Quality of Life Indicators and Policy Strategies to Advance Sustainability in the Pearl River Delta

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Preface

The Department of Housing and Urban-Rural Development (HURD) of Guangdong Province in the People's Republic of China asked RAND to develop a system of quality of life indicators and identify policy options to advance sustainability in the Pearl River Delta (PRD), a region of Guangdong Province in southeastern China. Guangdong's interest in measures of quality of life stems from a national interest in looking at measures of progress that go beyond gross domestic product (GDP) and other measures of economic output to address sustainability. *Sustainability* is a broad and often ill-defined term, but is generally used to address the idea that actions taken today should consider the needs of both present and future generations—and not preempt their ability to have a clean environment, productive agriculture, and other benefits. Quality of life indicators provide a foundation for measuring progress toward socioeconomic and environmental goals and can be an important guidance and monitoring mechanism for policy- and decisionmaking.

The primary audiences for this report include officials at HURD and technical staff of other provincial departments and bureaus related to urban planning and urban rural development in Guangdong and the nine major cities in the PRD. The overall framework for linking indicators directly to goals and strategies may be helpful in other planning contexts elsewhere in China and perhaps other countries as well.

This study follows two earlier RAND reports that consider pathways for China's regional economic development authorities to follow in their transition to a more innovation-driven economy:

- Keith Crane, Howard J. Shatz, Shanthi Nataraj, Steven W. Popper, and Xiao Wang, *An Outline of Strategies for Building an Innovation System for Knowledge City*, MG-1240-GDD, 2012 (www.rand.org/t/MG1240).
- Richard Silberglitt, Anny Wong, S. R. Bohandy, Brian G. Chow, Noreen Clancy, Scott Hassell, David R. Howell, Gregory S. Jones, Eric Landree, and Parry Norling, *The Global Technology Revolution China, Executive Summary: Emerging Technology Opportunities for the Tianjin Binhai New Area (TBNA) and the Tianjin Economic-Technological Development Area (TEDA)*, MG-776-TBNA/TEDA, 2009 (www.rand.org/t/MG776).

About RAND Environment, Energy, and Economic Development

The research reported here was conducted in the RAND Environment, Energy, and Economic Development Program, which addresses topics relating to environmental quality and regulation, water and energy resources and systems, climate, natural hazards and disasters, and eco-

nomic development, both domestically and internationally. Program research is supported by government agencies, foundations, and the private sector.

This program is part of RAND Justice, Infrastructure, and Environment, a division of the RAND Corporation dedicated to improving policy and decisionmaking in a wide range of policy domains, including civil and criminal justice, infrastructure protection and homeland security, transportation and energy policy, and environmental and natural resource policy.

Questions or comments about this report should be sent to the project leader, Debra Knopman (Debra_Knopman@rand.org). For more information about the Environment, Energy, and Economic Development Program, see http://www.rand.org/energy or contact the director at eeed@rand.org.

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Summary

The term *quality of life* is commonly used by urban planners to capture the many facets of the physical environment of residents that contribute to their productivity, satisfaction, and happiness. Improving quality of life is essential for any region seeking to satisfy the needs of current residents as well as attract and retain new employers, workers, and others.

The Department of Housing and Urban-Rural Development (HURD) of Guangdong Province of the People's Republic of China asked RAND to develop a system of indicators of quality of life in five policy areas. The purpose of the indicator system is to help inform decisionmaking throughout the greater Pearl River Delta (PRD), almost all of which is within Guangdong Province, and inform measures to increase regional economic integration with the Special Administrative Areas of Hong Kong and Macao. This report proposes a set of land use and transportation goals and strategies and an accompanying system of indicators to examine and monitor quality of life in the greater PRD. Goals, strategies, and indicators are also developed in less detail for the environment, housing, and economic development policy areas.

To supplement the indicator system with subjective measures of quality of life, HURD asked RAND to design a pilot test of a resident satisfaction survey for the Pingshan New District of Shenzhen. The purpose of the pilot survey was to gather baseline information on residents' perception of conditions pertaining to quality of life in this district, gain experience in managing and fielding such surveys, and make recommendations for deployment of an improved resident satisfaction survey in other districts and cities of the PRD. The study was conducted with support from the Shenzhen Graduate School of Beijing University and Guangdong City Development Research Center.

Development of Goals and Strategies

RAND gathered information on challenges, goals, and indicators currently in use in the PRD from broad sources: statistical data, literature reviews, discussions with PRD officials, and a survey of residents. This information, combined with subsequent analysis of data, was used to develop the quality of life indicator system and the policy recommendations that were derived from its application.

A policy goal is a desired outcome within the realm of a government's mission to improve the economic and social well-being of its people. These goals derive from understanding key challenges that are within the responsibility of governments to affect. To the extent possible, RAND drew on existing policy goal statements at the provincial, city, or district level. When we could not clearly identify an existing goal, we defined new goals that would be both realistic and challenging.

A strategy is a policy action (or series of connected actions) that a government agency undertakes. For each goal, we have identified one or more strategies to achieve that goal; other strategies could be added or substituted over time while still maintaining the goal and indicators associated with it. Strategies can include adoption of new laws and regulations, enforcement actions to protect public health and safety, provision of a public service such as a bus or subway line, and public information or outreach campaigns. We also sought to differentiate priorities among the proposed strategies along several dimensions: impact on attainment of goals as measured by the proposed indicators, ease of implementation, and the time frame within which a strategy could be implemented.

Different levels of government may adopt different strategies based on their own special circumstances, abilities, and administrative constraints. In this project, broad common policy goals were identified, but different local governments may undertake different strategies to reach them, depending on their individual circumstances and capabilities. Further, strategies will need to be continuously improved and updated to meet changing conditions and needs, based on their effectiveness as measured by the indicators.

A very important caveat must be highlighted with regard to strategies suggested in this report. Strategies in each of the five policy areas vary in complexity; their success in a given place at a given time cannot be assured without more detailed analysis and attention to implementation in the specific context of the PRD. This study was not of sufficient scope to enable RAND to conduct a thorough comparative policy, benefit-cost, or cost-effectiveness analysis across potential strategies or critique policies now in place in the PRD. These strategies are intended to be suggestive of promising approaches used successfully in other places. As a general matter, we opted for strategies that met the test of practicality and established success over those that might be new and different, but also less certain in effectiveness.

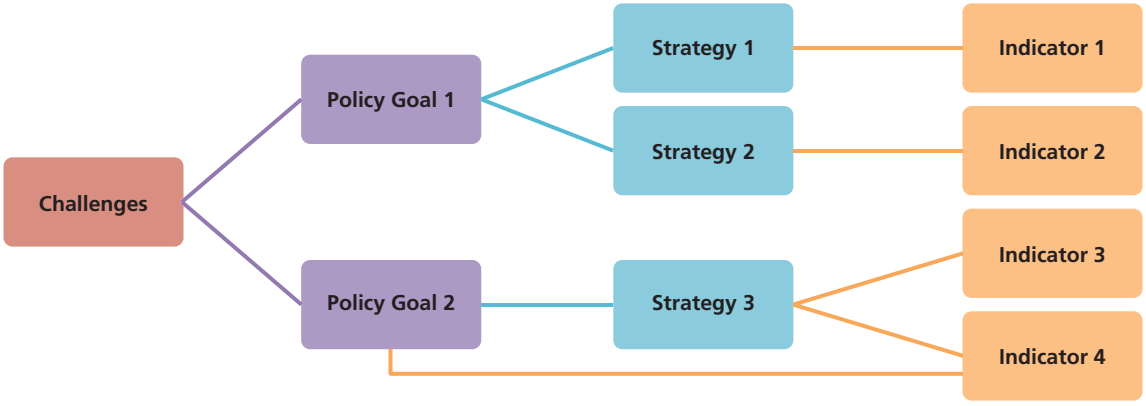
Indicator Framework

We developed a conceptual framework for the indicator system in the five selected policy areas that would contribute collectively to the improvement of quality of life in the PRD. Strategies and indicators are placed within a decision framework in which challenges and policy goals are first defined. Both objective and subjective indicators provide systematic and temporally consistent evidence to provincial and municipal decisionmakers as to whether policy goals are realistic, existing strategies are working as intended to meet policy goals, incentives are properly aligned at all levels to achieve goals, and new strategies are needed to augment or replace existing strategies. Figure S.1 illustrates the framework used for this study. Across the five policy areas, we have identified 12 challenges, and we propose 21 goals, 53 strategies, and 85 indicators to address these challenges.

Resident Satisfaction Survey

The Pingshan New District was selected by HURD as the location for the pilot test because of its location within Shenzhen, one of the PRD's largest and most dynamic cities. The primary purpose of the pilot survey was to gather baseline conditions pertaining to quality of life in Pingshan New District. A second purpose was to gain experience in fielding such surveys and

Figure S.1
Conceptual Framework for Indicator System



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then make recommendations for deployment of a resident satisfaction survey in other districts and cities of the PRD.

Pingshan New District was home to many export-oriented factories but is now at the forefront of economic transition to higher-value manufacturing and services. Resident status of survey respondents was representative of the demographics in Pingshan New District. The vast majority of those interviewed (95 percent) were members of Pingshan New District's floating (migrant) population; 3 percent were original to the area; and 2 percent were not original but had Shenzhen *hukou* (registration). Consistent with the dominance of the floating population, 58 percent of the respondents were male. About two-thirds of survey respondents were between the ages of 18 and 34. More than half of the respondents have not received formal education beyond junior high school, and about a quarter were better educated, with a secondary specialized or tertiary degree.

Most respondents considered quality of life in Pingshan New District to be good (48 percent) or average (48 percent); few reported that it was very good (5 percent) or poor (3 percent). Looking to the future, most residents (72 percent) believe that the quality of life in Pingshan will improve a little, and 13 percent think it will improve a lot. However, responses to specific questions about various facets of life in Pingshan reveal a more nuanced view of conditions. For example, less than 50 percent of respondents liked the way their district looks and feels, with 43 percent saying they neither agreed nor disagreed with the statement that they like its look and feel.

These results, particular for Pingshan, need to be carefully interpreted and kept in perspective. Survey results have an error of plus or minus 10 percent (at a 95 percent confidence level). Further, comparison of survey responses across communities and cities are of limited use because the baseline will be different from place to place. These responses are not suitable measures for ranking places in the PRD. Instead, these results are intended to be meaningful to decisionmakers and the public within a given district, county, or city.

Apart from the particular results for Pingshan, the pilot exercise enabled the study team and HURD to gain valuable experience in conducting an extensive survey with in-person interviews. The survey's sample size was deliberately designed to provide sufficient statistical power to report results at the community level. Some cities may wish to conduct a citywide

survey and not focus on conditions and trends within particular districts or communities, with samples sizes reduced accordingly. Cost-effectiveness of administering a survey is one of the important considerations for future and wider deployment. The cost of conducting a survey of this kind depends in large measure on the logistics of training and supporting interviewers as they conduct their interviews.

Strategic Themes

Several common themes among the strategies in the five policy areas emerged from the study. We chose strategies that would

- increase transparency and accountability in regulation
- increase compliance with regulations by improving the effectiveness of incentives
- expand access to public services and quality improvements
- accelerate the improvements in public services and the environment
- improve data and analysis to better guide decisionmaking
- reduce pollution and improve health and safety.

In all areas, but particularly in land use, environment, and housing, there is an overarching need to increase transparency and accountability in regulation. Laws and rules are in place in many instances, but their implementation and enforcement are weak. Given widespread noncompliance with regulation of commercial activity, businesses, whether private or state-owned enterprises, appear to lack the appropriate economic incentives to comply with these regulations. For this reason, we recommend strategies across the policy areas that are intended to increase the incentives for both compliance and enforcement. As revealed in the Pingshan Resident Satisfaction Survey, residents have expectations for public services and physical amenities, including clean air, clean water, and green space, that are not being met at the levels desired. Reducing pollution and improving health and safety of residents are the desired outcomes of the environmental, transportation, and land use strategies. Several strategies are intended to improve the physical surroundings of cities, districts, and counties. Across all five policy areas, we identified the need for strategies to improve data and analysis to better guide decisionmaking.

Building a culture of evidence-based policymaking throughout the PRD could be an important legacy of this indicator system. The process of choosing indicators first requires a careful analysis of the pathway to desired outcomes in each of the policy areas. Getting to desired outcomes sometimes requires a number of intermediate steps. For example, cleaner air and cleaner water are the *outputs* of environmental regulation. Better human and ecological health are the *outcomes* of having cleaner air and water. However, getting to these outputs and outcomes requires all the necessary ingredients (*inputs*) for successful environmental regulation: adequate staffing, incentives for compliance, strong and consistent enforcement, and a solid scientific basis for regulation and monitoring. For this reason, across all policy areas, we emphasize the need for investing in strategically designed data collection and conducting analysis to assess policy strategies before, during, and after implementation. Indicators that are viewed as accurate and grounded in sound data collection methods will lend credibility to claims of improving quality of life in the PRD.

Land Use

Measures of performance related directly to land use decisions are difficult to define within any indicator system. This is because there is no single goal of land use policy that is unambiguously associated with improving the quality of life. Rather, land use choices can enable the achievement of other goals. The proper balance among varying uses depends on the economic and social context; there is no correct "formula" for how much land should be devoted to specific uses or what the right population density should be.

We therefore focus land use goals and strategies on addressing four challenges that have been brought on by rapid urbanization and inadequate land use planning. The first challenge is around the unplanned nature of urban development in terms of its encroachment into rural areas. We recommend a goal of increasing contiguity of both urban and rural land, through two strategies: mapping land to be protected and creating mechanisms to ensure protection.

The second challenge deals with improving land use within the urban development areas, to provide high-quality residential areas and efficient infrastructure and services. Three goals are suggested here. The first is to increase the density of residential space and employment opportunities through provision of high-quality compact development. We propose transit-oriented development, form-based zoning, better-connected street networks, and more attractive public spaces—all intended to mitigate the potential negative effects of high densities. The second goal is to increase access to public services and facilities. Here we suggest a strategy to create incentives for developers to build in certain neighborhoods based on provision of public infrastructure. Finally, the third goal is to reduce the presence of industrial properties in prime residential and commercial areas, and we propose a strategy to develop a brownfields program that includes remediation standards and clear roles for various agencies.

The third challenge addresses historic preservation, which has been somewhat neglected in the rush for modern development. The goal here is to strengthen measures to preserve historic properties and assets to foster cultural identity and tourism. The two related strategies are to identify and prioritize buildings and neighborhoods with historical and cultural value and to enact and enforce historic preservation regulations.

Finally, the fourth challenge addresses the need for reducing vulnerability to natural disasters in land use planning, an important topic given the potential for wind damage from storms, flooding, and earthquake damage in the PRD. The goal for this challenge is to reduce vulnerability to natural hazards. We propose here a strategy to evaluate assets at risk of flooding, wind damage from typhoons, and earthquakes through a comprehensive mapping program.

Transportation

We identify three major challenges: the imperative to reduce high-polluting forms of transportation; the safety, traffic congestion, and environmental impacts of freight transportation; and the high number of deaths and injuries on the roads. We recommend four goals to overcome the challenge of providing a high-quality alternative to driving.

The first goal is to mitigate the need for people to travel by private passenger vehicle. Strategies to further this goal are to (1) enhance the competitiveness of bus and rail through improvements in service coverage and frequency and (2) promote bicycle-sharing, car-sharing, taxi services, and dynamic ridesharing services.

The second goal is to improve connectivity among transportation modes and among PRD cities. Strategies include (1) developing multimodal transit hubs to enhance transportation connections, choices, and coordination among modes, (2) implementing smart, interop-

erable ticketing within the PRD to make it easier to use multiple forms of public transit for a single trip, and (3) developing a travel survey that captures inter- and intracity travel flows and mode use to be implemented at regular intervals.

The third goal is to create an environment that emphasizes nonmotorized transportation modes. The associated strategy is to connect pedestrian and bicycle greenways and paths to major employment destinations.

The fourth goal is to manage parking demand and supply. Three strategies are presented to achieve this goal: (1) instituting a parking pricing system for on-street parking and encourage entrepreneurs to develop smart phone applications that facilitate making payments, (2) encouraging entrepreneurs to develop smart phone applications that provide real-time information on available parking spaces, and (3) enforcing parking regulations and imposing high penalties for illegal parking.

To address the negative effects of the second challenge of road-based freight transport, we recommend one policy goal of reducing interactions between passenger cars and trucks, primarily in urban areas. The two strategies to further this goal are to (1) implement peak-period delivery restrictions in the central business district and other highly congested areas and (2) create freight consolidation centers in urban fringe areas.

For the third challenge, we propose a goal of reducing deaths and injuries on the roads. One proposed strategy supports this goal: integrate road safety audits (RSAs) into the project development process for new roads and intersections.

Environment

We identified two challenges that apply throughout the PRD, Guangdong, and most of China. The first challenge is that water and air pollution and soil contamination are causing significant harm to human health and ecological resources, and diminishing economic growth. The second challenge is that regulators have insufficient resources and incentives to enforce laws and standards. We propose goals to improve key indicators of environmental quality that will ultimately lead to improved health and well-being of the PRD's residents and ecology:

- Improve water quality in the PRD by reducing unlawful industrial and municipal wastewater discharges into rivers and groundwater.
- Reduce contamination of current and former industrial lands.
- Reduce air pollution from vehicles, major coal-burning power plants, and industrial facilities.

However, environmental quality cannot be measurably improved without simultaneously increasing enforcement and accountability throughout the environmental protection system in China. For this reason, we recommend three complementary types of strategies:

- Align environmentally friendly land use and transportation strategies to reduce pressure on air and water quality as well as land contamination and ecological resources.
- Publicly disclose information about polluters; their discharges and emissions; and the officials (including heads of bureaus) responsible for issuing permits, monitoring compliance, imposing fines, and shutting down facilities that are in violation with the law.

- Increase incentives to comply with laws and regulations for the individuals and corporations who run the polluting facilities, including state-owned enterprises, and public officials who lead the local Environmental Protection Bureaus.

Housing

We identify two primary challenges: lack of affordable housing for middle-income residents and lack of affordable rental housing for lower-income residents. For the first challenge, we recommend a goal of ensuring that reasonably priced housing is available to households at middle-income levels through government intervention. We suggest three strategies to accomplish this: (1) create incentives for developers to build more affordable rental housing through competitive requests for proposals; (2) limit speculation by levying property taxes on homes; and (3) require a certain percentage of affordable units in transit-oriented development.

The second challenge relates to both affordability and availability. Migrant workers, who form a substantial proportion of the population, are not always eligible for housing assurance programs or allowed to purchase housing. We recommend a goal to increase construction of rental housing that will be affordable to lower-income groups. The strategies to further this goal are to (1) redevelop "villages in cities" using land readjustment techniques; (2) adjust housing assurance programs to allow smaller and lower-cost rental units; (3) provide housing vouchers to low-income residents; and (4) implement and enforce building and amenity standards for rental units.

Economic Development

The PRD's export-oriented growth model has been hurt by lower demand from the global market and competition from lower-cost producers in other countries. A critical challenge for the PRD region will be to identify new engines of growth by developing new export markets, expand sales to China's domestic market, and create conditions that will enable growth of new low-carbon industries and services. At the same time, steps will need to be taken to address growing income inequality.

We recommend three policy goals to address this overarching challenge and seven strategies linked to raising residents' standard of living. The first goal is to raise output and employment by encouraging businesses in Guangdong to sell more to other provinces in China. To assist firms in the PRD to expand sales to China's domestic market, we propose the following strategies: (1) reduce internal barriers to trade; (2) improve provision of market information on prices, quality, grade, and other product attributes in provinces where PRD businesses are targeting their sales efforts; and (3) pilot a preclearance program at the border crossing with Hong Kong–Macao so as to speed cross-border flows of goods and better penetrate China's domestic market.

The second goal is to reduce income inequality by improving access to higher education and developing a labor force with more sophisticated skills needed for higher-wage work. We propose three strategies to improve monitoring and training to meet the demands from emerging industries for a higher-skilled labor force: (1) better tracking changes in the PRD labor market, (2) attracting workers with higher skills to the PRD, and (3) training graduates for work in emerging industries.

