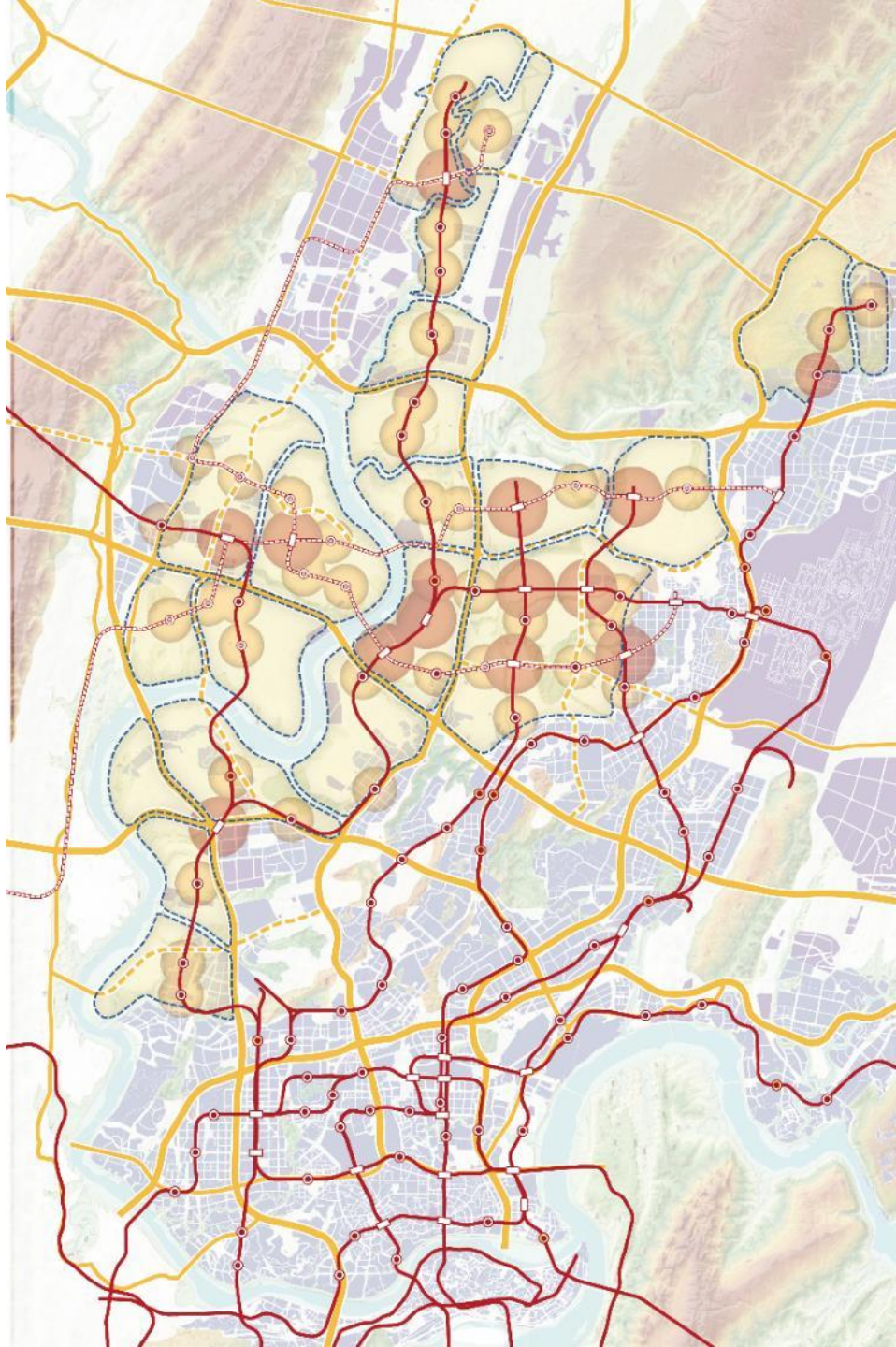


Fragmented, dispersed development will continue

Compact Growth Scenario

- Represents a coordinated implementation of polycentric Master Plan structure
- Development occurs to create a network of balanced TOD areas throughout the nine districts
- Core area receives infill and redevelopment to become more balanced
- Industrial growth dispersed throughout study area

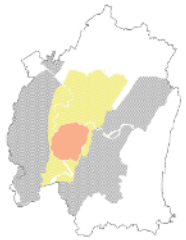
Balanced growth occurs strategically around transit, as in the Liangjiang TOD Plan