The third goal is to implement economic development strategies consistent with reducing emissions of greenhouse gases in the PRD while maintaining economic growth in the region. In the land use, transportation, and environment policy areas, we propose several strategies that

will yield outcomes that will contribute to reducing emissions of greenhouse gases: (1) promote transit-oriented development; (2) create incentives for more compact development; (3) pursue the six transportation strategies related to improving the efficiency and convenience of public transit, bicycling, and walking; and (4) pursue the four environmental strategies related to improving air quality. To support these strategies, we recommend an additional strategy of monitoring and verifying reductions in emissions of carbon dioxide achieved through implementation of the other strategies.

Summary of Indicators

Tables S.1–S.5 summarize the challenges, goals, strategies, and indicators across the five policy areas. Notations such as "Q26f" refer to items on the Pingshan New District survey.

Table S.1
Land Use Challenges, Goals, Strategies, and Indicators

Challenges, Goals, and Strategies		Proposed Indicators	
Challenge CL1	**Unplanned outward expansion of urban boundaries has led to fragmentation of both urban and rural land.**		
Goal GL1	Increase the contiguity of urban and rural land.		
Strategy SL1	Map ecological protection zones and agricultural land based on productivity.	L1	Land area within the ecological control line as percentage of total area of land in the region
		L2	Area of cultivated land as percentage of total areas of land in region
Strategy SL2	Enforce limits on development of more valuable ecological and agricultural lands.	L3	Land area within the ecological control line that was developed in the prior year as percentage of total land area within ecological control line (2013 as baseline year)
		L4	Portion of land area designated as cultivated that was converted to development in the prior year as percentage of total cultivated land (2013 as baseline year)
Challenge CL2	Urban land is not utilized in a way that allows for efficient provision of public services and facilities.		
Goal GL2	Increase density of residential space and employment opportunities through provision of high-quality compact development.		
Strategy SL3	Promote transit-oriented development near rail stations (both intercity and urban rail).	L5	Number of housing units within 0.5 kilometers of a rail station as percentage of all housing units (in region, city, district, or county) (Q26f)
Strategy SL4	Adopt and enforce a zoning system that uses control on space such as density and design ("form-based codes") rather than a system based on land use function.	L6	Percentage of residents who agree there is a good mix of building types (e.g., residential housing, shops, office buildings) (Q10a)
Strategy SL5	Create a well-connected street network.	L7	Average block length of new rebuilt roads
		L8	Percentage of residents who feel safe crossing at crosswalks (Q27h)

Table S.1—Continued

Challenges, Goals, and Strategies		Proposed Indicators	
Strategy SL6	Provide high-quality green space and attractive public spaces within residential and commercial areas.	L9	Percentage of residents who think the city, district, or county provides access to nature in parks, open spaces, or gardens (Q10c)
		L10	Percentage of districts with under 30 percent open space
		L11	Percentage of residents who think the city, district, or county provides attractive public spaces (Q10d)
Goal GL3	Increase efficiency and cost-effectiveness in the provision of public services and facilities.		
Strategy SL7	Create incentives to concentrate development by providing key infrastructure only in designated areas, consistent with compact development.	L12	Average distance to primary school (defined as elementary, middle, and other schools within the nine-year compulsory education system)
		L13	Average distance to community health service center
		L14	Average distance to hospital (general or specialized)
		L15	Average distance to (a) fire stations and (b) police stations
Goal GL4	Reduce the presence of industrial properties in prime residential and commercial areas.		
Strategy SL8	Develop a brownfields program that includes remediation standards and clear roles for various agencies.	L16	Number of brownfield sites that are available for redevelopment, according to redevelopment plans, as a share of all brownfields sites in the annual inventory
Challenge CL3	**Historic and cultural preservation has been neglected.**		
Goal GL5	Strengthen measures to protect properties and assets with historical importance and distinctive local characteristics.		
Strategy SL9	Identify and prioritize buildings and neighborhoods with historical and cultural value.	L17	Number of buildings listed on a historic registry
Strategy SL10	Enact and enforce historic preservation regulations.	L18	Percentage of residents who think their city, district, or county provides historic preservation of structures or buildings (Q10b)
Challenge CL4	**Current development patterns and processes do not adequately address the need for resilience from natural disasters.**		
Goal GL6	Reduce vulnerability to damage from natural disasters.		
Strategy SL11	Identify and evaluate assets at risk of flooding through mapping.	L19	Number of structures in flood-prone areas
		L20	Value of assets in flood-prone areas
Strategy SL12	Identify and evaluate assets at risk of typhoon damage through mapping.	L21	Number of structures in typhoon-vulnerable areas
		L22	Value of assets in typhoon-vulnerable areas
Strategy SL13	Identify and evaluate assets at risk of earthquake damage through mapping.	L23	Number of structures in seismically unsound areas
		L24	Value of assets in earthquake-prone areas

Table S.2
Transportation Challenges, Goals, Strategies, and Indicators

Challenges, Goals, and Strategies		Proposed Indicators	
Challenge CT1	**Without high-quality public transit alternatives, VKT in privately owned cars per capita will increase and congestion and air pollution will worsen.**		
Goal GT1	Mitigate the need for people to travel by privately owned cars.		
Strategy ST1	Enhance the competitiveness of bus and rail through improvements in service coverage and frequency.	T1	Annual VKT per capita in privately owned cars
		T2	Percentage commute mode (for driving a car, riding in a car, taxi/ridesharing, bus, rail, high-speed rail, bicycle, and walk)
		T3	Satisfaction with public transportation service frequency
		T4	Satisfaction with public transportation service coverage
Strategy ST2	Promote bicycle-sharing, car-sharing, taxi, and dynamic ride-sharing services.	T2	Same as above
Goal GT2	Improve connectivity among transportation modes and among PRD cities.		
Strategy ST3	Develop multimodal transit hubs to enhance transportation connections, choices, and coordination among modes.[a]	T5	Number of multimodal transit hubs
		T6	Average bus speeds on selected high-use corridors during morning and afternoon peak periods
Strategy ST4	Implement smart, interoperable ticketing within the region to make it easier to use alternative forms of public transit.	T7	Number of cars sold as a share of number of permanent residents
Strategy ST5	Develop a travel survey that captures inter- and intracity travel flows and mode use.	T8	Number of data entries as a consequence of implementation of travel surveys.
Goal GT3	Create an environment that emphasizes nonmotorized transportation modes.		
Strategy ST6	Connect pedestrian and bicycle greenways and paths to major employment destinations.	T2	Same as above
Goal GT4	Manage parking demand and supply.		
Strategy ST7	Institute a parking pricing system for on-street parking and encourage entrepreneurs to develop a mobile app that facilitates making payments.	T9	Proportion of paid parking spaces relative to all public parking spaces
Strategy ST8	Encourage entrepreneurs to develop apps that provide real-time information on available parking spaces to make finding parking easier and to avoid illegal parking.	T10	Satisfaction with parking availability
Strategy ST9	Enforce parking regulations and impose high penalties for illegal parking in central business district and other high-demand areas.	T11	Number of parking citations issued
		T12	Percentage of parking citations paid

Table S.2—Continued

Challenges, Goals, and Strategies		Proposed Indicators	
Challenge CT2	**Road-based freight transport is a major source of congestion and safety problems.**		
GT5	Reduce interactions between passenger cars and trucks.		
ST10	Implement peak-period delivery restrictions in the central business district and other highly congested areas.	T13	Truck volume counts on high-capacity urban roads during peak periods
Strategy ST11	Create freight consolidation centers in urban fringe areas to reduce the number of deliveries in the city center.	T14	Percentage of residents who think congestion from trucks is a problem
Challenge CT3	**An extremely high number of deaths and serious injuries are caused by everyday use of the roads.**		
Goal GT6	Reduce deaths and injuries on the roads.		
		T15	Number of traffic deaths per year
		T16	Number of traffic injuries per year
Strategy ST12	Integrate RSAs into the project development process for new roads and intersections.	T17	Number of RSAs conducted per year

Table S.3
Environmental Challenges, Goals, Strategies, and Indicators

Goals and Strategies		Proposed Indicators	
Challenge CE1	**Water and air pollution and soil contamination are causing significant harm to human health and ecological resources, and diminishing economic growth.**		
Challenge CE2	**Regulators have insufficient resources and incentives to enforce laws and standards.**		
Goal GE1	Increase enforcement capacity and accountability for air and water pollution and soil contamination.		
Strategy SE1	Increase the number of inspections by trained inspectors.	E1	Number of facilities inspected annually by trained inspectors as a percentage of the total number of facilities that have one or more permits for air emissions, water discharge, and hazardous chemical storage.
		E2	Number of facilities identified but lacking permits as a share of total number of facilities (permitted and unpermitted).
Strategy SE2	Increase incentives for enforcement.	E3	Number of facilities (above a specified size) with up-to-date air, water, and chemical storage permits as a percentage of all facilities (above a specified size) eligible for permitting
		E4	Percentage of total permitted facilities in full compliance with their permits
Strategy SE3	Increase incentives for compliance.	E5	Amount (in RMB) of fines collected per year
Goal GE2	Reduce unlawful industrial and municipal wastewater discharges into rivers and groundwater.		
		E6	Percentage of residents who feel that drinking water quality has improved
		E7	Percentage of residents who are dissatisfied with drinking water quality
		E8	Number of surface water monitoring stations where Class II water quality standards[a] have been met for 12 consecutive months
		E9	Number of groundwater well monitoring locations where Class II water quality standards have been met for 12 consecutive months
Strategy SE4	Allow cities, districts, and counties downstream of unlawful discharge of sewage and industrial waste to receive some percentage of the revenue from fines imposed on polluters.	E10	Amount (in RMB) of fines directed to cities, districts, and counties per year
Strategy SE5	Expand water quality monitoring networks for both surface and groundwater.	E11	Number of surface water monitoring stations fully operational for 12 consecutive months
		E12	Number of groundwater well monitoring locations fully operational for 12 consecutive months
Goal GE3	Reduce contamination of current and former industrial lands.		
		E13	Number of hectares requiring major cleanup based on site inventory

Table S.3—Continued

Goals and Strategies		Proposed Indicators	
Strategy SE6	Produce an annual inventory of contaminated waste sites in the PRD region. Assign responsibility to the director-general of the Environmental Protection Bureau for oversight of cleanup at sites within the appropriate jurisdiction, and publish a list of sites with the name of the facility owner and a description of the nature of the contamination.	E14	Number of sites identified
		E15	Number of hectares contaminated on the sites identified
Strategy SE7	Establish waste site cleanup funds at the municipal and provincial levels to use to remediate contaminated sites where the owner cannot be found.	E16	Expenditures (in RMB) for site cleanup from the provincial and municipal cleanup funds
Goal GE4	Reduce unlawful emissions from air pollution from stationary and mobile sources.		
		E17	Percentage of residents who feel that air quality has improved
		E18	Percentage of residents dissatisfied with air quality
		E19	Average daily and annual peak levels of $PM_{2.5}$ (E19a), ozone (E19b), sulfur dioxide (E19c), nitrogen oxides (E19d), and mercury (E19e)
Strategy SE8	Accelerate Guangdong's phase-out of coal use, especially for household heating and industrial use, and coal-fired power plants serving all PRD cities.	E19	Same as above.
		E20	Annual greenhouse gas emissions reported by type of source (e.g., power plants, industry facilities, residential and commercial buildings, and mobile sources)
Strategy SE9	Accelerate the implementation of green building codes and appliance efficiency programs.	E21	Annual energy consumption per square meter in public, commercial, and residential buildings
		E22	Floor area of certified newly constructed green buildings as a share of total floor area of all newly constructed buildings (annual)
Strategy SE10	Accelerate removal of highly polluting vehicles through incentive payments.	E23	Number of yellow-tag vehicles remaining in use
Strategy SE11	Increase the number of cleaner cars registered.	E24	Percentage of vehicles registered that meet China VI pollution control standards
Strategy SE12	Accelerate adoption of cleaner vehicle fuels.	E25	Percentage of fuels sold in Guangdong that meets the new China VI standard

[a] Suggested chemical pollutants include: dissolved oxygen, nitrogen, phosphorus, and cadmium. A particular biological species present in a river could also be used (e.g., population of a type of fish).

Table S.4
Housing Challenges, Goals, Strategies, and Indicators

Goals and Strategies		Proposed Indicators	
Challenge CH1	**There is a lack of good-quality public rental housing and housing for purchase for middle-income residents.**		
Goal GH1	Ensure that housing (for rental and purchase) remains affordable to households at medium-income levels.		
Strategy SH1	Create incentives for developers to build more affordable rental housing and housing for purchase through competitive requests for proposals (RFPs) for below-market-priced land.	H1	Among middle-income households, share of household income spent on rent or mortgage
		H2	Sum of public rental housing units and affordable rental housing units built by private developers as a share of all available housing units
Strategy SH2	Increase funding capacity and reduce government reliance on development fees by levying property taxes on homes.	H3	Units built as a result of awards made to private developers through RFPs
Strategy SH3	Require a certain percentage of public rental housing units and affordable housing for purchase in transit-oriented developments (TODs).	H4	Property tax income received by government
		H5	Share of public rental housing units and affordable housing for purchase built in TODs
Challenge CH2	**There is a lack of good-quality public rental housing for lower-income residents.**		
Goal GH2	Enhance construction of better-quality rental housing that is affordable to lower-income groups.		
		H6	Among lowest to lower-middle income households, share of household income spent on housing
Strategy SH4	Redevelop "villages in cities" using land readjustment techniques.	H7	Number of rental homes located in villages in cities in which lower-income households pay more than 30 percent of household income in rent
Strategy SH5	Adjust housing construction programs such as Cheap Rental Housing to allow developers to build low-cost rental units.	H8	Number of newly constructed low-cost units, defined as affordable to lowest and lower-middle income households, based on paying no more than 30 percent of income on rent
Strategy SH6	Provide housing vouchers to low-income residents, where voucher payments are directly provided to landlords after unit inspected and lease signed.	H9	Percentage of households that receive vouchers who pay more than 30 percent of their income for housing
Strategy SH7	Implement and enforce building and amenity standards for all public rental housing units and rental units built by private developers.	H10	Percentage of rental units that meet standards

Table S.5
Economic Development Challenges, Goals, Strategies, and Indicators

Goals and Strategies		Proposed Indicators	
Challenge CD1	**Accelerate the economic transition by encouraging more sales to other Chinese provinces, while seeking new, low-carbon opportunities to expand the regional economy.**		
Goal GD1	Raise output and employment by encouraging businesses in the PRD to sell more to other regions in Guangdong and elsewhere in China.		
Strategy SD1	Reduce internal barriers to trade.	D1	Annual number of shipping containers (in 20-foot-equivalent units (TEUs) to other regions
Strategy SD2	Improve provision of market information on prices, quality, grade, and other product attributes in provinces where PRD businesses are targeting their sales efforts.	D2	Annual growth rate in sales value, by province from base year
Strategy SD3	Pilot a preclearance program at a border crossing with Hong Kong–Macao.	D3	Wait times of goods traffic (trucks) when crossing Shenzhen (border with Hong Kong) and Zhuhai (border with Macao)
Goal GD2	Reduce income inequality by improving access to higher levels of education and developing a labor force with more sophisticated skills needed for higher wage work.		
Strategy SD4	Improve the tracking of changes in the PRD labor market.	D4	Number of new jobs created
		D5	Number of jobs lost
Strategy SD5	Attract workers with higher skills to the PRD.	D6	Number of workers in key areas: assembly (D6a), high tech (D6b), and services (D6c)[a]
		D7	Percentage of residents satisfied with their job situation
Strategy SD6	Train graduates for work in emerging industries.	D8	Number of graduates from local vocational-technical schools in relevant fields
Goal GD3	Implement low-carbon economic development strategies.		
Strategy SD7	Improve monitoring and verification of emissions reductions resulting from low carbon development strategies [SL3, SL7, ST1–ST6, SE8–SE12].	D9	Energy intensity of relevant sectors/areas: transportation (D9a), industry (D9b), and waste water treatment (D9c)

[a] According to the *Chinese Urban Statistics Yearbook* industries list, we consider the assembly sector to include the manufacturing industry; the high-tech sector to include the following industries: information, computer services, software, and scientific research; and the services sector to include the following industries: finance and real estate services; health care and social welfare; transport, storage, and postal services; hotels and restaurants; and environment and public facilities management.

Recommendations for Implementation

We sought to develop a workable indicator system that would be closely associated with policy strategies aimed at improving quality of life in the PRD. The indicator system is a set of individual indicators linked to attainment of multiple goals, and it is not intended to lead to the creation of an overall index that condenses the individual indicators into a single score. Practically speaking, implementation of the indicator system will need to be staged over several years as strategies are initiated and data collected. Periodic review and updating of the indicators will also be necessary as experience is gained about the value of existing indicators and the potential for new indicators as better data collection methods become available. In some cases, improved or expanded data collection methods may enable substitution of objective measures for some of the subjective measures derived from the resident satisfaction survey.

Although strategies will be implemented at the provincial and local levels by multiple agencies, central oversight and maintenance of the indicator system will be crucial to its success. We recommend a cross-agency and cross-government council approach with a single agency lead.

The success of the indicator system will be judged by its ability to focus public resources on improving conditions in the PRD that lead to both the perception and reality of a better quality of life for all of the region's residents. Priority setting is an important step in implementation. For each policy area, we recommend an order for implementing strategies based on their likely impact on progress toward goals, degree of difficulty, and time required to put the strategy in place. These evaluations are based on the RAND team's professional judgment and will require careful review and revision by the implementing authorities at the provincial and municipal levels.

The ability to attract higher-skill workers to the PRD will be enhanced if, over time, the PRD develops a reputation inside and outside of China as having made great strides in each of the policy areas addressed in this study. An indicator system is only one of many management tools that governments have to work with, but it can become a powerful tool if it can be seen as a credible representation of progress toward meeting challenges facing the PRD region and a reliable and trusted means of demonstrating that policy strategies are contributing to achievement of Guangdong's long-term goals of a better life for all residents.

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Abbreviations

CBD	central business district
CIO	chief information officer
CPC	Communist Party of China
CRH	Cheap Rental Housing program
EPA	U.S. Environmental Protection Agency
EPB	Environmental Protection Bureau
GDP	gross domestic product
GIS	geographic information system
HURD	Department of Housing and Urban-Rural Development of Guangdong Province
JOLTS	Job Openings and Labor Turnover Survey
NO_x	nitrogen oxides
OECD	Organisation for Economic Co-operation and Development
$PM_{2.5}$	particulate matter with diameters of 2.5 microns or less
PM_{10}	particulate matter with diameters of 10 microns or less
PRD	Pearl River Delta
RSA	road safety audit
SO_x	sulfur oxides
TEU	20-foot-equivalent unit
TOD	transit-oriented development
UCC	urban consolidation center
UGB	urban growth boundary
VKT	vehicle kilometers traveled
VOC	volatile organic compound

CHAPTER ONE

Introduction

This study developed quality of life indicators and policy options to advance sustainability in the Pearl River Delta (PRD), a region of Guangdong Province in southeastern China. These indicators and options are also intended to enable increased regional economic integration with the Special Administrative Areas of Hong Kong and Macao.

Quality of life is an integral component of the concept of sustainability. Sustainability is meant to capture the durability of favorable environmental and socioeconomic conditions in a particular place over time, implying that choices and opportunities for future generations will not be precluded by depletion or degradation of resources undertaken to satisfy the needs of the present generation. China's leaders have set sustainability as a national goal (12th Five-Year Plan, 2011; Chinese Embassy, 2012).

Quality of life is a shorthand term for many facets of socioeconomic well-being that contribute to sustainability. Indicators that capture key features associated with the various dimensions of quality of life can provide a foundation for measuring progress and can be a useful guidance and monitoring mechanism for policy- and decisionmaking. The Department of Housing and Urban-Rural Development of Guangdong Province (HURD) of the People's Republic of China asked RAND to conduct this study to help inform decisionmaking throughout the PRD and Guangdong on policy initiatives to improve quality of life in the region. The study was conducted in collaboration with the Shenzhen Graduate School of Beijing University and Guangdong Urban and Rural Planning and Design Institute.