RAPIDFIRE MODELING AND ANALYSIS FLOW

SET STUDY AREA

Region / Subregional Areas
or District



DEMOGRAPHIC PROJECTIONS

- Base year
- Future year

POPULATION

Base and New Growth

HOUSING UNITS

Base and New Growth

JOBS

Base and New Growth

DEFINE LAND USE FOR SCENARIOS

LAND USE OPTION DEFINITIONS

% Population and Units by regional location and Place Type for each scenario

HOUSING UNIT BREAKDOWN

Housing units by Place Type

COMMERCIAL SPACE ALLOCATION

Total floor space based on per-employee requirements by sector and place type

APPLY PERFORMANCE ASSUMPTIONS

Development intensities by Place Type

Per-capita assumptions by Place Type

Per-housing unit assumptions by Place Type

Per-square meter assumptions by employment sector

CALCULATE RESULT METRICS

LAND CONSUMPTION METRICS

- Land consumed: total, per household, and per capita

FISCAL IMPACT METRICS

- Capital costs for local roads, water, and utilities
- Maintenance costs

TRANSPORTATION METRICS

- Light Duty Vehicle (LDV) Vehicle Miles Traveled (VMT)
- GHG and criteria pollutant emissions
- Fuel use
- Fuel cost

Greenhouse Gas (GHG) Emission Rates

- Auto fuel emissions per gallon
- Building energy emissions per kg SCE

WATER USE METRICS

- Residential water consumption
- Household water costs

ENERGY USE METRICS

- Commercial electricity and gas consumption
- GHG emissions

TOTAL GHG EMISSIONS

- VMT emissions
- Residential energy use emissions
- Commercial energy use emissions

Scenario Growth Allocations

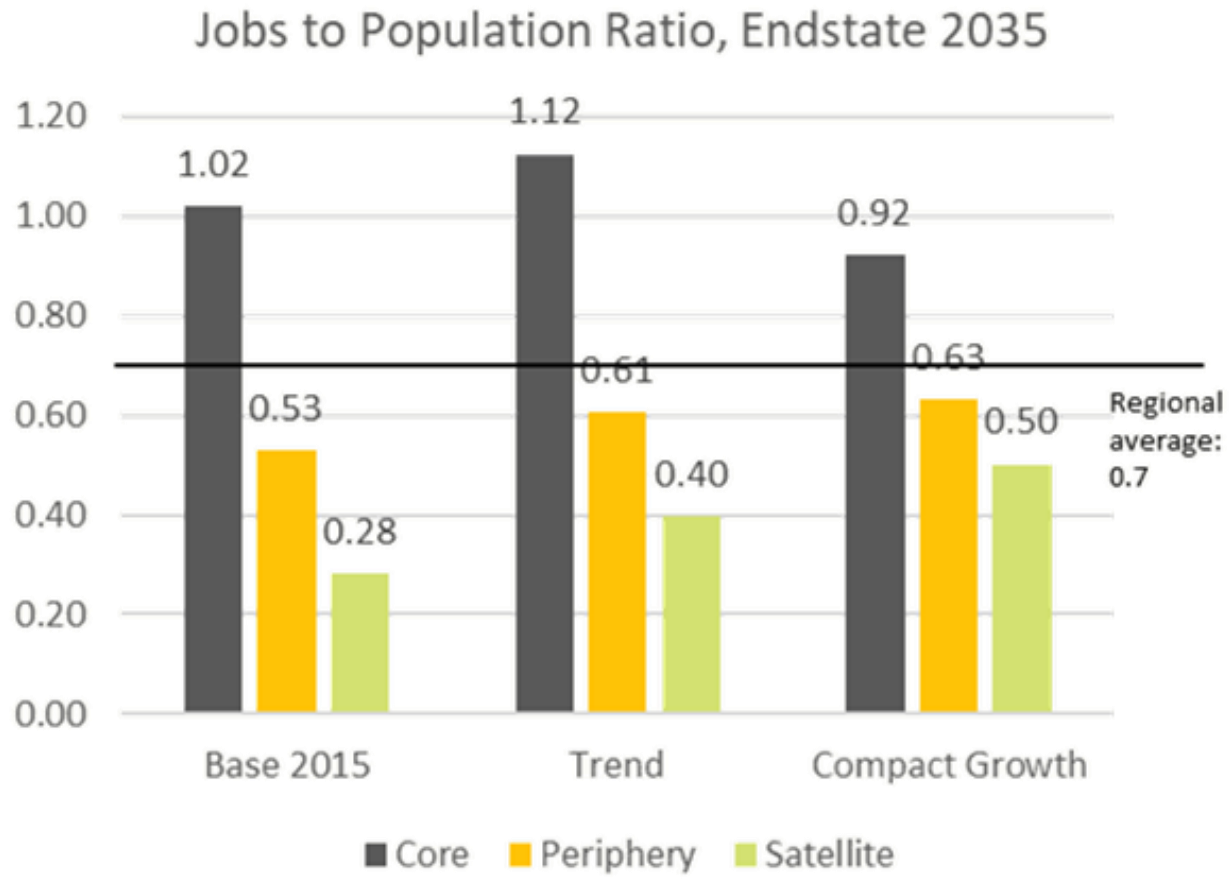
TREND

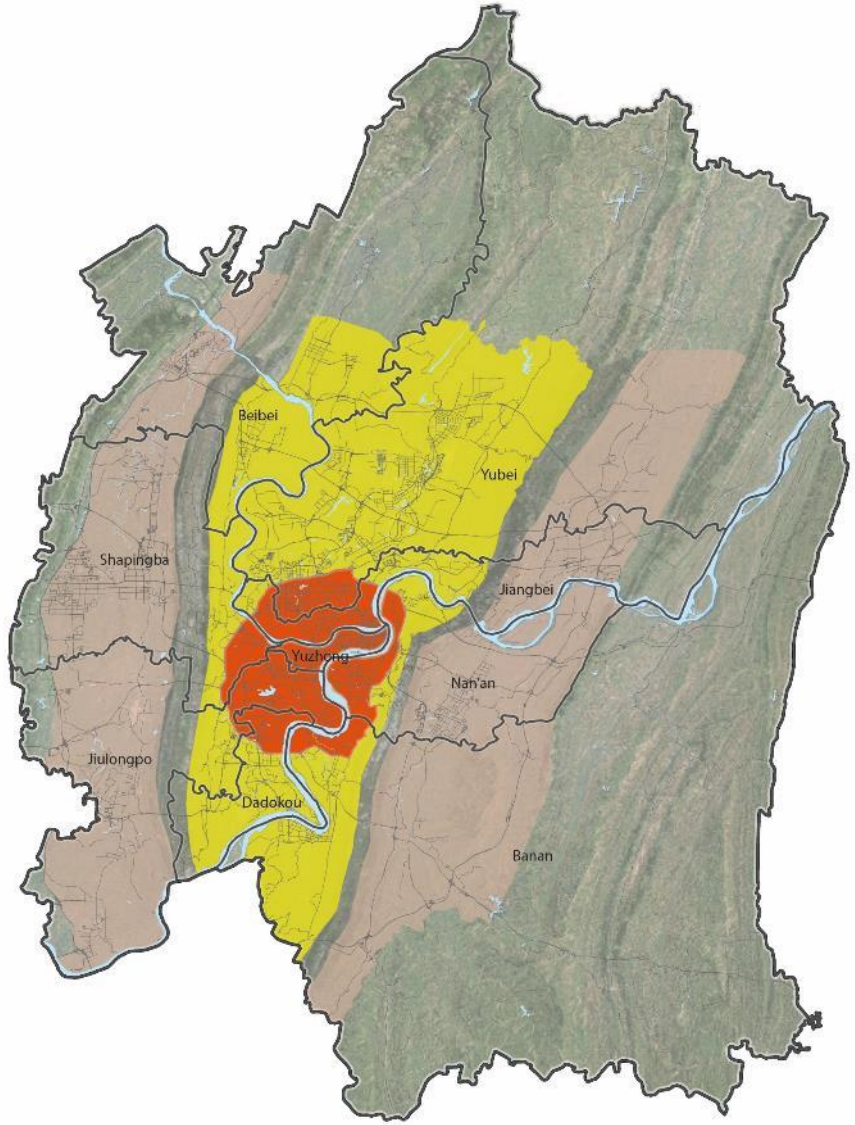
Population Growth Distribution	A. Walkable Commercial Mix	B. Walkable Residential Mix	C. Medium Density Residential Mix	D. Superblock Commercial Mix	E. Superblock Residential Mix	F. Superblock Industrial
Core Transit	1%	2%	1%	0.5%	2%	
Core no Transit				0.2%	3%	
Core-Adjacent Transit			1%		19%	
Core-Adjacent no Transit				1%	15%	8%
Extension Transit				1%	4%	
Extension no Transit				1%	24%	16%
Job Growth Distribution						
Core Transit	6%	2%	5%	5%		
Core no Transit				6%	1%	
Core-Adjacent Transit			0.5%	3%	2%	17%
Core-Adjacent no Transit				1%	1%	20%
Extension Transit				1%	0.4%	3%
Extension no Transit				1%	2%	22%