Defining Quality of Life

Sustainable development came into wide use in the early 1990s as the central organizing principle of international aid efforts, in contrast to policies that promoted economic growth above environmental protection and distributional equity. The idea of sustainability is simply that economic growth should be inclusive of all residents and environmentally sound to meet the needs of today's population as well as those of future generations. Thus, sustainable development is intended to deliver both near- and longer-term benefits (World Bank, 2012).

Like sustainable development, the concept of quality of life has been imbued with many different meanings, depending on disciplinary perspective, ranging from international development and health to urban planning, philosophy, and sociology. Over the past decade, there have been many projects and initiatives throughout the world related to quality of life indicators. For example, in the United States, three federal agencies (the U.S. Environmental Protection Agency [EPA], the U.S. Department of Housing and Urban Development, and the U.S.

Department of Transportation) joined together in 2009 to establish the Partnership for Sustainable Communities (Partnership for Sustainable Communities, no date). The interagency partnership proposed livability principles: provide more transportation choices; promote equitable, affordable housing; enhance economic competitiveness; support existing communities; coordinate and leverage federal policies and investment; and value communities and neighborhoods. *Livability* is a term often used synonymously with *quality of life*.

In fact, more than 100 different definitions of quality of life have been noted in the literature; no consensus exists on a definition or on how quality of life should be measured (Morais, Miguéis, and Camanho, 2011; Hagerty et al., 2001). Generally, these definitions capture aspects of well-being, happiness, above-average living standards, and life satisfaction, going well beyond gross domestic product (GDP) to encompass a broader range of indicators of social and economic well-being. They include economic well-being but also factors such as housing conditions, health conditions, education opportunities, public safety, environmental conditions, freedom of expression, recreational opportunities, work environment, social interaction, and mobility. For our study, we use a simple definition: Quality of life captures people's satisfaction or happiness with their surrounding environment and living conditions. We recommend both objective and subjective measures to assess quality of life in the PRD to capture not only physically measurable conditions—such as the amount of green space or number of parks, air and water quality, or availability of transportation options—but also the perceptions and level of satisfaction that residents have about their cities, districts, and counties and the services and amenities available to them.

Rationale for Measuring Quality of Life in the Pearl River Delta

China has achieved rapid economic growth over the past three decades; growth in GDP has averaged about 10 percent per year. Since the economic reforms that began in 1978, growth in GDP has been the most important measure of progress for China's leadership, a key driver of economic policies, and viewed as the foundation of a higher quality of life.

Rapid economic growth has come with both intended and unintended consequences, and has given rise to many social, environmental, and economic challenges in China. China also faces demographic pressures related to an aging population, an unprecedented surge of migrant labor from rural areas to cities, and an expanding middle class. China's 12th Five-Year Plan (2011–2015) sought to address these issues. The plan's annual growth target of 7.5 percent signaled intent to moderate the pace of economic growth to enable a shift in focus on improving quality of life. The three top priorities in this plan were sustainable growth, industrial upgrading, and the promotion of domestic consumption (12th Five-Year Plan, 2011). In 2013, the slate of reforms embedded in the Third Plenary Session of the 18th Communist Party of China (CPC) Central Committee deepened the commitment to improve quality of life ("CPC Central Committee's Third Plenary Session Party Sets Course for Next Decade," 2013). In his 2015 Report on the Work of the Government speech, Premier Li Keqiang also stated that "increasing people's quality of life" is the government's objective, and the government will "accelerate the development of social programs, reform and improve the income distribution system, do everything possible to increase people's income, and promote social equity, justice, harmony, and progress" (Li, 2015).

Within China, concern about and commitment to improved quality of living is no more evident than in Guangdong Province. Guangdong is China's most populous province and currently the largest provincial economy. Indeed, if it were a country, it would rank 16th in the world in terms of its GDP (OECD, 2010). Guangdong also is China's largest exporting province, stimulated by its strategic geographic location (adjacent to Hong Kong), its three special economic zones established in 1980, the advent of globalization of supply chains that relocated manufacturing to developing countries, and its cheaper land and labor costs in the 1980s and 1990s. But in the past decade, Guangdong has had a harder time holding on to the top economic spot in the country, largely because of rising labor costs and increasing competition from other developing countries. Guangdong has also faced fierce competition from other regions along China's east coast, especially from Jiangsu Province (OECD, 2010).

These economic challenges are exacerbated by rapid urbanization and attendant environmental degradation in the PRD region. The PRD is home to a dense concentration of nine major cities as well as the Special Administrative Regions of Hong Kong and Macau. Over the past 30 years, the PRD has undergone extraordinary economic growth, along with rapid industrialization and urbanization. This has, in turn, placed stress on water, transportation, and other infrastructure systems that support daily life. While some progress has been made, water and air pollution remain serious problems throughout the PRD, as do solid waste disposal and land contamination.

By emphasizing quality of life in its policy- and decisionmaking, HURD is seeking to improve living conditions that will attract firms that produce higher-value-added products as well as higher-skill and better-educated persons to work in them. In addition, this strategy recognizes that quality living for all residents is important for social stability and further development.

Study Objectives

Economic transition and quality of life improvements are intertwined goals that can be achieved through a range of policy actions in the broad categories of environmental protection, finance and taxation, infrastructure investments, resource use, education, workforce development, and health care, among others. As a first step, our study focuses on five policy areas within the broader categories listed above: land use, transportation, environment, housing, and economic development. By agreement with HURD, land use and transportation have received more attention than the other three policy areas.

This report presents guidance for monitoring, and policy options for improving, quality of life in these five areas. We have developed a quality of life indicator system within a conceptual framework that links major challenges faced by Guangdong to policy goals to meet those challenges, strategies to achieve those goals, and indicators to measure progress toward goals. Suggested policy options and recommendations for indicators will provide a foundation for facilitating quality of life improvements in the PRD. We also anticipate spillover benefits in other places in Guangdong Province outside of the PRD.

Organization of This Report

In the following chapter, we provide the economic and demographic context within which a quality of life indicator system would function within the PRD and Guangdong Province. Chapter Three describes the conceptual framework for the proposed indicator system. Chapter Four outlines the structure and key findings from the Pingshan Resident Satisfaction Survey, with details of the survey provided in Appendixes A through C. Chapters Five through Nine present challenges and the proposed goals, strategies, and indicators to meet those challenges in the five policy areas of land use, transportation, environment, housing, and economic development. Chapter Ten addresses questions of how the indicator system could be implemented to increase its chance for success. Finally, Chapter Eleven presents our final conclusions on the study and the indicator system. Appendixes D and E summarize in tabular form the availability of data for the indicators and our judgments about the priority, timing, and ease of implementing the recommended strategies.

CHAPTER TWO

Context for Improving Quality of Life in the Pearl River Delta

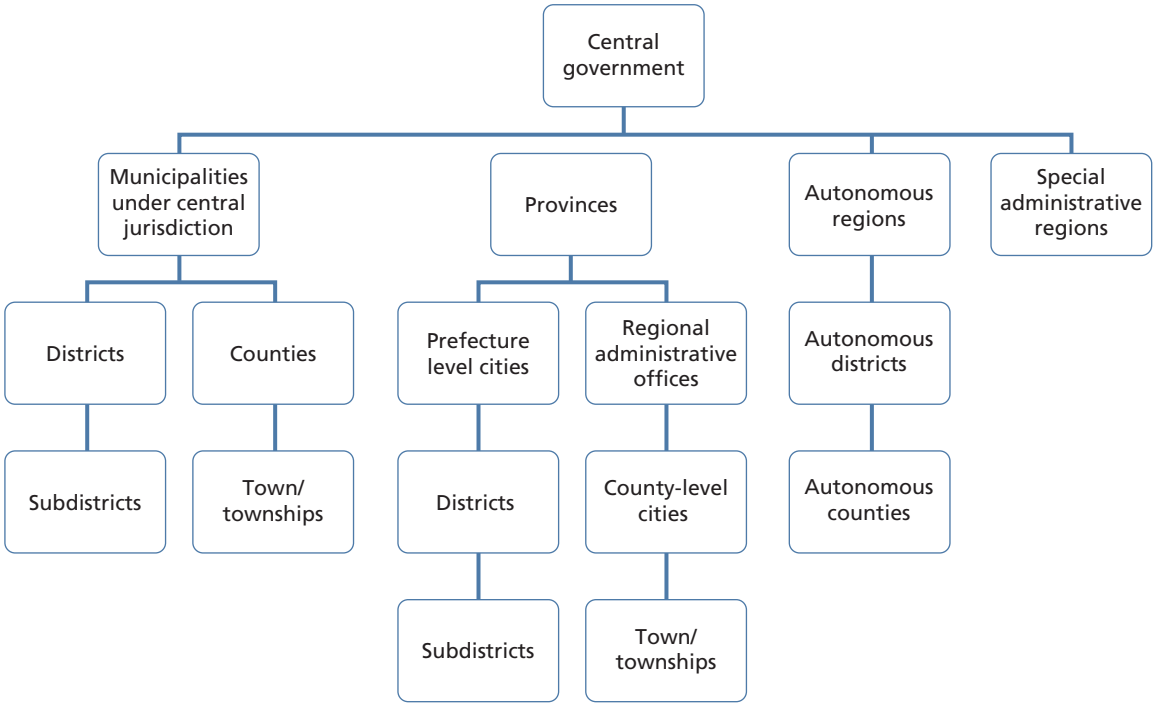
The PRD in southern China is home to a dense concentration of nine major cities, as well as the Special Administrative Regions of Hong Kong and Macau. Over the past 30 years, the PRD has undergone extraordinary growth. The 2010/2011 *State of the World's Cities* report, published by the United Nations Human Settlements Programme, estimated that the greater PRD region is home to 120 million people and accounts for nearly a tenth of the Chinese economy (United Nations Human Settlements Programme, 2010). Nearly all areas in the region have experienced rapid industrialization and urbanization. This has, in turn, placed stress on water, transportation, and other infrastructure systems and also has caused serious environmental problems.

Government officials, planners, commercial interests, and the public have all recognized the need for more coordinated and planned development to accommodate the rapid rate of urban growth while minimizing the negative consequences that accompanied the previous 30 years of growth. Relevant government agencies in Guangdong, Hong Kong, and Macao have identified priority actions, with particular attention paid to the need to examine and monitor quality of life in the region (HURD, 2011). An understanding of quality of life will help city planners better serve residents in both urban and rural areas and guide policy choices to make communities more livable (that is, more pleasant and comfortable). Credible information about quality of life can also influence whether investors enter a market, firms relocate to the region and market products and services most likely to be in demand, and shape allocations of public resources.

Governance in the Pearl River Delta

That relevant agencies were able to decide and cooperate on identified priorities, including examining quality of life in the PRD, is remarkable given the complexity of governance in the province. China is a centralized state, and national government bodies are at the top of the decisionmaking structure, as shown in Figure 2.1 (Loh and Yuk, 2008). At the subnational level, however, there is less clarity of hierarchy. Provincial-level government units are directly under the jurisdiction of the central government. There are 22 provinces, five autonomous regions, four municipalities, and two Special Administrative Regions. The four direct controlled municipalities are Beijing, Shanghai, Chongqing, and Tianjin. Every province has a CPC provincial committee, headed by a party secretary. The party secretary is effectively in charge of the province. A municipality has the same political, economical, and jurisdictional rights as a province.

Figure 2.1
Structure of Government in China



SOURCE: OECD, 2010.
RAND *RR871-2.1*

From a functional perspective, governing ministries (departments) at the central government level are mostly replicated in the provinces (or municipalities, etc.) and the prefecture-level cities. For example, city finance bureaus report to provincial finance bureaus, which in turn report to the Ministry of Finance at the national level (OECD, 2010). Authority rests with the senior government executives at each level, but these executives are also required to comply with the decisions or priorities of their administrative counterpart at the next higher level.

As shown in Figure 2.2, the PRD contains nine prefecture-level cities—Guangzhou, Shenzhen, Zhuhai, Foshan, Huizhou, Dongguan, Zhongshan, Jiangmen, and Zhaoqing—of which Guangzhou and Shenzhen have slightly higher status (i.e., subprovincial). Hong Kong and Macau are also included in the Greater Pearl River Delta region. In addition, the PRD region contains six county-level cities and seven counties (OECD, 2010). All of these administrative units are under the jurisdiction of the Guangdong Provincial Government.

While the responsibilities of subnational government levels are not precisely defined in China and may differ by province, prefecture-level city authority tends to include urban planning, infrastructure construction, and market regulation, among other functions and services. As described in Soon and Pan (2009, pp. 193–214), each city has the same general departmental structure to carry out local planning functions. In Guangdong, prefecture-level cities and county-level cities have significant authority (Loh and Yuk, 2008). Indeed, there is intense competition among cities to attract investment, business, and higher-value labor. While the competition has stimulated innovation and experimentation in economic and social develop-

Figure 2.2
Pearl River Delta and Major Cities

RAND *RR871-2.2*

ment strategies, it has also led to duplication of infrastructure and uncoordinated regional planning.

Policy Direction

The CPC sets policy at the national level. Party congresses are held approximately every five years, most recently in November 2012. Based on the priorities set at the Party congress, priorities at the provincial, city, or district levels may shift in importance or change altogether. In the past five years, two key documents have outlined policy objectives to be followed at lower administrative levels: the *Proposal of the CPC Central Committee for Formulating the Twelfth Five-Year Plan for National Economic and Social Development* (12th Five-Year Plan, 2011), and the *Report of Hu Jintao to the 18th CPC National Congress* (Chinese Embassy, 2012). The 12th Five-Year Plan (2011–2015) advanced sustainable economic growth, industrial restructuring, scientific and educational advancement, resource conservation and environmental protection, and improvement of people's living conditions, among other issues. As part of its industrial restructuring, the plan targeted development of seven industry sectors: new energy, energy conservation and environmental protection, biotechnology, new materials (i.e., rare earths), new information technology, high-end equipment manufacturing, and clean energy vehicles (KPMG Advisory [China], 2011).

The *Report of Hu Jintao* cited above put forth as top priorities the following: comprehensive development, improvement in people's well-being, ecological progress, and innovation. It called for a doubling of China's 2010 GDP and of per capita income levels for both urban and rural residents by 2020. These priorities flowed down to all of the provinces and municipalities,

including Guangdong Province and the administrative units that report to it, and provided the basis for focusing on improving the quality of life in China.

More recently, the Third Plenary of the 18th Central Committee that was held in November 2013 acknowledged that economic growth was facing a downturn as China approached middle-income-level status. Labor costs have been increasing, and, as a consequence, China had become less competitive in the lower value-added industrial sectors that had helped drive exports and its initial economic growth. The Plenum put forward five priorities: liberalizing the financial system, mitigating monopoly power across some industry sectors, opening the market to foreign investment and competition, improving labor mobility through reform of the *hukou* (resident passport) system, and placing greater emphasis on environmental protection and ecological preservation ("China's New Roadmap for Reform," 2014). The Guangdong Provincial Government also released a series of policies to promote economic transition, with a particular focus on urbanization. These include the *Guangdong Province New Type of Urbanization Plan (2014–2020)* (Development and Reform Committee of Guangdong Province and HURD, 2014) and the Guangdong Provincial Government's *Recommendation on Promotion of Urbanization* (People's Government of Guangdong Province, 2014).

Forces of Urbanization and Economic Transition

Much of recent national policy has been a reaction to the negative consequences of rapid urbanization. Urbanization is simply the increase in populations of cities as residents move from rural areas, driven by the prospect of better economic opportunities in cities. Urbanization has contributed to poverty reduction and social progress in many developing countries (World Bank, 2013). For millennia, the clustering of people and economic activity has been an important driver of development. Cities tend to account for the bulk of production, distribution, and consumption, and consequently drive a nation's economic output. But when unmanaged and poorly planned, urbanization can lead to many serious negative consequences, such as air pollution, traffic congestion, excessive sprawl of urban boundaries into agricultural lands, degraded water quality, and inefficiencies in the provision of public infrastructure and services.

The rate of urbanization in China has been unprecedented. After adopting reform and open-door policies in the late 1970s, China's urban population increased from 190 million in 1980 to 636 million in 2010 (Oizumi, 2011). Over the same period, the urbanization ratio climbed from 19 percent to 50 percent. By 2050, the urbanization ratio is expected to reach 73 percent and the urban population 1,038 million (United Nations, 2010). Urbanization in China has been characterized not only by the rapid expansion of the urban population, but also by the emergence of numerous major cities. In 1980, there were just four cities with populations in excess of 3 million (Shanghai, Beijing, Shenyang, and Tianjin). By 2010, the number had increased to 22 (Oizumi, 2011).

These statistics about China's rapid urbanization are mirrored in the phenomenal growth of Guangdong Province. Chosen as a test bed for a wide range of economic reforms when China introduced the open-door policy in 1978, Guangdong was transformed from a largely agricultural region to the home of manufacturing centers of global importance (Enright, Scott, and Chang, 2005). It is China's most populous province. With a total resident population of 104 million in 2010, its population size represents about one-third of that of the United States, and with a landmass almost equal to the United Kingdom. Guangdong's population den-

sity was 530 inhabitants per square kilometer in 2008, higher than the average in China and all Organisation for Economic Co-operation and Development (OECD) countries (OECD, 2010). The urban population accounted for 66 percent of the total population in Guangdong in 2010, higher than the national average of 50 percent (Li and Fung Research Center, 2011). Population growth has been fueled by migration from farms to cities. Guangdong Province has the most migrant workers in the country, followed by Zhejiang Province ("China: Migrants, Hukou," 2013).

Guangdong is also the province with the largest economy, with growth that has been driven by exports and government investments. The province has a GDP of more than $1 trillion. Only 11 countries (including China itself) have a larger population, and only 15 have a larger economy. Guangdong's population profile has been heavily influenced by migrants, including both those from within Guangdong and those from other provinces, who have benefited from increasingly reduced restrictions on population mobility (OECD, 2010). Migration to the province has been due to a confluence of "pull" factors, such as economic expansion, export-driven job creation, and higher per capita income, as well as "push" factors, such as the abundant supply of labor force released from the agricultural sector, scarce non-agricultural job opportunities in rural areas, low availability of cultivated land, and very low per capita income that tends to drive migrants from their home locations.

For migrants from both within and outside of Guangdong Province, the main destination has been the PRD, where urbanization is most advanced and about half of the province's residents live. The region has the world's largest concentration of low and medium value-added manufacturing. Today, the PRD accounts for 30 percent of the total land area in Guangdong Province, but the resident population accounts for 54 percent of the total, and its GDP accounted for 79 percent of the whole province (Statistics Bureau of Guangdong Province and Guangdong Survey Office of National Bureau of Statistics, 2013). Guangdong's cities, such as Shenzhen and Guangzhou, are among the most affluent in the China. With close links to Hong Kong, consumers in the PRD have been early adopters of consumption habits more international in nature than most other places in China.

Rapid urbanization has created demand for transportation services, housing, water systems, other public services, and goods associated with urban development. As the PRD's urban areas have grown, greater demands have been imposed on the PRD's environment and natural systems and surrounding agricultural lands. Like the rest of China, most of the PRD's growth has been fueled by coal-fired electric power, contributing to air pollution and rapidly growing greenhouse gas emissions.

Since China began to open up, Guangdong has pursued aggressive urbanization and industrialization strategies to promote economic development, and has led the nation in growth in GDP for the past two decades. However, in recent years, Guangdong's export-driven economic model has been facing fierce competition; factory owners in the PRD have moved to locations with cheaper labor such as Cambodia, Vietnam, and Mexico and also other provinces within China. Income inequality has also emerged as an issue, with GDP per capita in the PRD about three times greater than in other parts of the province (Statistics Bureau of Guangdong Province and Guangdong Survey Office of National Bureau of Statistics, 2013).[1]

[1] In 2011, GDP per capita was 77,637 yuan in the PRD, in contrast to 21,850 yuan in Guangdong's eastern district, 27,485 yuan in the western district, and 22,205 yuan in the north mountain district.