COMPACT GROWTH

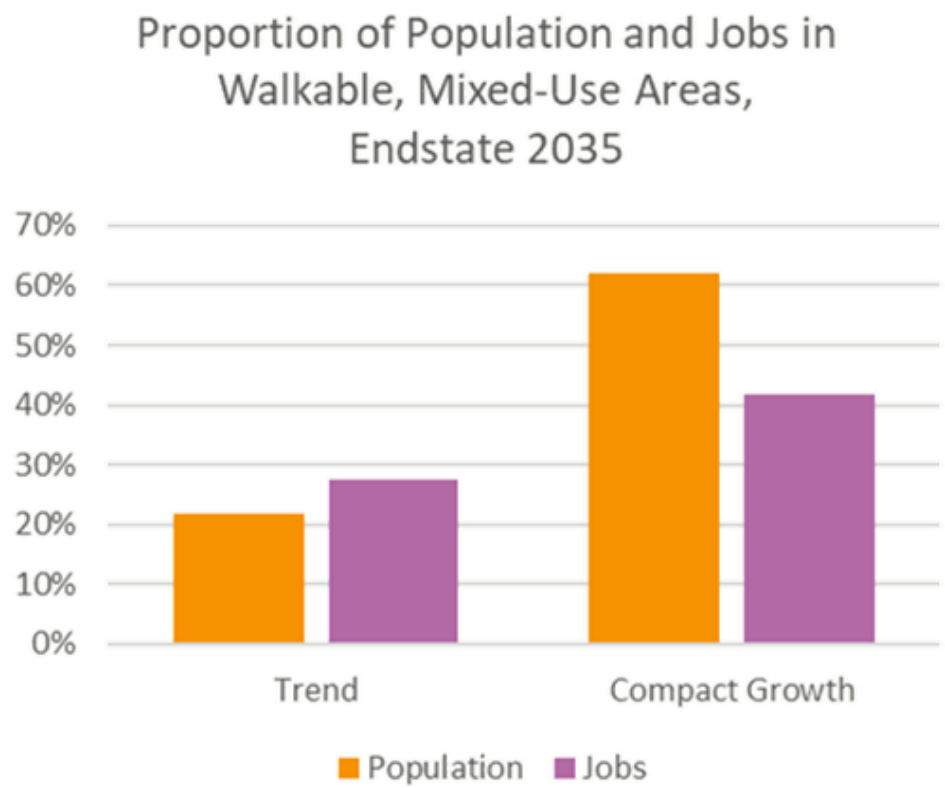
Population Growth Distribution	A. Walkable Commercial Mix	B. Walkable Residential Mix	C. Medium Density Residential Mix	D. Superblock Commercial Mix	E. Superblock Residential Mix	F. Superblock Industrial
Core Transit	2%	6%	3%			
Core no Transit						
Core-Adjacent Transit	19%	35%	22%			2%
Core-Adjacent no Transit						2%
Extension Transit	1%	4%	5%			0.4%
Extension no Transit						1%
Job Growth Distribution						
Core Transit	4%	1%				
Core no Transit						
Core-Adjacent Transit	43%	8%	3%			2%
Core-Adjacent no Transit						24%
Extension Transit	0.5%	0.2%	0.2%			4%
Extension no Transit						11%

Prioritizing better jobs/housing balance





Supporting compact, walkable mixed-use development

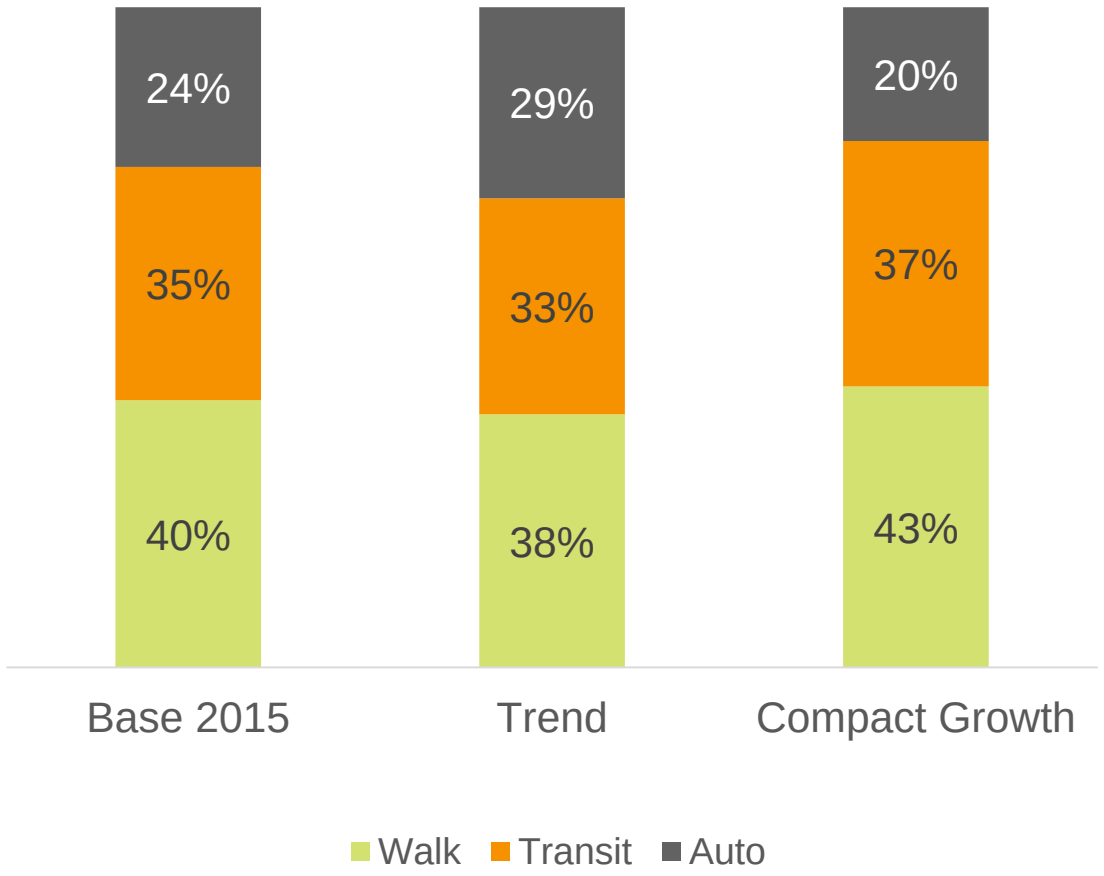


Greenfield Land Consumed

Trend requires 553 km^2 of land –
195 km^2 more than Compact Growth.