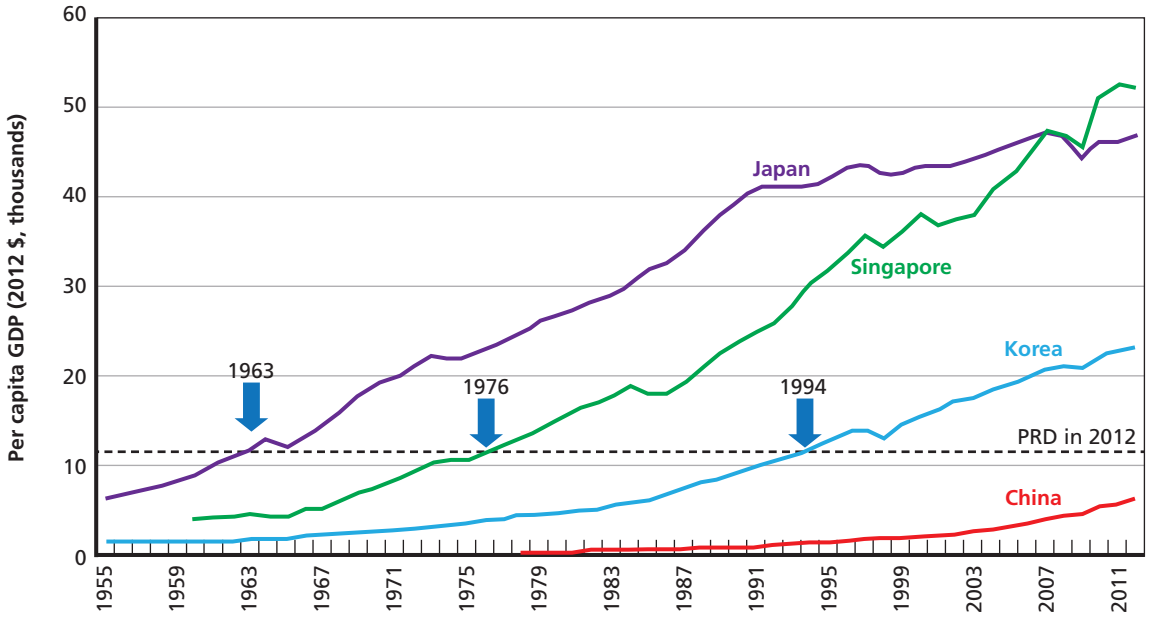
Guangdong now seeks, in the words of former Guangdong Party Secretary Wang Yang, to "replace the bird but keep the cage," which means moving away from the outdated and polluting, low value-added parts of the economy to make room for innovative, higher value-added manufacturing and service activities (Asian Business Council, 2011). In doing so, an ample supply of highly trained human capital is a critical factor. Shortages of highly trained workers make Guangdong less attractive to firms producing higher-value products that are making location choices. Such shortages stem not only from the growing scarcity of young workers relative to retirees and the existing low educational attainment of permanent residents but also from a decline in migration rates as job opportunities have dwindled (Shen, 2007).

International Benchmarks for Guangdong's Development

To place the consequences of urbanization, aggressive economic growth, and the current economic transition in context, we compared the current stage of development in the PRD with the development of Japan, Korea, and Singapore over the past 65 years. As shown in Figure 2.3, per capita GDP in the PRD in 2012 was about the same as per capita GDP of Japan in 1963, Singapore in 1976, and Korea in 1994 (normalized in 2012 US$).

The first 35 years of growth in GDP per capita for Japan beginning in 1945, Korea in 1956, Singapore in 1965, and China in 1978 show that China outperformed the other countries by a factor of two. These starting dates were chosen to coincide with the years when each

Figure 2.3
GDP Per Capita in 2012 for Guangdong, the Pearl River Delta, and Shenzhen Relative to Japan, Singapore, and Korea



SOURCES: Figures for China, Japan, Korea, and Singapore calculated from data from International Financial Statistics, International Monetary Fund. Figures for the PRD from Statistics Bureau of Guangdong Province, 2012; Statistics Bureau of Guangdong Province and Guangdong Survey Office of National Bureau of Statistics, 2013; Statistics Bureau of Shenzhen Province, 2012.

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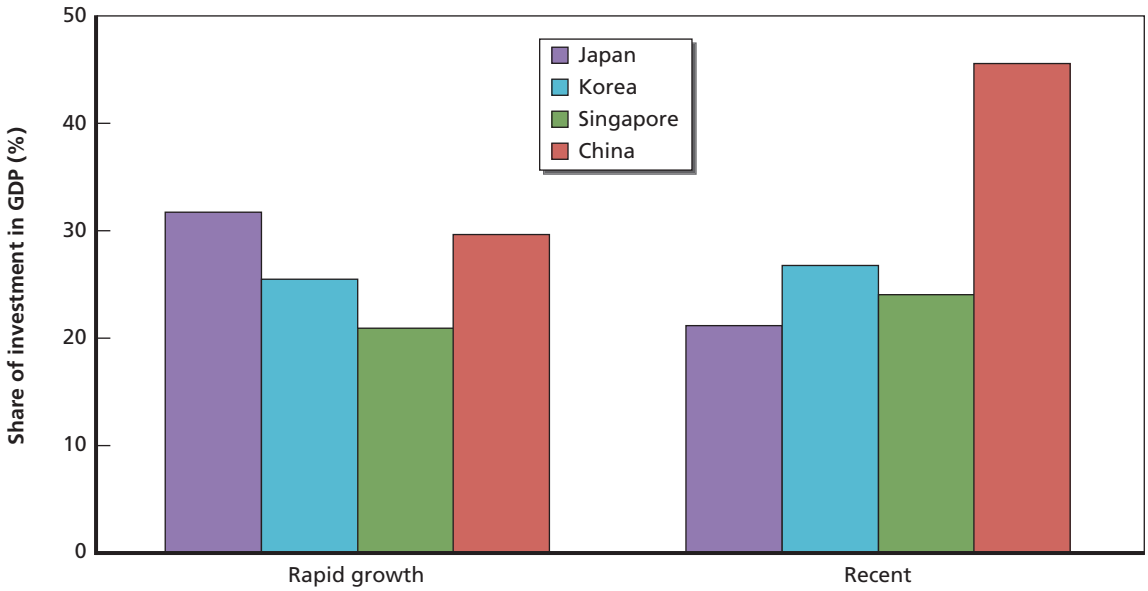
of these countries initiated major economic change and provide a basis for comparing those countries' first 35 years under new economic policies to China's opening up and reform in 1978. While the drivers of growth in Japan, Singapore, and Korea have many similarities with those in China, the share of investment as a driver of growth in China is now quite high relative to the periods when those countries experienced their rapid growth spurts, as shown in Figure 2.4. Since China began to open up, market forces have increasingly been used to allocate resources, labor has shifted out of agriculture, and human capital has increased through education.

To serve as a point of reference, we also looked at indicators relevant to land use and transportation from other countries or cities. A direct comparison between PRD cities and these selected cities is not valid, because the time when the studies were conducted, the assessment methodologies used, and the definition of indicators varied greatly across cities. For example, accessible public green space is an important source of health and well-being, and availability of such green space varies based on the city's geographical characteristics and its development status. However, as Table 2.1 indicates, selected cities in the developed world have managed to maintain a significant share of their areas as urban green spaces.

In terms of transportation, passenger transport mode share is one indicator of the provision and usage of public transportation system in cities. As shown in Table 2.2, Guangzhou appears to have a high percentage of both public and private transport usage, while cities such as Hong Kong and Tokyo have much higher usage among nonprivate transport modes.

Comparing measures of quality of life in the PRD relative to the other countries when they were poorer is difficult because of lack of comparable time series data, standard definitions, and data collection methods. Further, with automobiles much cheaper and pollution control technology both better and cheaper now than in the earlier decades of Japan's, Korea's,

Figure 2.4
Share of Investment as Percentage of GDP



SOURCE: International Monetary Fund, 2013.

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Table 2.1
Share of Green Space in Selected Cities

City	Percentage of Public Green Space (Parks and Gardens)	Year
Hong Kong	41 (2012)	2012
London	38.4 (2003)	2003
New York	14 (2012)	2012
Singapore	47 (2011)	2011
Tokyo	3.44 (2011)	2011

SOURCE: World Cities Culture Forum, 2015.

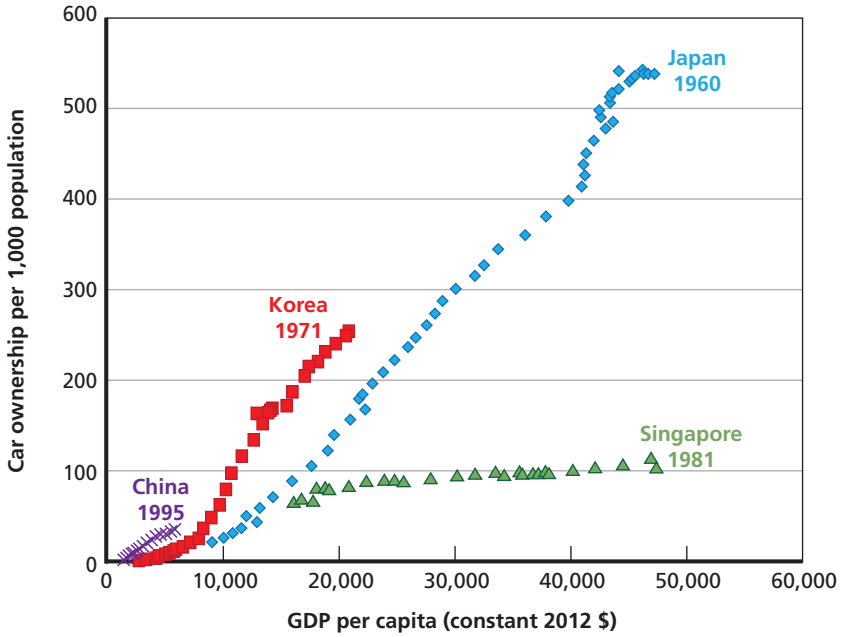
Table 2.2
Passenger Transport Mode Share in Selected Cities (%)

City	Private Transport	Cycle	Public Transport	Walk	Other
Beijing (2011)	20	32	23	21	4
Berlin (2010)	32	13	26	29	
Guangzhou (2010)	40		49		11
Hong Kong (2011)	11		80		8
New York (2010)	33		22	39	6
Tokyo (2009)	12	14	51	23	

SOURCE: Land Transport Authority, 2011.

and Singapore's periods of rapid growth, comparisons are even more problematic. However, car ownership has grown faster at lower levels of GDP per capita than in the other countries when they were in the early stages of their development trajectories, as shown in Figure 2.5. Car ownership rates aside, it is nonetheless difficult to make meaningful comparisons with regard to pollution levels and other measures of quality of life between the PRD and the other countries.

Figure 2.5
Car Ownership in China Relative to Japan, Singapore, and Korea



SOURCES: Japan Statistics Bureau, various years; Australia Department of Infrastructure and Transportation, Bureau of Infrastructure, Transport and Regional Economics, 2012; International Road Federation database, Table IV, "Vehicle in Use," no date; ProgTrans, 2011. Population data come from World Bank World Development Indicators.

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CHAPTER THREE

Measuring and Monitoring Quality of Life

Indicator systems are new to neither China nor Guangdong Province. Many indicator systems, models, and targets have been developed over the years at the provincial, prefecture city, and district level.[1] Virtually all of these indicator systems measure current conditions with a score card, but were not designed to directly link to policy- and decisionmaking. In this project, RAND sought to develop an indicator system that would serve as a practical management and decision support tool aimed at keeping the attention of responsible officials focused on continuous progress toward policy goals.

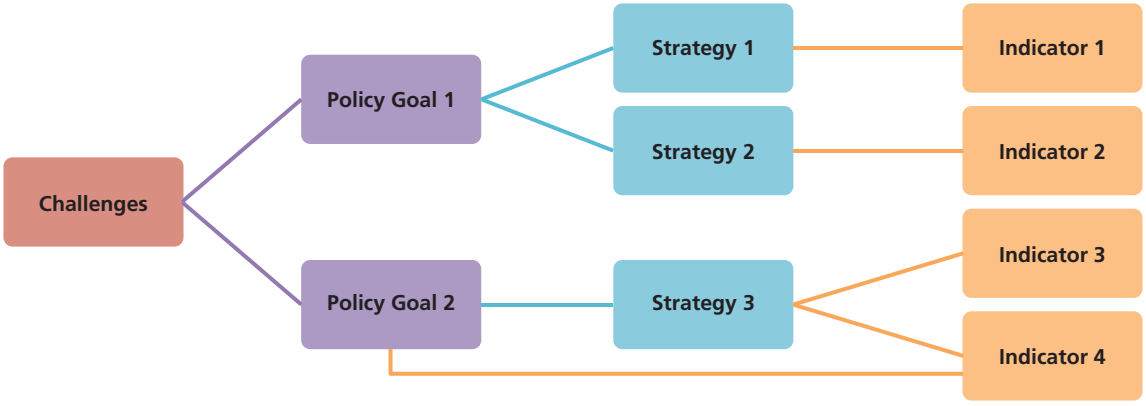
The starting point for such a system is a clear understanding of the *challenges* facing Guangdong in the policy areas of interest. From challenges we moved to identification of policy *goals*—whether set at the national, provincial, or municipal level—that are responsive to these challenges. *Strategies* are policy actions undertaken at the appropriate levels of government to help meet goals in a timely and direct manner. *Indicators* inform policymakers and the public as to whether strategies are working and progress is being made toward meeting goals. Figure 3.1 illustrates the framework for the indicator system, showing the relationships among the challenges, goals (i.e., desired outcomes), strategies (i.e., policy actions), and indicators (i.e., measures of impact of strategy or achievement of goals).

Units of Analysis: Region, City, District

This framework is intended to apply not just to the PRD cities, but throughout Guangdong Province to the province, city, and district levels of government. As such, it will require that policy areas and goals are generally consistent across the levels of government. However, differences among levels of government or across geographic regions may arise in adopting strategies and setting targets. As an example, perhaps all levels of government share the goal of providing

[1] Those currently in use at the provincial level include: "Happy Guangdong" Index System, Guangdong Province Livable City Development Basic Assessment Index System, Guangdong Provincial Economic and Social Scientific Development Evaluation Indicator System, and the Guangdong Province Environmental Protection Responsibilities Evaluation Indicator System (personal communication with Gu Zhengjiang of the Shenzhen Graduate School of Beijing University). The prefecture-level cities have also developed their own indicator systems. For example, Shenzhen uses the Shenzhen Livable City Development Performance Assessment indicators, Shenzhen Eco-civilization City Development Indicator System, "Harmony Shenzhen, Efficient Shenzhen" Regulation Indicator System, Shenzhen Living and Social Welfare Indicator System, Shenzhen Social Development Assessment Indicator System, and the Green Shenzhen and Low Carbon Transportation Indicator System, among others (personal communication with Gu Zhengjiang). Even some districts within cities have their own indicator systems. Pingshan New District has developed or is developing the Happiness Pingshan Indicator System and Pingshan New District 12th Five Year Plan Regulation Indicator System.

Figure 3.1
Conceptual Framework for Indicator System



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more green space for residents, but a particular district or city prefers to seek a higher area per resident than the province as a whole.

Figure 3.1 is a simplification of the relationships among goals, strategies, and indicators that are found in Chapters Five through Nine. There may be several indicators for a single strategy. Some indicators may be supportive of more than one strategy. Further, there may be several strategies for each goal, and different levels of government may pursue different strategies in pursuit of the same goal. For example, if the goal is to reduce traffic congestion, one city may implement restrictions on driving, while another may change its traffic operations or build new roads. Each of these strategies may be measured using one or more indicators. For a given strategy, indicators will need to be consistent (in terms of definitions and types of data sources) from one place to another to enable comparisons and tracking.

The PRD region includes nine prefecture level cities that vary in their level of GDP, urban built environment, environmental conditions, and residents' satisfaction level and concerns. We therefore wish to emphasize that the selection of strategies and indicators of the proposed approach will need to be tailored to meet the circumstances and priority goals of each city and district or county. As noted above, not all strategies and indicators will be applicable or useful to every city within the PRD.

Linking the Indicator System to Policy Goals

A policy goal is a desired outcome within the realm of a government's mission to improve the economic and social well-being of its people. These goals derive from understanding key challenges that are within the responsibility of governments to affect. For this initial effort, HURD asked RAND to concentrate on land use and transportation policy, with secondary attention paid to the environment, housing, and economic development. Goals in each of these policy areas all address some aspect of quality of life and apply across different levels of government, although the relative emphasis among the goals may vary from place to place.

To the extent possible, we drew on existing policy goal statements at the provincial, city, or district level. When we could not clearly identify an existing goal, we defined new goals that

would be both realistic and challenging: If goals are met quickly, they probably were not sufficiently challenging; if no goals are met, they may be too ambitious. Part of the test for realism is that the goals are generally within the ability of government efforts to achieve through public policy. For example, in the realm of air quality, government can enforce regulations that limit pollutant discharge from factories but cannot (easily) control how many kilometers people drive. Bearing in mind that the motivation for goal-setting is to improve performance, a more challenging goal can still lead to success even if the goal is not met—as long as progress is nonetheless made. Having too many goals of this nature would likely discourage interest or action in implementation.

Identifying Strategies to Meet Policy Goals

A strategy is a policy action (or series of connected actions) that a government agency undertakes. For each goal, we have identified one or more strategies to achieve that goal; other strategies could be added or substituted over time while still maintaining the goal and indicators associated with it. Strategies can include adoption of new laws and regulations; enforcement actions to protect public health and safety; provision of a public service such as a bus or subway line; and public information or outreach campaigns. For example, if the goal is to provide more affordable housing, one strategy could be to build new housing, while another strategy might be to subsidize rental of existing units for low-income households.

Different levels of government may adopt different strategies based on their own special circumstances, abilities, and administrative constraints. In this project, we identified broad common policy goals, but different local governments may undertake different strategies to reach them, depending on their individual circumstances and capabilities. Further, strategies will need to be continuously improved and updated to meet changing conditions and needs, based on their effectiveness as measured by the indicators.

A very important caveat must be highlighted with regard to strategies suggested in this report. Strategies in each of the five policy areas vary in complexity; their success in a given place at a given time cannot be assured without more detailed analysis and attention to implementation in the specific context of the PRD as well as the city and district or county. This study was not of sufficient scope to enable us to conduct a thorough comparative policy, benefit-cost, or cost-effectiveness analysis across potential strategies or critique policies now in place in the PRD. These strategies are intended to be suggestive of promising approaches used successfully in other places. As a general matter, we opted for strategies that met the test of practicality and established success over those that might be new and different, but also less certain in effectiveness.