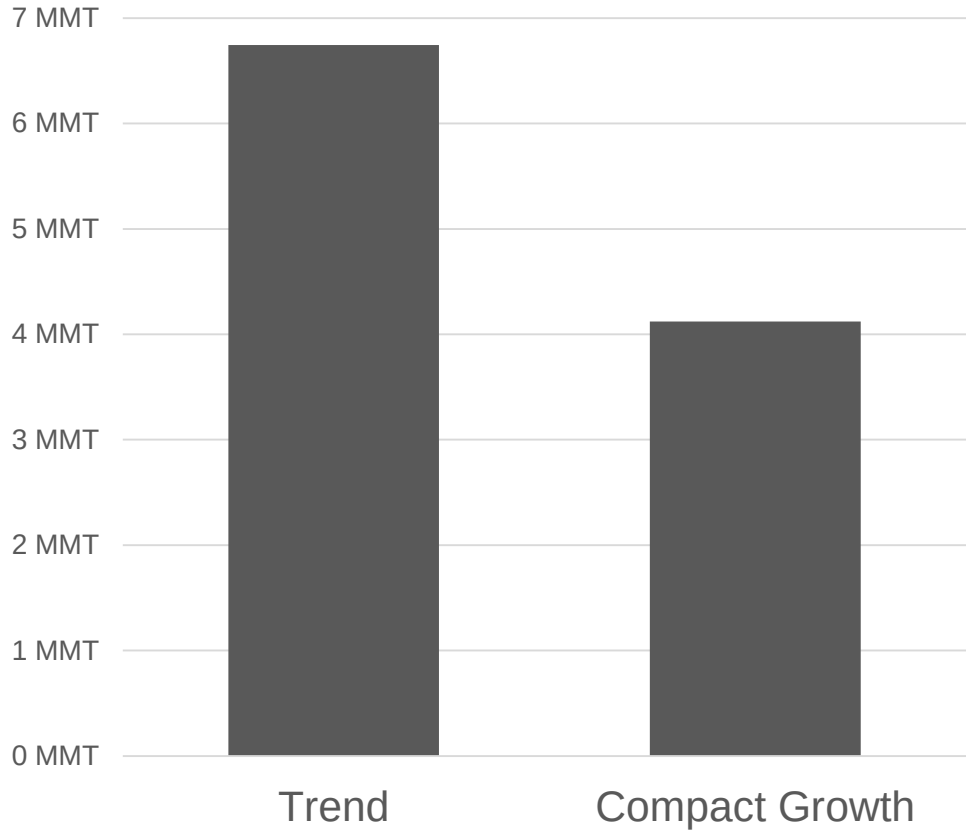
Transportation Mode Share

Walk + transit share is **9% higher** in Compact Growth as compared to Trend.



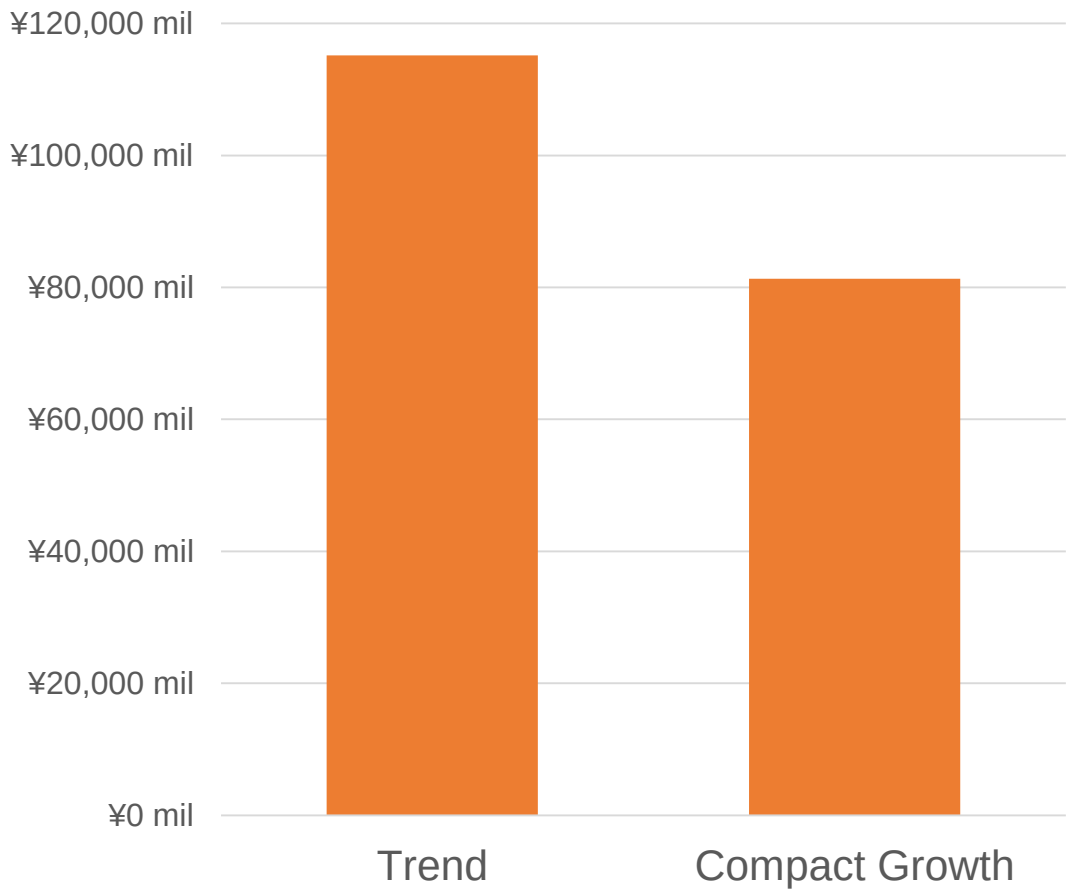
Greenhouse Gas Emissions from Autos

Compact Growth saves 2.6 MMT annually as compared to Trend.



Infrastructure Costs

Compact Growth saves RMB 33.9 billion ($5.4 billion) to in capital costs for new road, water, wastewater, and utility infrastructure as compared to Trend.



Questions?

Thank you!

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