Setting Priorities Among the Strategies

We sought to differentiate priorities for implementation among the proposed strategies along three dimensions: potential impact on attainment of goals, as measured by the proposed indicators; ease of implementation; and the time frame within which a strategy could be implemented. Table 3.1 summarizes our proposed qualitative scoring approach. The first column of the table is linked to potential progress toward one or more policy goals, as reflected in subjec-

Table 3.1
Criteria for Ordering Implementation of Strategies

Relative Impact	Time Required for Initial Implementation	Relative Ease of Implementation
High	Within 1 year	Easy
Medium	Between 1 and 3 years	Moderate
Low	More than 3 years	Hard

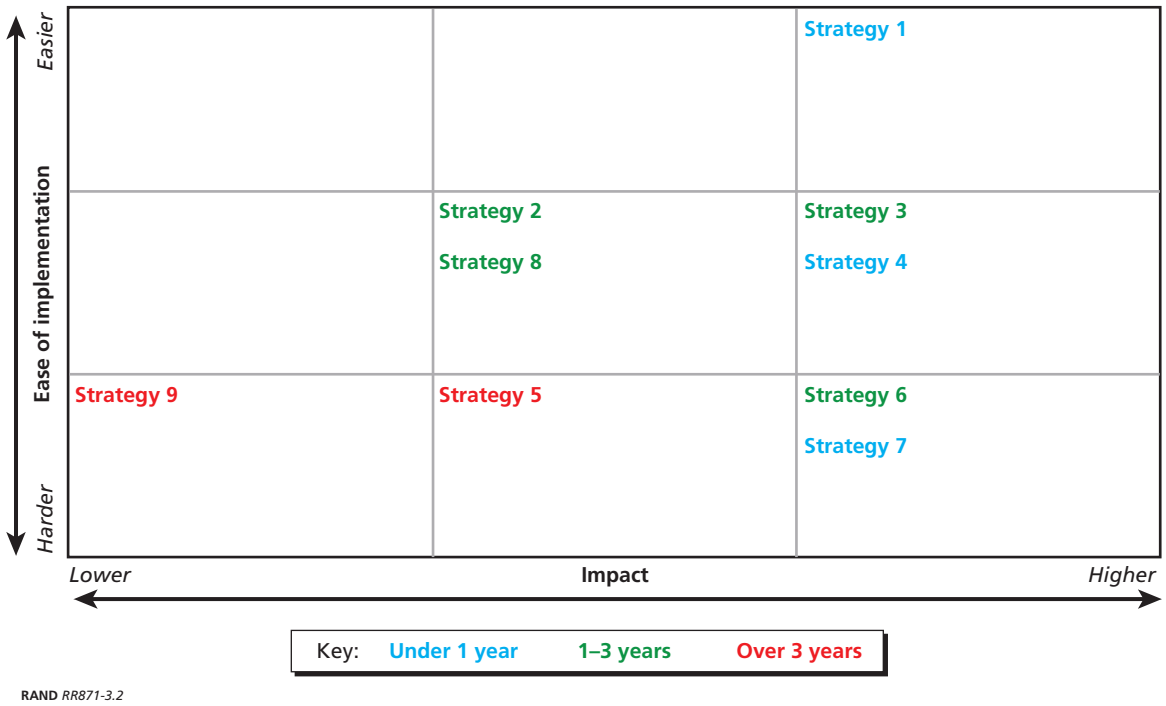
tive or objective indicators associated with the goals: Will the strategy reduce resident dissatisfaction or increase resident satisfaction with a public service or amenity? Will air quality or the level of a public service improve? This is where policy analysis should be used to ground these projections in evidence, to the extent possible. The relative impact of policy strategies should be based on sound modeling and analysis that allows for comparison of projected outcomes. Such analysis has not been done in this study, but we strongly recommend that such analysis be undertaken prior to implementation.

For illustrative purposes in this study, we rely on a simple scale of high, medium, and low when assessing potential impact. "High" means that we recommend a strategy be implemented as soon as possible because higher benefits are likely to accrue, relative to other strategies, or because the action is on the critical path of other strategies. In terms of the time required for initial implementation, we employ our best judgment about the likelihood of effective and efficient deployment. We expect that HURD and other provincial or municipal agencies responsible for implementation will improve on these initial estimates based on their experience and conditions. Finally, we make a judgment about relative difficulty and complexity of implementing a strategy, with "easy" signifying a relatively low level of complexity, either because the strategy builds on existing practices or because a single agency may initiate action without necessarily undertaking extensive consultation and coordination.

Figure 3.2 is an example of a graphical display of the three dimensions of information in Table 3.1. The horizontal axis represents relative impact. The vertical axis represents relative ease of implementation. Estimated time of implementation is color-coded: Less than 1 year in blue, between 1 and 3 years in green, and over 3 years in red. A higher-impact strategy, such as Strategy 1, that is also relatively easy to implement (and therefore placed in the upper right box) should be a high priority for implementation. These figures appear at the end of each policy area chapter (Chapters Five through Nine), with RAND's initial projection of priorities among strategies based on our professional judgment. These initial projections are intended to provide a starting point for discussions within HURD and HURD's discussions with other provincial departments as plans progress on implementation of the indicator system.

Our approach to notional priorities across strategies in each of the five policy areas is limited in several ways. First, we consider the impact on goal attainment in a relative sense within each of the individual policy areas; we have not made judgments about relative priorities across the policy areas. Second, in the absence of more detailed discussions with those who would be implementing the strategies, we make assumptions about the degree of difficulty and the time required for implementation based on professional judgment; few published accounts of strategies provide sufficient level of detail for more precise estimates. Finally, the ordering of

Figure 3.2
Example of Graphical Display of Proposed Strategies for Ordering Implementation



strategies within each cell of the chart should not be considered to imply priority. More refined priority setting would require comparative benefit-cost or cost-effectiveness analysis.

Building an Indicator System

To track effectiveness, each strategy requires one or more indicators. An indicator can be either an objective measure of an attribute of a system or a subjective measure of resident satisfaction with services provided by that system. In either case, the system could be defined as, for example, transportation services in a city, air quality in a region, rental housing stock, park and undeveloped green space, or markets for highly skilled knowledge workers. To represent the state of the economy, governments typically use indicators of economic output: for example, per capita, per square kilometer, or percentage growth on an annual basis. Similarly, to represent the state of transportation services, measures such as vehicle kilometers traveled, passenger volume per transit route, or travel time are frequently used. To characterize the state of air quality, concentrations of key pollutants such as particulate matter, sulfur dioxide, or nitrogen oxides are commonly used indicators. We chose indicators that could be linked directly to implementation of strategies and achievement of goals. In several cases where the policy goal was important and a new strategy needed to meet the goal, we identified indicators for which data may not become available until the strategy is actually implemented. Appendix D provides our assessment of data availability, based on information provided to us by HURD and our local partners.

For the most part, indicators are linked directly to an individual strategy to measure how well it is working. However, in a few areas we sought indicators to measure overall progress toward a goal based on several strategies. This was particularly the case for the environment, where policy goals are linked to achieving international standards for air and water quality. For example, with regard to air quality, we want to know whether the concentration of a pollutant is decreasing (toward meeting the standard) and whether a strategy is effective in bringing about that reduction. Hence, we have an indicator for the overall policy goal, as well as indicators linked to specific strategies, to help determine whether, for example, closing down polluting factories is a more or less effective strategy than adopting more stringent vehicle regulations.

Good indicators of quality of life have several common properties, with the 13 criteria developed by the Jacksonville (Florida) Community Council often cited as the most definitive (Swain, 2002).[2] Here we expand on these criteria that are particularly relevant to the PRD. Related to validity and accuracy, indicators should be resistant to manipulation. For example, industrial discharges would need to be measured frequently enough for regulators to detect whether the facility is in compliance with its discharge permit or whether it only appears in compliance on the occasion of an infrequent visit from an inspector. Indicators should be stable and reliable: Measurement of the indicator should not vary by who is collecting it as long as standard practice is followed, whether by survey, laboratory measurement, map analysis, or otherwise. Related to importance and timeliness, collection of indicator data should be cost-effective relative to their value in assessing whether a given strategy is working. Part of the cost-effectiveness criterion is determining appropriate time intervals and geographic scope for data collection to ensure that progress can indeed be detected over time and across areas. Availability is another criterion identified in the Jacksonville list. The project team looked at whether data are available at the different levels of government. Understandability and clarity are also important for public communications. A good indicator should not require extensive explanation of what it is measuring.

Indicators can measure inputs to strategy or process (e.g., how many inspectors are available to enforce water quality standards), outputs (e.g., how many rental housing units have been built), or outcomes (e.g., less traffic congestion). Measuring outcomes directly is most desirable but not always possible. Measuring outcomes or outputs is more useful for assessing effectiveness of strategies than measuring inputs. There is a tendency to measure inputs because these data are generally easier to collect. For example, in the area of housing, it is fairly easy to measure the number of affordable housing units built in a year. However, if the policy goal is to provide residents with access to affordable housing, then an indicator related to affordability, not just the number of units, is needed. In transportation, it may be easy to measure the total operating mileage of rail transit, but if the policy goal is reducing kilometers traveled by car, the associated indicator should measure whether the rail transit is convenient and affordable for residents.

Consistent with the definition of quality of life given in Chapter One that we use in this report (i.e. quality of life captures people's satisfaction or happiness with their surrounding environment and living conditions), the proposed system of indicators includes both objective

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[2] The Jacksonville Community Council criteria include importance, validity and accuracy, relevance, responsiveness, anticipation, understandability, availability and timeliness, stability and reliability, outcome orientation, asset orientation, scale, clarity, and representativeness.

and subjective indicators. Some policy goals may be best measured with objective measures, such as amount of green space and air pollution levels that describe the status of the surrounding environment and living conditions in real and concrete terms, independent of differences in human perception. Others, such as satisfaction with housing or commute times, are subjective in nature. They may not reflect reality, but they are important in reflecting individual perceptions of happiness and well-being—at the very heart of the concept of quality of life. As Morais, Miguéis, and Camanho (2001) note: "some organizations, such as the European Commission (Rojas, 2011) and the World Health Organization (WHO—Quality of Life Group), consider that quality of life is a concept that embraces a subjective component." For the WHO, quality of life is "an individual's perception of his/her position in life in the context of the culture and value systems in which he/she lives in relation to his/her goals, expectations, standards and concerns" (Van Kamp et al., 2003, p. 7).

Some strategies are best tracked by using both objective and subjective indicators to identify whether there are indeed gaps between perception and reality. In addition, subjective data may be used when there are no objective data available. For this project, we have recommended use of subjective data from a survey of residents.

Approaches to Information Gathering

We gathered information from broad sources: statistical data, literature reviews, discussions with PRD officials, and a survey of residents. We used this information, combined with subsequent analysis of data, to develop the quality of life indicator system and the policy recommendations that were derived from its application.

In terms of literature, we reviewed publications on quality of life indicator systems, both in terms of international best practice and those in use for developing countries. We examined relevant research on current challenges in land use, transportation, environment, housing, and economic development in China, Guangdong Province, and the PRD. In addition, we relied on summary reports provided by the local partners, the Shenzhen Graduate School of Beijing University and Guangdong City Development Research Center, on indicator systems used in Guangdong Province, its cities, or districts; the factors important to the economic transition in Guangdong; and policy objectives at the national and provincial levels. We also reviewed reports provided by staff of the nine cities comprising the PRD on policy challenges and goals in the five policy areas that are the focus of this research.

We also gathered information directly from various PRD officials. As arranged by HURD, in August 2013 we visited four cities in the PRD (Foshan, Dongguan, Zhuhai, and Shenzhen), where we conducted group interviews with staff of urban-rural planning bureaus and toured the cities. In addition, HURD arranged a workshop in November 2013, at which we presented preliminary thoughts about the challenges, goals, strategies, and indicators and gathered feedback from the 14 officials from all nine PRD cities who attended.

As our third method of information gathering, RAND and its local partners jointly conducted a survey of resident quality of life in Pingshan New District, an outlying district of Shenzhen. RAND designed the survey instrument, and our local partners fielded the survey and entered the data. RAND staff then analyzed the data. The survey was designed to elicit responses about quality of life in the five policy areas with the intent of using it in other cities and districts in the province. Survey methods and results are summarized in the next chapter.

Data Availability

The practicality of the indicator system depends on the ability of the various levels of government to collect the data to populate the indicators, and do so efficiently and at reasonable cost. For these judgments about reliability and cost, we relied on our local partners. After we initially identified indicators in the five policy areas, we asked our local partners to review the indicators and provide feedback on both their advisability and availability. In some cases, they suggested modifications in wording or scope to better match available data.

For those indicators for which data already exist, we then asked for baseline information, as available, for Guangdong Province, the PRD cities, and Pingshan New District. The work of collecting these data is still in progress. These data can be used to determine baseline conditions for measuring quality of life going forward. The results of this iterative process are discussed further in Chapter Ten and summarized in the tables in Appendix D.

CHAPTER FOUR

Pilot Resident Survey in Pingshan New District

Quality of life can be evaluated at various levels. But at its most fundamental level, quality of life is a reflection of an individual's satisfaction with his or her own life situation. For this reason, this study included a resident satisfaction survey as an important component in developing the quality of life indicator system. Sample surveys such as a resident satisfaction survey are useful when it is not possible or desirable to collect data from every single member of the population of interest because of cost, burden on residents, and operational feasibility.

The primary purpose of the pilot survey was to gather baseline conditions pertaining to quality of life in Pingshan New District. A second purpose was to gain experience in fielding such surveys and then make recommendations for deployment of an improved resident satisfaction survey in other districts and cities of the PRD. RAND was responsible for survey design, guidance, and oversight. Our local partners, Shenzhen Graduate School of Beijing University and Guangdong City Development Research Center, contributed to the questionnaire development and managed the survey fieldwork. Students from several universities in Shenzhen administered the survey.

This chapter provides a description of the survey design and selected results from a pilot test of the survey that was conducted in Pingshan New District. Details about the survey can be found in the appendixes. Appendix A summarizes the number of interviews completed in each community; Appendix B presents the frequencies of response distributions for each question; and Appendix C presents a more complete summary of survey findings.

Profile of Pingshan

Pingshan New District was established in 2009 and is directly managed by the Shenzhen Municipal Government. (See Figure 4.1.) The original proving ground for China's economic reforms in the early 1980s, Shenzhen is now a city of over 10 million people with a land area of nearly 2,000 square kilometers (km^2). Shenzhen considers Hong Kong and Singapore as its benchmarks for raising living standards over the coming decade, making better use of space and increasing engagement with the public (CPC Shenzhen Municipal Committee and the People's Government of Shenzhen, 2011).

Pingshan New District has a total area of 168 km^2, of which 30 km^2 of land are still available for development, one of the largest areas for development remaining in Shenzhen. Originally, the new district was composed of Pingshan and Kengzi townships and belonged to the Longgang District of Shenzhen. At the time of our survey, Pingshan had about 700,000 residents, of which about 94 percent were "floating," a term that is applied to migrant workers

Figure 4.1
Administrative Map of Shenzhen

without *hukou* or household registration in Shenzhen. Pingshan's current population is now closer to 600,000. Only about 4 percent of Pingshan's population is considered "original" to the district with Shenzhen *hukou*; and 2 percent have Shenzhen *hukou* but are not original, meaning that they transferred their *hukou* to Shenzhen from another place.

Pingshan has about 1,400 employers, most of which are manufacturing enterprises. But there are a growing number of information, biological and biomedical, and other high-technology firms. Transportation infrastructure is a priority, including high-speed rail to form a convenient half-hour "living circle" with Hong Kong. Pingshan was designated a national low-carbon pilot zone by the Ministry of Housing and Urban-Rural Development of the People's Republic of China and was selected to pilot a "Smart City" program by the Guangdong HURD. Finally, Pingshan's leadership expressed considerable interest in the RAND study and in gaining insights that could lead to their development of strategies to improve quality of life in their communities. For these reasons, HURD recommended that RAND work with Pingshan to test the resident satisfaction survey and report on its results.

Design of the Resident Satisfaction Survey

The resident satisfaction survey was designed as a sample survey. We used *stratified random sampling*, a type of probability sampling, to select the people to be surveyed. The total population for Pingshan New District was organized by community; the sampling was performed independently within each of its 23 communities. The sample was selected from a list of residents in each district aged 15 and older, as maintained by the Smart Society Service Center in Pingshan.

The sampling plan allocated interviews to each of the communities relative to their population, but we made some adjustments to meet our objective of being able to present meaningful results for each of the communities. That is, we chose to undersample some communities, such as Xiuxin (with large populations), and oversample others, such as Maluan (with small populations). Hence, 96 people were interviewed in each of the largest communities to achieve

a sampling error of plus or minus 10 percent with 95 percent confidence; 50 people were interviewed in the smallest communities (also with a sampling error of plus or minus 5 percent with 95 percent confidence). The number of individuals from other sized communities sampled fell between those two. We also wanted to increase the likely sample sizes for original residents and those with Shenzhen *hukou* (thus oversampling some smaller communities) because these populations (while a small percentage overall) were clustered there. Appendix A lists the communities and both the targeted and actual number of interviews completed. We sought to interview a minimum of 1,822 residents. Although the response rate was 98.6 percent, with 1.4 percent of the originally selected sample refusing to participate, we ultimately were able to complete 1,869 interviews by 31 interviewers over a period of 25 days.

The survey questionnaire was developed in English and then translated into Chinese, back-translated into English, and finally, again into Chinese. The local partners refined the Chinese script to be appropriate for the local population. The questionnaire has a total of 48 questions on topics related to land use planning, transportation, environment, housing, and economic conditions. There are also a few questions that gather information about the social and economic characteristics of the respondents. It took 20 minutes on average to administer the questionnaire.

Interviews were conducted in person at the respondent's place of residence. Interviewers read from a paper questionnaire and marked the answers on the questionnaire. There was one questionnaire completed for each respondent. Interviewer training emphasized standardization of the interviewing process. Such standardization is very important and strengthens the validity of the data collected. The goal of standardization is to expose each respondent to the same experience with questions. Answers are also recorded with consistency so that differences in answers can be correctly interpreted as reflecting differences between respondents rather than differences in the process that produced the answer.

Three attempts were made to successfully complete an interview with the selected person. The biggest challenges were in entering apartment buildings due to locked doors and because interviewees were not at home at the time of the interviewer visit. If a new family was found to be living at the sampled address, interviewers were allowed to interview a new family member of the same gender and age bracket.

After completed questionnaires were reviewed and corrected, the local partner entered information into an English-language online database. This database showed the questions and answer choices on the screen to help ensure that data were entered efficiently and accurately. RAND performed quality assurance checks on the entered data.

Profile of Survey Respondents

Resident status of survey respondents was representative of the demographics in Pingshan New District. The vast majority of those interviewed (95 percent) were members of Pingshan's floating population; 3 percent were original to the area; and 2 percent were not original but had Shenzhen *hukou* (registration). Consistent with the dominance of the floating population, 58 percent of the respondents were male. About two-thirds of survey respondents were between the ages of 18 and 34 (Figure 4.2), and about a quarter have a secondary specialized or tertiary degree (Figure 4.3), a category we henceforth refer to as "better educated." More than half of the respondents have not received formal education beyond junior high school.

Figure 4.2
Age Distribution of Survey Respondents

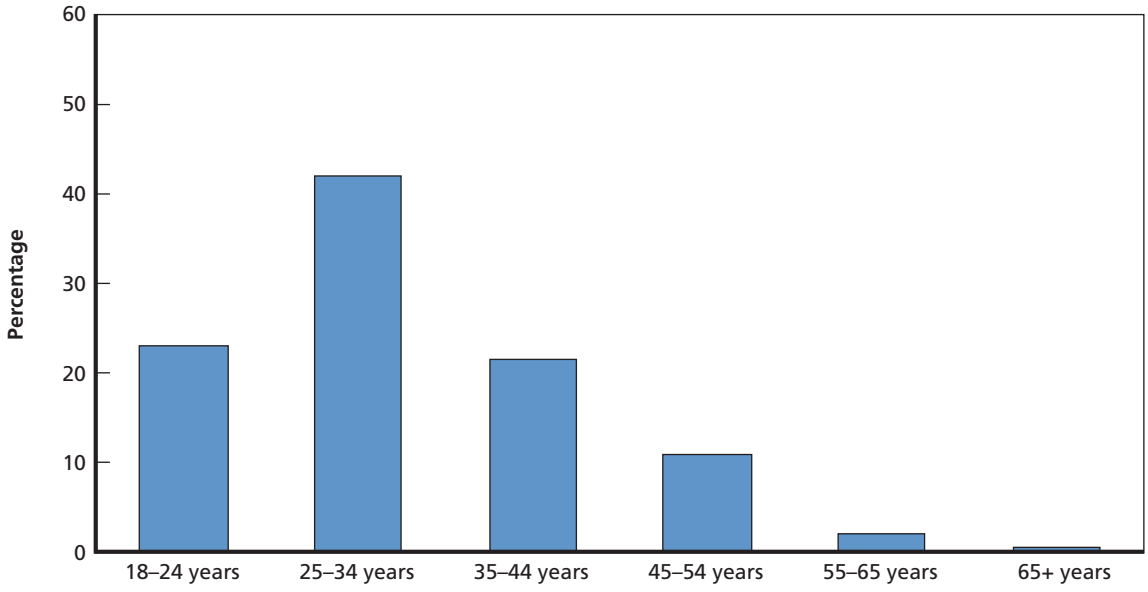

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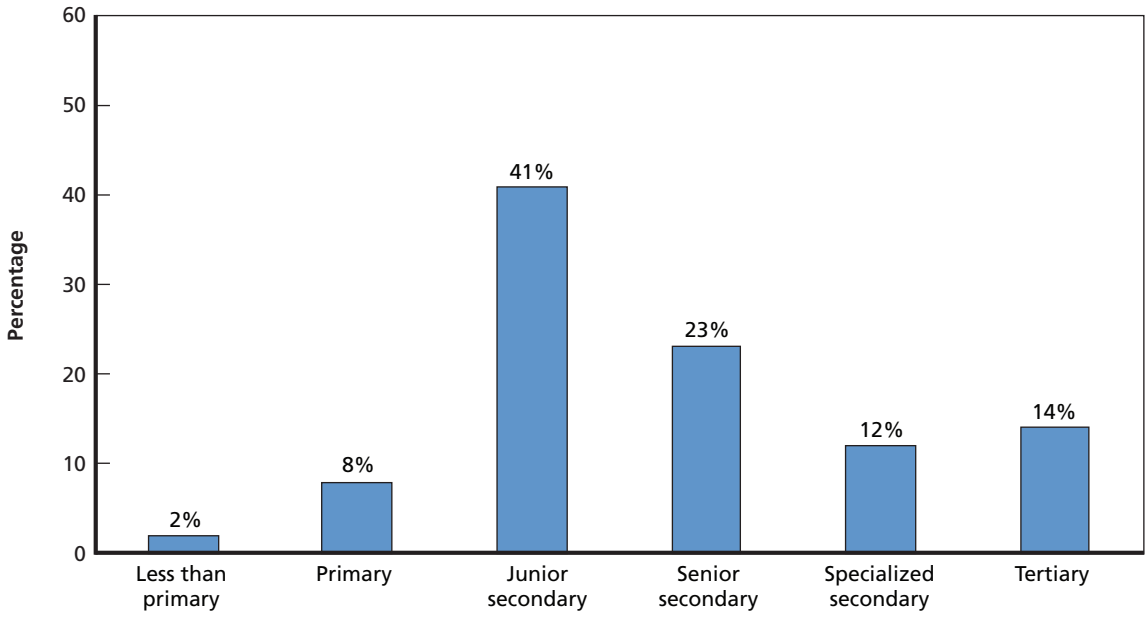
Figure 4.3
Educational Background of Survey Respondents



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Most respondents (84 percent) are renting their apartments in units built by the village; only 7 percent own their residence. About 85 percent live in households with four or fewer people. Less than a quarter of the households of the respondents own a car. Most respondents (79 percent) report being fully employed, 9 percent partially employed, and 11 percent not employed at all. The dominant form of employment was in manufacturing (58 percent) followed by wholesale and retail stores (11 percent). For those that are employed, most respondents walk to work (55 percent) or ride a bicycle (32 percent); only 8 percent say that they drive. Over 80 percent report that their place of work is in their community, and another 15 percent work elsewhere in Pingshan New District. As a consequence, over 85 percent report commuting times of less than 20 minutes.

Key Findings for Pingshan

Appendix B provides the frequency of responses to all of the survey questions for Pingshan New District as a whole, and Appendix C provides a more complete overview of results in graphical form. The results of the survey informed our selection of some of the strategies and indicators in each of the five policy areas. These connections are noted in Chapters Five through Nine. In this section, we highlight some of the results that shed light on the challenges that Shenzhen and possibly other cities in the PRD face in seeking to improve quality of life in ways that matter most to residents.

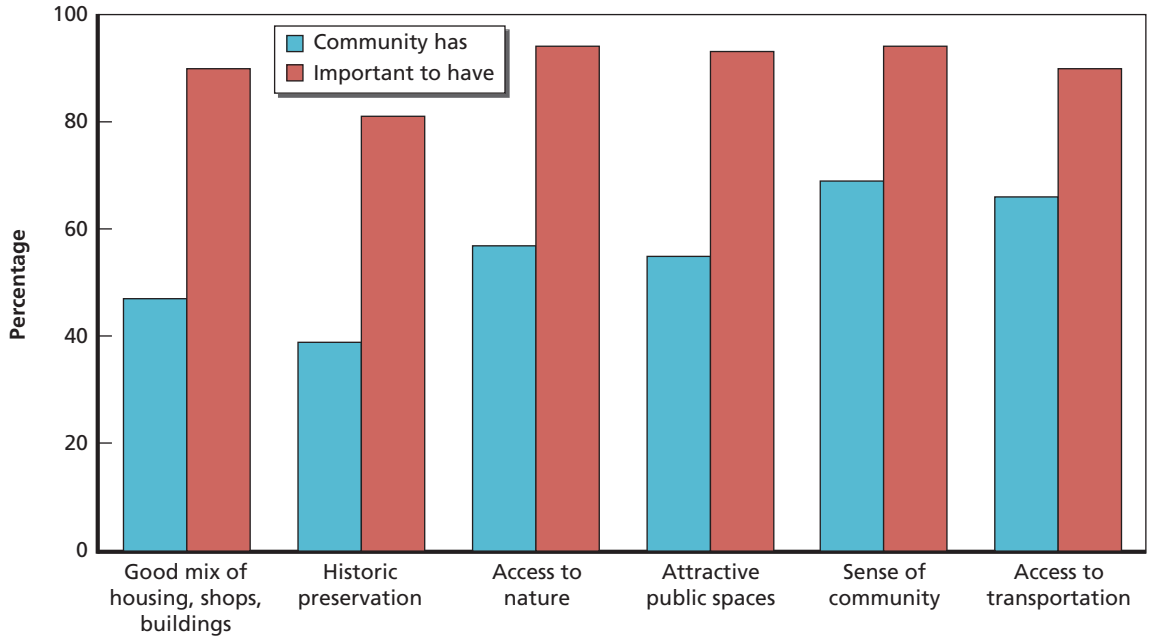
Most respondents considered quality of life in Pingshan New District to be good (48 percent) or average (48 percent); few think it is very good (5 percent), and even fewer think it is poor (3 percent). Looking to the future, most residents (72 percent) believe that the quality of life in Pingshan will improve a little, and 13 percent think it will improve a lot. However, responses to specific questions about various facets of life in Pingshan reveal a more nuanced view of conditions. For example, less than 50 percent of respondents liked the way their community looks and feels, with 43 percent saying they neither agreed nor disagreed with the statement that they like its look and feel.

When asked about the importance of various land use characteristics, there was a notable gap between respondents' assessment of what their community already has and what they think is important to have, as shown in Figure 4.4. Land preservation, access to nature, and attractive public spaces emerged as very strong preferences across all ages and educational backgrounds, but about half of the respondents do not feel that their communities have these characteristics.

Three critical transportation issues emerged from the survey: dissatisfaction with the extent of connectivity to downtown Shenzhen and other cities in the PRD, concerns about traffic safety, and often long travel times on public transit. Few people currently own cars, but this number likely will grow, as most survey respondents said that owning a car is important. Availability of parking and parking management is less of an issue now but can be expected to become more so as the number of cars grows.

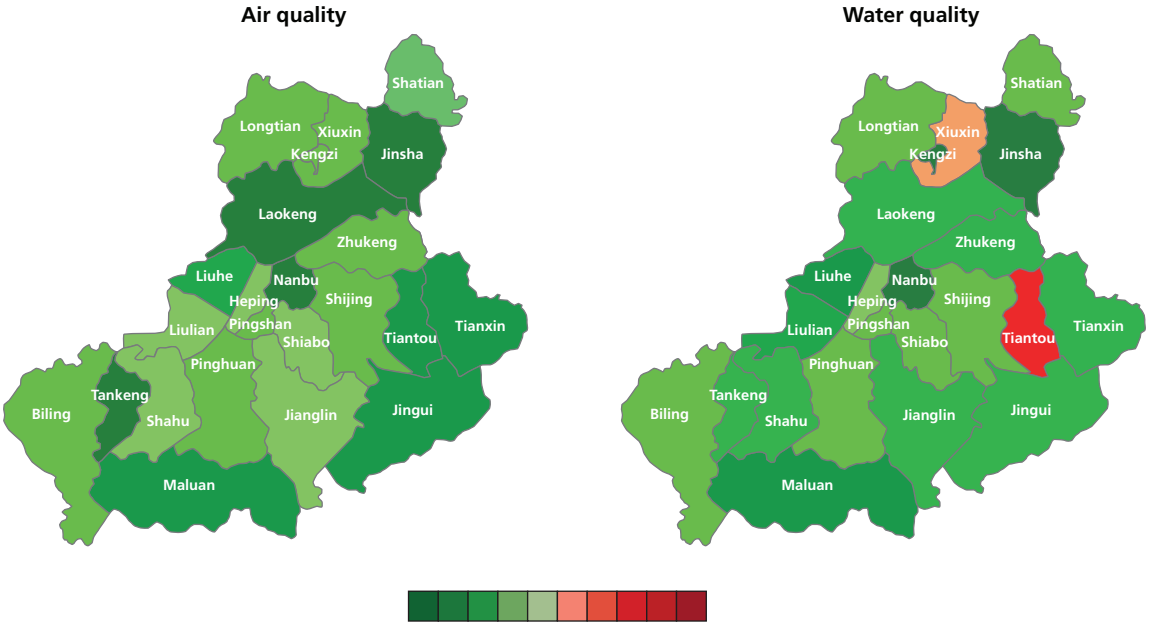
Between 60 and 70 percent of respondents believe that air quality and drinking water quality have either stayed the same or gotten worse. However, responses differed across the 23 communities in the district on the question of the quality of drinking water, as shown in Figure 4.5. Among the better educated, dissatisfaction with air and water quality was higher

Figure 4.4
Perceptions of Land Use Characteristics and Their Importance



RAND *RR871-4.4*

Figure 4.5
Perceptions of Air and Water Quality by Community



NOTE: Dark green means the most satisfaction with water or air quality. Red indicates greatest dissatisfaction with water or air quality.

RAND *RR871-4.5*

than among the general population. This group also voiced greater dissatisfaction with government's environmental protection efforts.

Regardless of the type of housing in which they live, most respondents felt that where they live is affordable considering their salary and said they were satisfied with the size of the living space, construction quality, and bathroom facilities. That said, about one in four were dissatisfied with the availability of good housing that is affordable, suggesting that what these respondents could afford was not what they would like. These people tended to be better educated and older. Important public services or facilities are accessible, defined as within a 10-minute walk, to most residents. There was one exception: younger people (18–24 years) in particular were least satisfied with the quality of nearby public libraries or cultural buildings. Few respondents were satisfied with their personal financial situation, although more were satisfied with their personal job situation, an unsurprising result indicating that people wish they had more money.

Recommendations for Pingshan New District

The survey findings indicate that the government of Pingshan New District has been successful in achieving a satisfactory level of quality of life for its residents, but it will be challenged to maintain resident satisfaction into the future. To increase the level of overall satisfaction with quality of life, Pingshan's leaders will need to address, at a minimum, the specific areas of concern that emerged from the survey: expanded opportunities to earn better wages; better access and faster travel on public transit; better connectivity between Pingshan and Shenzhen and other cities; more access to attractive public spaces, nature, mixed use development, and cultural heritage sites; and improved air and drinking water for all residents, particularly in those communities where dissatisfaction is highest.

In this section, we propose several general recommendations on policy strategies to the government of the Pingshan New District based on the findings from the resident satisfaction survey. We focus primarily on land use and transportation. More information about some of these strategies can be found in Chapters Five through Nine. Additional analysis will be needed to confirm the cost-effectiveness of recommended measures and formulate detailed plans for implementation.

Land Use

Preserving ecological land is very important to most residents and so should be prioritized in land use decisionmaking. Related to this, residents considered access to nature and attractive public spaces to be important for their communities, but half did not feel that their communities had these characteristics. An inventory of such elements and promotion of what the local government is already doing to provide these attractive public and green spaces should be a near-term priority. Residents also considered mixed-use development important for their communities, and most people said that their community lacked this type of development. New development or redevelopment activities should therefore continue to focus on opportunities for mixed-use designs.

- Pingshan should focus on the following strategies described in Chapter Five: SL3, SL4, SL6, and SL8–10. Figure 5.1 shows SL4 (form-based building codes) as both difficult to

implement and lower-impact for PRD cities in general, but given the preference of Pingshan's residents for more mixed-use development, this new approach would be particularly beneficial. The other strategies suggested for Pingshan are consistent with priorities identified in Figure 5.1 and Table E.1.

Transportation

Public transport is essential for connectivity. The biggest complaint residents have with public transport currently is total travel time. Minimizing the number of transfers, improving efficiency of intermodal connections, and increasing the free flow speed of public transport should be priorities for Pingshan. Few people currently own cars, but this number will grow as most survey respondents said that owning a car is important. Parking management will become an issue as the number of cars grows. Since availability of parking, not cost, is considered a problem now, the efficient pricing of parking should be seriously considered as a management strategy.

The government of Pingshan also should focus on strategies that promote safe driving and pedestrian safety. As more cars travel on Pingshan's roads, the likelihood of vehicle-pedestrian accidents will only increase. While there may be existing government-sponsored traffic safety education programs, few residents appear aware of them. Effective outreach to the public on this topic can be as important engineering or transportation planning solutions.

- Pingshan should focus on the following strategies described in Chapter Six: ST1, ST3, ST6, and ST12. These strategies address preferences identified by Pingshan residents in the survey and are generally consistent with the priorities in Figure 6.1 and Table E.2.

Environment

Residents are generally satisfied with both air and drinking water quality. But there are specific communities for which drinking water quality is more of a concern. Solutions therefore may need to be community-specific. As previously noted, better-educated residents seem to be more dissatisfied with these two important environmental issues than others. This group also voiced greater dissatisfaction with the government's environmental preservation efforts. This finding suggests that improvements in these areas will be an important element of a larger strategy of attracting and retaining better-educated residents to Pingshan.

Housing

With about one in four residents, primarily the better educated and elderly, dissatisfied with the availability of good-quality affordable housing, Pingshan will want to continue its focus on providing better housing stock for these populations. Younger persons (18–24 years) were least satisfied with the quality of nearby public libraries or cultural buildings, indicating that they may have higher expectations for these types of facilities. In planning new development, Pingshan should consider the provision of these types of facilities, in conjunction with transit-oriented development that will also improve connectivity for these residents and workers.

Economic Development

Optimism about quality of life improvements in Pingshan are tied to beliefs that the economy will grow and that Pingshan has good development potential. Economic development activities that increase the competitiveness of Pingshan in attracting and retaining better-paying jobs

relative to other districts and cities in the province will be necessary to maintain resident satisfaction. A clean environment, affordable housing, and efficient transportation services should be critical elements of any plan to attract new and better-educated residents and better-paying jobs.

Recommendations for Future Surveys of Pearl River Delta Residents

One purpose of the survey was to provide the leadership of Pingshan New District with actionable information about the concerns of its residents and guidance on how these concerns could be addressed through enhanced, better implemented, or new government policies. These are discussed in the next five chapters. A second purpose of the survey was to use the experience as a pilot to test out the survey instrument itself, gain experience in conducting such surveys using in-person interviews, and identify ways in which it could be improved if it were to be more widely deployed throughout the PRD, whether at the city or district level.

With respect to the first purpose, as with all surveys of this kind, results need to be carefully interpreted and kept in perspective. Perceptions are not the same as facts. Perceptions depend on the particular conditions within a community and often can be affected by other household members and neighbors. As such, comparisons of survey responses across districts, counties, and cities are of limited use because the baseline will be different from place to place. These responses are not suitable measures for ranking places in the PRD. Instead, these results are intended to be meaningful to decisionmakers and the public within a given district, county, or city over time.

Guidance on Survey Design

In this section, we provide some general guidance to districts, counties, and cities that plan to conduct their own resident satisfaction surveys. There are several important first steps of information gathering and analysis that need to be carefully done to ensure the validity of the resulting sample survey data:

1. **Sampling Frame.** The sampling frame is a list that includes all residents in the city or target geographic area and other information that will be used in the sampling process such as contact information, gender, or resident status. A household registration list was used for the survey in the Pingshan New District. Sampling frames should be up to date and accurate; otherwise, new residents may not be included in the survey. To be representative, a random or systematic process should be used to select the residents from the sampling frame. There are Internet-based random number generators that can be used for this purpose.
2. **Sample Design**. There are three types of sample designs: simple random sampling, stratified sampling, and cluster sampling. We recommend that a stratified design be used for a resident satisfaction survey. This design helps to ensure representativeness in some important characteristics. The Pingshan survey's sample size was deliberately designed to provide sufficient statistical power to report findings by community and resident type (e.g., original, registered, floating). To ensure representative sampling in these categories, RAND organized the sampling frame by community, and independent samples were drawn from each community. Because the distribution of resident

types differed across community, RAND's stratification of the sample by community also ensured that original residents, who were small in number, were adequately represented in the sample. However, some cities may wish to conduct a citywide survey and not focus on conditions and trends within particular districts or communities. Samples sizes can be reduced accordingly.

3. **Sample Size.** Statisticians use a variety of factors to guide their choice of an appropriate sample size, and, for this reason, we cannot provide a simple formula. Larger sample sizes generally lead to more precision. When determining sample size, it is important to be clear about survey objectives. For example,
   - Setting the preferred confidence interval (also called margin of error) is a key decision in determining sample size. The confidence interval is the plus-or-minus figure usually reported in newspaper or television opinion poll results. The wider the confidence interval, the more certain that responses from the whole population would be within the range of the survey responses. Narrower confidence intervals generally require larger sample sizes.
   - The confidence level represents the percentage of times that the confidence interval around the estimate of a particular survey response captures the true value of the "true" response for the whole population. Most survey researchers use the 95 percent confidence level and set their sample size accordingly. Higher confidence levels would require larger sample sizes than the size determined for the 95 percent confidence level.
   - Stratifying a sample, as was done for the Pingshan resident satisfaction survey, increases the efficiency of sampling by grouping similar sampling units together. By reducing variability within each stratum, fewer samples are needed.
   - Sample sizes are also influenced by purpose. If the primary focus of the survey is to understand the differences among subgroups of the community, district, county, or city, then each subgroup must have an adequate sample size to produce statistically valid results.
   - Finally, for probability-type sampling as recommended here for the resident satisfaction survey, the size of the overall population does not matter unless the population is very small. This means that, for a given confidence interval and confidence level, a sample of 500 people could be equally useful in examining the opinions of a province of 15,000,000 as it would be for a city of 100,000.

Cities will need to consult with trained survey statisticians to ensure that the sample size is adequate for their intended purposes. Internet-based sample calculation tables can provide some guidance in sample size requirements (e.g., www.surveysystem.com/sscalc.htm).

Administering the Questionnaire

With respect to the questionnaire itself, residents at all levels of education, age, and ability were interested in the survey and were willing and able to answer the questions in the 20- to 30-minute period. As part of the training for interviewers, we emphasized the need to maintain an objective view of the abilities of all residents to provide meaningful responses. Interviewers needed to "learn" the questionnaire; interview length declined with interviewer practice. In fact, interviewers were required to practice reading the survey questions aloud to gain proficiency in asking them to respondents. We also emphasized the need for interviewers to read the questions as written, and not make even a slight change in wording. Interviewers

were further instructed to accept the responses provided by respondents even if they differ from their observation of the respondents' environments. For example, a respondent could believe that their building is well constructed even if the interviewer can hear neighbors talking through the walls or observe signs of deterioration.

Migrants made up nearly 90 percent of the survey population. This population by nature is transient, raising the likelihood that information on addresses will become out of date. Substitution for the respondent was permissible but only if the new householder was of the same gender and age. The efficiency of the interviewing process could have been higher if more names were given to the interviewers in each survey shift than the number of interviews that actually could be completed during that shift. People were not always at home, requiring the interviewer to move on to the next person on the list and then return at another time or day to conduct the interview. The most common reason for not conducting an interview was the inability of the interviewers to enter an apartment building. This constraint should be considered when allocating samples to interviewers for a survey shift.

Cost-Effectiveness

The cost-effectiveness of administering a survey is an important consideration for future and wider deployment. The cost of conducting a survey of this kind depends in large measure on the logistics of training and supporting interviewers as they conduct their interviews. When local interviewers can be used, lodging, food, and transportation costs can be mostly avoided and only daily stipends provided. In this survey, our local partner recruited 32 college students and designated five of its staff to manage and coordinate the students. Recruitment costs included the cost of production of recruiting posters. Training costs included printing fees for training materials, as well as labor costs and the cost of car rental for the pilot survey. Interview costs included hotel expenses, travel allowance, meal subsidy, labor cost, and gift costs. Data entry costs were mainly the cost of labor. These costs are summarized in Table 4.1 and total 237,000 RMB (approximately $38,300). In future surveys, it may be possible to reduce interviewing costs by using students who have their own local housing and will not require hotel rooms. Relative to collecting some of these data by other means, the survey appears to be an efficient means of populating some indicators.

In the following chapters, we identify a number of survey questions that could serve as subjective indicators to either supplement objective indicators or serve as surrogates for objective indicators until better measurement tools or data collection can be implemented.

Table 4.1
Estimated Costs of Conducting a Resident Satisfaction Survey

Survey Activity	Unit Cost (in RMB per person)	Total Cost (in RMB)
Recruitment	200	1,000
Training	350	11,200
Interviews	400/day	217,600
Data entry	200	7,200
Total		237,000

CHAPTER FIVE

Land Use

This chapter identifies major challenges in land use confronting Guangdong's cities and proposes land use goals to address these challenges, along with strategies and indicators. As will become evident in Chapters Six through Nine, land use challenges and goals are closely associated with challenges and goals for transportation, environment, housing, and economic development. We summarize those interrelationships in Table 10.1. The goals addressed here derive from goals previously articulated in government documents for the PRD region and our understanding of the challenges related to land use. For each recommended strategy, we present the rationale for adopting that strategy based on a selective review of relevant strategies in international use, and a discussion of possible indicators and targets associated with successful implementation of the strategy. Below, we discuss the context for land use in the region and how land use differs from the other policy areas.

Background

The PRD has grown at an extraordinarily rapid pace over the last three decades. Shenzhen, for example, has grown from a fishing village of 30,000 people to a metropolis of over 10 million (Tam, 2010). Population and economic growth have been fueled by the success of the PRD as an industrial zone, where products have been made for export markets and, more recently, domestic markets. This period of explosive growth has now slowed, and the region's leaders seek to transform the PRD to a destination for businesses that produce higher-value products and employ more highly educated workers.

During this period of high growth, land use decisions in the PRD cities were driven more by a desire to increase economic output than to improve quality of life. Many areas were built quickly to keep pace with the increasing population, without much attention to integrating transportation and land use, separating factories from residential areas, or upgrading the quality of housing for factory workers.

In addition to the sheer speed of development, two other factors have made China's urbanization different from other countries. First, land in China is designated officially as either urban or rural land. Individual land ownership is not permitted. Instead, urban land is owned by the government, and rural land is owned collectively by villagers. This has led to the phenomenon of "villages within cities"—essentially pockets of rural land that stood in the path of urbanization. Many cities have within their boundaries land that is considered rural and is controlled by village leadership rather than the city government. Cities cannot enforce their building codes within these villages, and as a consequence, these villages often contain

substandard buildings. Second, cities have a strong financial incentive to convert rural land to urban for development. For many municipal governments in China, the land transfer fees obtained from real estate developers have constituted an important source of revenue, given the lack of a broad-based property tax. These factors are unique to China and help explain the dynamics of land conversion at the level of municipal governments. Changes in these rules and incentives would need to be initiated at the central government level.

Cities and districts within the PRD operate under these same land use dynamics to varying degrees, but there are differences among them. One difference is that some cities are land-constrained, while others have room to expand their footprint into rural areas. Another difference is that current population trends vary; some cities continue to grow, while others have lost population following the 2008 recession. The challenges described below, along with recommended goals and strategies, thus vary across cities and districts.

Challenges and Overview of Goals and Strategies

Measures of performance related directly to land use decisions are difficult to define within any indicator system. This is because there is no single goal of land use policy that is unambiguously associated with improving quality of life. Rather, land use choices can enable the achievement of other goals. In the other four policy areas, goals can be more easily defined: a clean environment, a healthy economy, a sufficient supply of housing for all income levels, and a safe and efficient transportation network. In each of these areas, measures of achievement toward goals can be expressed as established standards (such as parts per million of air pollutants), desirable end points (such as reductions in traffic fatalities), or desirable paths (such as increasing per capita income).

For land use, the proper balance among varying uses depends on the economic and social context; there is no correct "formula" for how much land should be devoted to specific uses or what the right population density should be. We have deliberately not used terms such as "optimizing" land use structure, since this is not a concept that can be easily defined or measured.

For this reason, we focus our land use goals on addressing four challenges that have been brought on by rapid urbanization and inadequate land use planning. The first two deal broadly with land use planning. The first challenge is around the unplanned nature of urban development in terms of its encroachment into rural areas. The second deals with improving land use within the urban development areas, to provide high-quality residential areas as well as efficient infrastructure and services. The other two challenges deal with overarching issues that affect all development areas. The third challenge addresses historic preservation, which has been somewhat neglected in the rush for modern development, Finally, the fourth addresses the need for reducing vulnerability to natural disasters in land use planning, an important topic given the potential for major flood damage in the PRD.

Three of the four challenges relate to lands in need of protection from development: arable land, historic areas, and lands vulnerable to natural disasters. We gave serious consideration to including ecosystem services (generally defined as benefits provided by the land itself, such as water filtration) as a fourth reason to preserve land. However, this concept is difficult to operationalize and measure, and has not as yet been widely implemented in other countries.

The remaining sections of this chapter discuss each challenge, goals to address each challenge, strategies to achieve the goals, and suggested indicators to measure progress.

Challenge CL1: Unplanned Outward Expansion of Urban Boundaries Has Led to Fragmentation of Both Urban and Rural Land

Fragmentation is the opposite of contiguity. If a region grows in a contiguous fashion, newly developed parcels are adjacent to existing developed parcels, and large parcels of rural land remain on the outskirts of the urbanized areas. With fragmentation, new development is created in a "leapfrog" fashion, meaning new developments are far from existing urban areas and thus more difficult and expensive to provide with municipal services and infrastructure. From a rural perspective, lack of contiguity tends to lead to parcels of land that are too small for efficient farming. This pattern of urbanization works against being able to develop larger parcels over time.

Cities with room to grow face the potential loss of productive farmland. While all cities have targets for the amount of land they are required by the central government to retain as undeveloped, it is not always clear that cities have used empirical research methods to choose which lands to conserve for agriculture. In addition, requirements for land preservation can conflict with incentives to increase revenues from development activities.

Goals and Strategies

We recommend a goal of increasing contiguity of both urban and rural land, through two strategies:

- Map land to be protected.
- Create mechanisms to ensure protection.

Challenge CL2: Urban Land Is Not Utilized in a Way That Allows for Efficient Provision of Public Services and Facilities

As opposed to the first challenge, which deals with how best to determine the boundaries of urban areas, this challenge is about the quality of development within those areas. Lack of well-integrated planning has meant that many urban areas lack nearby services, efficient transportation options (including a street pattern that would encourage the use of nonmotorized modes), and high-quality public spaces.

Goals and Strategies

Three goals are suggested here. The first is to increase the density of residential space and employment opportunities through provision of high-quality compact development. While the direct connection between quality of life and land use is difficult to specify, our strategies are designed to mitigate the potential negative effects of high densities:

- Promote transit-oriented development near rail stations (both intercity and urban rail).
- Adopt and enforce a zoning system of "form-based codes" that regulates density and design but not use.
- Create a well-connected street network.
- Provide high-quality green space and attractive public spaces within residential and commercial areas.

The second goal is to increase access to public services and facilities. Within the region, residents experience highly variable access to destinations that are important to maintain a high quality of life: jobs, educational opportunities, health care, and recreational activities.

This can happen because these destinations are not spread evenly throughout the city. Private car ownership can exacerbate differences in access; those who rely on public transit and nonmotorized transportation are often at a disadvantage. Here we suggest a strategy to create incentives for developers to build in certain neighborhoods based on infrastructure.

Finally, the third goal is to reduce the presence of industrial properties in prime residential and commercial areas. Development in many cities fails to comply with internationally accepted standards of siting, construction, and environmental quality—old factories that in some cases have polluted the soil and water, buildings constructed using poor construction practices, housing that does not meet modern demands as residents' expectations rise. Especially in cities with severe land constraints, the only places to accommodate new residences and businesses are in these built-out districts. The strategy proposed here is as follows:

- Develop a brownfields program that includes remediation standards and clear roles for various agencies.

Challenge CL3: Historic and Cultural Preservation Has Been Neglected

Many historic buildings that reflect centuries of Lingnan tradition have been demolished in favor of modern structures or industrial uses. While some decisions may be justified on a case-by-case basis, the overall impact is to disconnect residents from their own unique history and culture.

Goal and Strategies

The goal here is to strengthen measures to preserve historic properties and assets to foster cultural identity and tourism, via two related strategies:

- Identify and prioritize buildings and neighborhoods with historical and cultural value.
- Enact and enforce existing historic preservation regulations.

Challenge CL4: Current Development Patterns and Processes Do Not Adequately Address Vulnerability to Natural Disasters

Cities, districts, and counties in the PRD face serious risks from natural disasters. For example, a recent study ranked the region as the most vulnerable urban area in the world in terms of the number of residents who could be affected by storms, storm surge, and river flooding (Swiss Re, 2013). However, the ability to recover quickly from disasters and to adapt to changing circumstances is not often considered in land use planning.

Goal and Strategies

The goal for this challenge is to reduce vulnerability to natural hazards. We propose here a strategy to evaluate assets at risk of flooding, wind damage from typhoons, and earthquakes through a comprehensive mapping program.

Rationale for Strategies, Recommended Practice, and Proposed Indicators

The remainder of this section explains in greater detail the rationale for each strategy, selected examples of successful implementation, and a discussion of indicators and targets. Each strategy is supported by one or more indicators, which are intended to contribute to achieving the

goal. For some goals and strategies, relevant data are already being collected (in indicator systems such as Happiness Pingshan and in annual publications such as the *Guangdong Statistical Yearbook*), and we have noted this where appropriate. For Pingshan, six of the 22 proposed indicators have already been collected via a survey (see Chapter Four and Appendixes A–C for details). However, for most goals and strategies, we recommend additional data collection. In some cases, we also note that better indicators may be available and describe their potential future use.

Goal GL1: Increase the Contiguity of Urban and Rural Land

The goal is to contain urban development such that most urbanization takes place either inside existing urbanized areas (a process known as infill development) or at their immediate boundaries, and that remaining rural lands are generally protected from development.

Strategy SL1: Map Ecological Protection Zones and Agricultural Land Based on Productivity

Rationale: Before adopting practices to preserve land from development, it is important to know which lands are most in need of protection. Ecological protection zones are land areas defined by their favorability for various species as well as their vulnerability to loss of ecological functions as a consequence of development. Ecological protection zones might include wildlife habitat, watersheds for drinking water, or high-productivity agricultural land.

Recommended practices: Cities in the PRD have designated ecological zone boundaries, although their criteria are not entirely clear. For example, Zhuhai reported that "Zhuhai has drawn up water source conservation zones and designated eight nature conservation zones according to the condition of obtaining and using water." (Zhuhai City, Housing, Urban Planning, and Construction Bureau, 2013). Many methods have been developed to identify lands for protection. Processes begin with a clear statement of the goals of protection and selection of measures that would reflect both the current and the desired future state of the lands to be protected.

According to one review of farmland preservation policy (Alterman, 1997), across six countries, the United Kingdom and the Netherlands were considered to be the most successful of the six, but neither country has a specific farmland preservation policy. Instead, they have strict development controls that form part of a broader "urban containment" policy. For example, in both countries, all development proposals are subject to government approval, and the national government can reject development proposals. Owners of rural land are not entitled to compensation if their requests to develop their land are rejected by a local government. They also share a strong cultural heritage of preservation of farmland, not necessarily motivated by agricultural production per se but rather as "countryside preservation." Many cities and towns in the United Kingdom have a strong greenbelt policy. Greenbelts are open spaces that surround the urbanized area. They may include other green space in addition to farmland. In the Netherlands, governments purchase farmland and keep it as open space.

Seoul instituted a greenbelt in 1971 that has changed relatively little through today. It encircles the main city of Seoul, but much development has taken place in the metropolitan area outside the greenbelt. One review concluded that the greenbelt policy has kept development out of the greenbelt, which serves an important function in preserving green space, but that more land has been consumed for development than would have been the case without the greenbelt, because it pushed development outward during a time of rapid urbanization. It

has also contributed to some extent to higher land prices and longer commutes (Bengston and Youn, 2005).

Indicators:

- L1: Land area within the ecological control line as percentage of total area of land in the region.
- L2: Area of cultivated land as percentage of total area of land in the region.
  - Explanation: The province and cities already track the total amount of land that is protected from development, so these indicators build on that existing knowledge and transform it into a percentage.[1]
  - Data source and availability: Individual cities will have this information after they have identified boundaries of ecological protection zones.
  - Frequency: Annual.

Strategy SL2: Enforce Limits on Development of More Valuable Ecological and Agricultural Lands

Rationale: Cities face pressures to develop land close to population areas, including farmland, and urban land is usually more valuable than rural land. However, China has concerns about preserving its ability to grow sufficient food for its population. In addition, retaining productive agricultural lands near cities has other important advantages: fresher food, less spoilage, lower transportation costs, and fewer emissions from transporting food. The coastal regions of China, including the PRD, tend to have higher-quality farmland than many inland provinces (Lichtenberg and Ding, 2005), making it particularly important to preserve agricultural land in the region.

Another reason to strengthen these regulations is to provide a basis for developing larger parcels of rural land over time. State-level changes to China's rural land use policies in 2008 and 2009 were supposed to make it easier for farmers to increase their plot sizes through relaxation of approvals on the exchange of use rights between farmers (Dean and Damm-Luhr, 2010). A successful program that protects farmland should complement these policies and lead over time to larger, more efficient parcels of agricultural land.

China has one of the lowest amounts of arable farmland per capita in the world (Woetzel et al., 2009), and agricultural productivity has not yet improved to the level of more developed countries. While China has a quota system in place to protect cultivated land, under which each province is responsible for preserving an amount of farmland specified by the central government, it has not been fully effective in significantly slowing the rate of farmland conversion to urban uses. In addition, it does not necessarily protect the highest-quality farmland. While the intent of the policy is to protect the highest-quality farmland, in practice, the policy competes with stronger financial incentives for both cities and village residents to convert arable

[1] The Woo and Guldman (2011) study used population and employment density gradients to measure effectiveness of protection of valuable lands. Density gradients measure changes in density over distance from a central district. As a substitute, the average density of the area within an urban growth boundary (UGB) could be measured, as an indicator of the effectiveness of the UGB in pushing new development into existing urbanized areas. Alternative indicators for ecological protection zones might include the percentage of vulnerable land protected using these zones (based on geographic information system [GIS] mapping of land designated as vulnerable for various reasons), or the amount of development within these parcels.

land to urban uses. Therefore it might be useful to bring important arable lands into areas with stronger protections.

Recommended practices: Both incentives and limits should be incorporated into the master planning process. Incentives, which are voluntary for developers, are means to encourage certain types of development whereas limits to prohibit development in protected areas require an enforcement mechanism.

In terms of limits, UGBs and ecological protection zones are both ways for governments to prevent development from encroaching on undeveloped areas. UGBs set the limits for outward urban expansion, while ecological protection zones keep development from disturbing lands that are ecologically fragile or valuable, such as wetlands. Ecological protection zones could also include arable farmland. We distinguish arable land from cultivated land: Cultivated land is land that is currently in agricultural production growing specific types of crops, whereas arable land is farmland that has high potential productivity, regardless of whether it is currently in production.

A number of American cities and states have UGBs that restrict urban development outside them (development compatible with rural uses is still allowed). The restrictions are enforced through the permitting process; any developer wishing to build requires a permit, and permits that violate the terms of the UGB would not be issued. While there is debate regarding the desirability of restricting growth in this fashion, if the policies adopted are sufficiently robust they tend to be effective in achieving their goals of steering new development inside the UGB. One study found that UGBs that are imposed by states tend to be more effective in promoting development within the boundaries than those imposed by cities (Woo and Guldman, 2011). The best-known of these UGBs is in the Portland, Oregon, metropolitan area. A state law adopted in the early 1970s requires that all cities in Oregon adopt UGBs.

The United States also has an extensive network of lands that are protected because they are considered valuable for environmental or historic reasons. Lands are protected in two ways: direct public ownership and easements. With regard to public ownership, lands can be administered by the federal government (for example, national parks or wildlife refuge areas), the states, or local governments. The degree of development and public access within these areas is determined by the entity that administers the land. For example, some national parks restrict development to accommodate overnight visitors (roads, visitor centers, and lodging), while others severely restrict access because of the possibility of environmental damage caused by visitation.

Easements are legally binding restrictions on landowners that prevent them from developing or using their lands to a degree that would otherwise be allowed. For example, a conservation easement would restrict certain types of development on a parcel of land, while allowing the landowner to retain the other rights associated with ownership (such as leasing it, leaving it to heirs, etc.). A conservation easement is generally negotiated between a landowner and either a government entity or a nonprofit organization that agrees to enforce the restrictions. The easement remains in place even if the land is sold to another owner. As one example, the U.S. Environmental Protection Agency (EPA) has provided funding to local governments to develop conservation easements to protect drinking water from contamination (EPA, no date).

Indicators:

- L3: Land area within the ecological control line that was developed in the prior year as percentage of total land area within ecological control line (2013 as baseline year).

- L4: Portion of land area designated as cultivated that was converted to development in the prior year as percentage of total cultivated land (2013 as baseline year).
  - Explanation: This builds on data from the previous indicator. There should be one number per city for the number of hectares that are undeveloped.
  - Data source and availability: Individual cities are required to protect cultivated land and therefore should have that information already. The cities will have information about ecological lands after they have identified boundaries of ecological protection zones.
  - Frequency: Annual.

Ideally, in the future a more desirable indicator would be the percentage of high-quality arable land that remains undeveloped. However, this requires an evaluation of the quality of farmland.

Table 5.1 summarizes the goal, strategies, and indicators for challenge CL1. Notations such as "Q26f" refer to items on the Pingshan New District survey.

Goal GL2: Increase Density of Residential Space and Employment Opportunities Through Provision of High-Quality Compact Development

Higher-density development can provide a number of advantages: Workplaces and residences are closer together, reducing the need for long-distance commuting; persons living in higher-density areas tend to drive fewer miles, because many needs can be met within the neighborhoods; and public services can be provided more cost-effectively. But higher-density neighborhoods can also have their disadvantages: overcrowding, tall buildings that form canyons blocking out natural light, lack of open space, and congestion. The overall goal is to reap the benefits of higher-density development while minimizing the disadvantages.

Table 5.1
Land Use Goals, Strategies, and Indicators for Challenge CL1 (Fragmentation)

CL1	**Unplanned outward expansion of urban boundaries has led to fragmentation of both urban and rural land.**		
Goals and Strategies		**Proposed Indicators**	
GL1	Increase the contiguity of urban and rural land.		
SL1	Map ecological protection zones and agricultural land based on productivity.	L1	Land area within the ecological control line as percentage of total area of land in the region
		L2	Area of cultivated land as percentage of total areas of land in region
SL2	Enforce limits on development of more valuable ecological and agricultural lands.	L3	Land area within the ecological control line that was developed in the prior year as percentage of total land area within ecological control line (2013 as baseline year)
		L4	Portion of land area designated as cultivated that was converted to development in the prior year as percentage of total cultivated land (2013 as baseline year)

Strategy SL3: Promote Transit-Oriented Development Near Rail Stations (Both Intercity and Urban Rail)

Rationale: The cities of the PRD are investing substantial resources into building rail, both intercity rail and urban systems. One important way to ensure the long-term value of these systems is to implement transit-oriented development (TOD), which is high-density development within walking distance of rail stations. Ideally, this would be mixed-use development (residential, commercial, and institutional), although the mix could vary from station to station. The goal is to concentrate development near rail stations to make it easy to use rail as a travel mode, because the walking distances from stations to destinations are short.

Recommended practices: Singapore has employed a very successful strategy of creating TOD along its heavy rail system. In outlying areas, most housing estates are constructed around rail stations. These housing estates consist of high-rise apartment buildings and local-serving retail (restaurants and food stalls, grocery and drug stores, clothing stores), as well as other services, such as schools and health care. Much of the planning was undertaken by Singapore's Urban Redevelopment Authority.

In the United States and Canada, TOD programs are generally undertaken at the municipal level. One example of a state-level program is in New Jersey, where two state agencies (the Department of Transportation and the Transit Authority) have formed a partnership called the Transit Village Initiative. Cities apply to be designated transit villages, and the state provides funding and technical assistance. Before receiving this designation, cities must meet a set of criteria that includes committing to population growth, adopting a redevelopment plan or zoning ordinance that encourages TOD (generally including design guidelines and lower parking requirements), identifying specific sites for development projects, identifying bicycle and pedestrian improvements, and establishing a management organization responsible for place-making. The state has designated 28 cities as Transit Villages (New Jersey Department of Transportation, 2014).

Indicator:

- L5: Number of housing units within 0.5 kilometers of a rail station as a percentage of all housing units (in region, city, district, or county).
  - Explanation: This provides an objective basis for determining whether the TOD strategy results over time in a higher proportion of housing units conveniently located near rail transit.
  - Data source and availability: This can be developed using GIS data after the strategy has been implemented.
  - Frequency: Survey frequency is recommended every two years.

Other indicators are also possible, but those data would be harder to collect. One potential indicator could be the total transit ridership at a particular station or along a particular line, because this would indicate whether TOD is succeeding as a strategy to encourage people to ride transit. A second is the density within a certain area of the station (generally, in the United States, the "walk shed"—the distance that people will walk to a transit station—is considered to be about one-half mile, or 0.8 kilometers). This could be measured in density of population or housing units. These both assess the success of specific TOD areas (because they are based on specific stations) rather than the program as a whole.

SL4: Adopt and Enforce a Zoning System That Uses Control on Space Such as Density and Design ("Form-Based Codes") Rather Than a System Based on Land Use Function

Rationale: In cities where zoning is widely used to regulate land use, zoning codes typically specify the type of land use for which parcels with that designation can be used. In contrast, a "form-based code" is a type of zoning system in which any type of land use is allowed, as long as it meets certain guidelines about density and form (for example, height limits, floor-area ratios, or set-back requirements). So on a given parcel of land, residential, commercial, retail, educational, health, and institutional uses are all allowed.

Such a code might also include design guidelines, which are regulations that control various elements of buildings and urban spaces. The aim is to ensure that new buildings and other public space elements form a coherent, attractive urban district, especially in districts where historic buildings are being preserved. For example, to prevent residential and commercial buildings from becoming too high and creating "canyons" that block light and views, new buildings can be constructed at a variety of heights.

These codes and guidelines do not mean that developers can build anything they want. Restrictions may be imposed based on health and environmental factors (such as forbidding uses that discharge certain types of air or water pollutants). Similarly, building codes can address safety and noise.

Recommended practices: In France, a national Code of Urbanism requires cities to have land use plans based on four land use types: urban (already built-out), urbanizing (available for future building), agricultural, and natural (open space). The land use plan for Paris designates the vast majority of the city as "general urban," which allows most types of use—housing of various densities, retail, restaurants, offices, and so forth. While there are some subzones within the general urban zone, the two largest both allow mixed use; the distinction is in the percentage of the building that can be nonresidential. On the other hand, many other elements of construction are highly regulated, such as heights, setbacks, and parking, and there are particularly strict regulations about historic preservation. However, developers who meet these restrictions are allowed to develop without any additional interference (Hirt, 2012).

Design guidelines are most often implemented in neighborhoods rather than entire cities, since a city may include many types of districts and the type of development that is appropriate for one may be inappropriate for another. Design guidelines differ from building codes that specify safety features.

While they differ from city to city, generally design guidelines address the following:

- **Street frontage:** the types of uses on the ground floor, the placement and type of doors and windows, and building setbacks (the distance between the building and the street)
- **Height:** the minimum or maximum height, or the relationship between the height of the building and the width of the street (generally with the goal of having higher buildings on wider streets)
- **Materials:** the type of materials and colors allowed on the exterior of buildings
- **Street amenities:** requirements to provide lighting, sidewalks, and outdoor seating.

As an example in China, design guidelines for Chenggong New Town near Kunming include mixes of building heights and scales, retail along side streets, south-facing buildings, and private courtyards, along with a variety of street types (Calthorpe Associates, 2010). Vancouver's design guidelines call for tall towers separated by lower buildings, so that residents in

the towers have access to daylight and views. Vancouver's guidelines also designate "protected view corridors" to ensure that these views are preserved. Each protected area is mapped as a wedge, and the heights of the buildings in these view corridors are determined on a case-by-case basis (City of Vancouver, no date).

Indicator:

- L6: Percentage of residents who agree there is a good mix of building types (e.g. residential housing, shops, office buildings).
  - Explanation: As the goal of this strategy is to develop a mixed-use and attractive urban environment, it is difficult to specify an objective indicator. It is particularly difficult to develop an indicator for mixed land use because of the question of scale—every city is mixed-use when considered as a whole. We therefore recommend this subjective measure, with the further clarification that "good mix" means that housing, shops, and office buildings are all present, without one type dominating.
  - Data source and availability: The indicator proposed is based on residents' responses to a survey question, "Tell me whether you strongly agree, agree, disagree or strongly disagree that [your community, district, or county] has a good mix of housing, shops, and other types of buildings" (Q11a on the Pingshan survey). Some PRD cities already ask general questions about the quality of life that might be relevant for this strategy, such as a question on the Shenzhen Livable City Development Performance Assessment about "recognition of the city's characteristics."
  - Frequency: Survey frequency is recommended every two years.

Strategy SL5: Create a Well-Connected Street Network

Rationale: Street grids have a major influence on how people travel. Smaller grids (meaning small blocks and frequent intersections) can encourage nonmotorized travel since they are safer to walk and bicycle on (because they tend to slow traffic). Smaller grids are also better for traffic flow because they offer multiple routes around congestion or accidents. Some land use strategies enable these types of street designs; others present major impediments. This strategy largely concerns areas of new development. While it is difficult to retrofit existing districts with new street networks, this strategy can be employed in some circumstances when major new development is planned.

Recommended practices: In the United States, the main mechanism used to develop this type of street network is a policy that commits a local government to providing streets that can be safely used by all forms of transportation (as opposed to streets designed primarily for cars). Three important elements are a high degree of street connectivity (that is, to the greatest extent possible streets should connect with other streets to shorten travel distances), short blocks (that is, the distance between intersections should be easily walkable), and intersections that are safe for pedestrians and bicyclists to cross (both in terms of design as well as traffic sig-

nals). Nearly 500 U.S. cities have adopted such policies (Smart Growth America and National Complete Streets Coalition, 2013).

Indicators:

- L7: Average block length of new and rebuilt roads.
  - Explanation: Block length captures one important and easy-to-measure element of a well-connected grid.[2] We do not suggest using this indicator at a larger regional scale (beyond an individual city) because its descriptive power can be distorted by long intercity connecting roads and highways.
  - Data source and availability: This can be measured through a GIS system. Data should be available from the Department of Transportation at the city level.
  - Frequency: Annual.
- L8: Percentage of residents who feel safe crossing at crosswalks.
  - Explanation: One goal of a well-connected street network is creating a better walking environment for pedestrians. This subjective indicator measures the percentage of pedestrians that feel safe crossing streets at crosswalks. While this may not explicitly measure the effects of a finer-grained street network, it helps show the results of an environment in which we expect vulnerable road users to be safer.
  - Data source and availability: This question can be asked on a survey. In the Pingshan survey, the question asked was, "To what extent is safety in crossing the street at pedestrian crosswalks a problem for you in your daily life?"
  - Frequency: Survey frequency is recommended every two years.

Strategy SL6: Provide High-Quality Green Space and Attractive Public Spaces Within Residential and Commercial Areas

Rationale: High-density districts are made more pleasant and livable by the presence of high-quality green space for residents and visitors to enjoy. While *high quality* is difficult to define objectively, we mean green space that is clean, safe, aesthetically pleasing, and well maintained. Green space can have positive environmental impacts, such as reducing surface temperatures in urban areas, as well as effects on other quality of life measures such as access to attractive areas for walking and quiet places for contemplation (Byrne and Sipe, 2010).

In addition to green space, other public spaces—meaning outdoor spaces that are accessible to the public—are integral to high quality of life. Public spaces are defined as areas accessible to the public for gathering; these can include markets, waterfronts, plazas, public buildings, and pedestrian streets. They provide a venue for entertainment and celebrations and a place to meet and a source of community identity. The New York–based Project for Public Spaces characterizes successful public places as having four qualities: "they are accessible; people are engaged in activities there; the space is comfortable and has a good image; and finally, it is a sociable place: one where people meet each other" (Project for Public Spaces, no date-a). While it is certainly important that spaces be available for all types of recreational activities, this strategy specifically addresses only outdoor public spaces.

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[2] The connectivity of the street grid can be measured objectively in terms of density (number of centerline kilometers per square kilometer) or connectivity (number of intersections per square kilometer). Some cities may measure this already; for example, the Shenzhen Livable City Development indicators include a primary and secondary trunk road network density. However, for some cities, these measures may be more challenging to derive than the recommended indicator.

Best practice: High-quality green space includes a mixture of types of parks, such as those that provide active recreation (that is, places to walk or run, or play sports) and passive recreation (places to sit). Vibrant cities include a variety of types of parks, from major urban parks (such as Central Park in New York, Golden Gate Park in San Francisco, Hampstead Heath in London) to linear parks (such as Rock Creek Park in Washington, D.C.), park-like medians on major streets (such as Portland's park blocks or the Esplanade in Helsinki, both of which accommodate cars as well as pedestrians and bicyclists), and small parks of one block or less in both residential and commercial areas that serve nearby residents and workers.

Green space can include functional outdoor spaces other than parks. For example, a paved plaza with trees and landscaping can provide functional and beautiful outdoor space. Green space could also be provided in the form of community gardens, where residents have access to a small piece of land on which to cultivate a garden. Cities and districts can set aside land designated as green space and build parks directly, or developers can provide parks as part of their proposals to build new developments. Parks also need to be maintained to remain attractive and safe.

Good public spaces mix various uses, attract people, and provide amenities such as food and seating. They can be grandiose or modest, old or new, built all at once or modified over time. The Bund in Shanghai and the Avenue of Stars in Hong Kong are examples of successful public spaces; both are waterfront promenades that serve as gathering places for residents and visitors alike. Many European and Latin American cities grew up around a central square or plaza that serves as a market and site for businesses and restaurants. Middle Eastern cities are known for their souks, or outdoor markets. Well-known public spaces range from the museum-lined Mall in Washington, D.C., to iconic buildings such as the Eiffel Tower in Paris.

The Project for Public Spaces provides guidelines on creating good public spaces; they include tapping residents for ideas, working with multiple organizations, physically locating facilities near each other to foster interactions, and updating the space over time as needed (Project for Public Spaces, no date-b).

Indicators:

- L9: Percentage of residents who think the district or county provides access to nature in parks, open spaces, or gardens.
  - Explanation: Cities in the PRD already specify goals and targets for providing urban green space. These generally address the amount of green space to be provided, either in per capita terms or in percentage of land, and in some cases the distribution of parks (that is, a target that 100 percent of residents should live within 500 meters of green space). We propose using survey results instead. While subjective, this captures people's experience of whether they think the existing green space is sufficient.
  - Data source and availability: This will be measured by survey by asking residents whether they think the district or county provides access to nature in parks, open spaces, or gardens. The Pingshan survey asked whether respondents agreed that their community has "Access to nature in parks, open spaces, or gardens" (question 10c).
  - Frequency: Survey frequency is recommended every two years.
- L10: Percentage of districts with under 30 percent open space.
  - Explanation: This is an objective indicator that complements perceptions about whether open space is adequate. Open space greater than 30 percent is consistent with the Lead-

ership in Energy and Environmental Design (LEED) rating system of the U.S. Green Building Council (2014) and has been adopted widely elsewhere in the world.
  - Data source and availability: This can be derived from the GIS system.
  - Frequency: Annual.
- L11: Percentage of residents who think the city, district, or county provides attractive public spaces.
  - Explanation: Quality of the space is an important component of the strategy. Quality can be defined as objectively measured elements of green space such as maintenance, lighting, facilities such as places to sit or play sports, physical safety, degree to which green space encourages activity, diversity of plants, and connection to other green space.
  - Data source and availability: This will be measured by survey by asking whether residents think the city, district, or county provides attractive public spaces.[3] The Pingshan survey asked whether respondents agreed that their community has "Attractive public spaces (social place like public square or park)."
  - Frequency: Survey frequency is recommended every two years.

Goal GL3: Increase Efficiency and Cost-Effectiveness in the Provision of Public Services and Facilities

Strategy SL7: Create Incentives to Concentrate Development by Providing Key Infrastructure Only in Designated Areas, Consistent with Compact Development

Rationale: Urban districts should include a sufficient number of public services for residents, such as schools, community health service centers, and libraries. Interspersing these facilities in residential districts contributes to quality of life by maintaining relatively short travel times. In neighborhoods with compact development, these services can be provided more efficiently because one facility can serve a higher number of people within a smaller area.

Recommended practices: One potential incentive could be the ability to develop sites on which the government provides the infrastructure. The state of Maryland in the United States has designed some parts of the state as Priority Funding Areas (PFAs). These are areas where development is targeted; they are generally in existing urban areas or directly adjacent to them. While it is not illegal to develop outside of PFAs, the state funds infrastructure such as water, sewer, and roads only inside the PFAs. Municipalities or developers must pay for the required infrastructure outside of PFAs (Knaap and Schmidt-Perkins, 2006). The state tracks its progress through a number of indicators, such as the percentage of new residential parcels and acreage inside PFAs (Maryland Department of Planning, no date).

The amount of land and size and type of facilities to be provided should be based on well-grounded assumptions about the demographics of the future population and information about the adequacy of existing facilities. Many cities have guidelines for providing these services based on population, as well as guidelines for the amount of land needed for facilities. For example, the United Kingdom's accessibility planning process measures the travel time from residences to various destinations. The guidelines are based on unspecified "reasonable" travel times that differ based on the type of facility. Statistics are compiled annually at various levels of government to determine whether the goals are met for various modes of transportation (for example, travel time is tracked using both cycling and driving).

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[3] Audit tools used by trained staff also can measure these elements of quality. Such audits could be performed at some point in the future.

Indicators:

- L12: Average distance to primary school (defined as elementary, middle, and other schools in the compulsory educational system).
- L13: Average distance to community health service center.
- L14: Average distance to hospital (general or specialized).
- L15: Average distance to (a) fire stations and (b) police stations.
  - Explanation: There are several possible ways to measure accessibility to public services from a land use perspective. We propose using a measure of physical distance for four commonly used services: primary schools, community health service centers, hospitals, and fire stations (for emergencies).
  - Data source and availability: The Pingshan survey asked residents "To which of the following can you walk from your current residence in 10 minutes?" for various types of services, including children's school and doctors/health clinic. Future surveys could include hospital and other emergency services. These data are not currently available but a question could be added to the survey, or the information could be obtained from GIS.[4]
  - Frequency: Survey frequency is recommended every two years.

Goal GL4: Reduce the Presence of Industrial Properties in Prime Residential and Commercial Areas

Strategy SL8: Develop a Brownfields Program That Includes Remediation Standards and Clear Roles for Various Agencies

Rationale: Brownfields are defined as land parcels that have been contaminated by previous industrial or commercial use. Before such lands can be redeveloped for other uses, remediation must be undertaken to clean up or isolate contaminated soil, water, and other pollutants. A brownfields program is a set of policies for determining who is responsible for this cleanup effort, what level of remediation is required for different uses, and how to make the land attractive to potential developers. Without such a program, contaminated sites may remain underutilized. PRD cities with contaminated sites may benefit from adopting a broad policy rather than trying to work with each site on a case-by-case basis.

In China, researchers have identified challenges to implementing effective brownfields programs (adapted from Xie and Li, 2010, pp. 28–30):

- Regulatory framework: This is currently weak at both the national and local level.
- Pollution standards: While some guidelines exist, there are no formal national or widely adopted standards for soil and water contamination, which hinders the development of a regulatory framework.
- Financing mechanisms: As of 2010, provinces and cities in China did not have funding mechanisms in place for remediation of sites.
- Government coordination: The roles of land management, urban planning, environmental protection, and other relevant departments are not clearly delineated.

[4] In the future, this indicator could transition to travel times, which requires a fully developed travel demand model, as self-reported travel times can be inconsistent or not reflect point-to-point travel distances (for example, if a person stops to run an errand en route to work).

Recommended practices: Well-developed brownfields programs exist in North America, Europe, Japan, and Taiwan. Japan's program consists of legislation at the national level that defines which industries and hazardous substances are covered and the allowable concentrations. The program began with standards for soil contamination in 1991 and later expanded to include standards for groundwater quality in 1997. The most recent amendments have divided contaminated land into two types, based on the level of soil contamination: More heavily polluted areas needing remediation, and less heavily polluted areas that must be registered when new development is proposed. Development is generally prohibited in the more polluted areas, but landowners are required to undertake remediation and monitoring. For those in the second category, landowners must undertake remediation if development is proposed. Remediation measures include raising the ground level, containing the contaminated areas, and monitoring (Gong, 2010).

Both Beijing and Chongqing have initiated brownfields programs. The Beijing Municipal Government created a regulatory framework for assessing and remediating former industrial sites, after factories moved out of the city. The "Site Environmental Assessment Guidelines" require site assessments, soil and groundwater testing, a risk assessment, and remediation measures. The "Notice on Implementing Soil Environmental Assessment for Sites Left from Industry Relocation" specifies that redevelopment cannot take place until the environmental targets have been achieved at the site. Almost 50 such sites were assessed between 2007 and 2010; some assessments found severe pollution extending 20 meters underground (Xie and Li, 2010).

Both Beijing and national documents emphasize the "polluter pays" principle, under which the factory owner that created the contamination is liable for cleanup. If that enterprise is no longer extant, the current site user is liable, and if that party cannot afford cleanup, the municipal government steps in and tries to recapture the cost of remediation through the land auction (Guo, 2009). This is generally consistent with international practice. In some instances, a developer will pay for the remediation, as happened in the case of the Beijing Hongshi Paint Plant site. However, this type of funding is viable only if the underlying value of the land is high and the developer is willing to pay (Xie and Li, 2010).

Within the PRD, a brownfields program would need to include specific environmental standards. These could be based on the ones adopted in Beijing or on another international standard. In addition, the provincial government should designate a lead department as well as clarify the roles of other departments that have interests and responsibilities in redevelopment.

Indicator:

- L16: Number of brownfields sites that are available for redevelopment, according to redevelopment plans, as a share of all brownfields sites in the annual inventory.
  - Explanation: We propose a simple indicator of the percentage of brownfields sites available for redevelopment, meaning that they have been cleaned up to the standards of the program.[5] The total number of brownfields sites (denominator) may change each year as industrial sites are shut down or relocated elsewhere and as sites are remediated. This indicator will reflect the percentage of sites available for redevelopment each year. An

[5] Bacot and O'Dell (2006) suggest a long list of economic and environmental indicators associated with brownfields redevelopment. However, some of these, such as the market value created by new buildings, are not appropriate in the Chinese context. Environmental indicators rely on highly technical measurement methods; Chapter Seven discusses specific issues around soil contamination.

increase in the percentage each year will reflect progress in executing redevelopment plans.
- Data source and availability: This requires a count of all potential brownfields sites, as well as measurement of how many have been cleaned up to a specific standard. Data will be available after the strategy is implemented.
- Frequency: Annual.

Table 5.2 summarizes the goal, strategies, and indicators for challenge CL2.

Table 5.2
Land Use Goals, Strategies, and Indicators for Challenge CL2 (Inefficiency)

CL2	**Urban land is not utilized in a way that allows for efficient provision of public services and facilities**		
Goals and Strategies		**Proposed Indicators**	
GL2	Increase density of residential space and employment opportunities through provision of high-quality compact development.		
SL3	Promote transit-oriented development near rail stations (both intercity and urban rail).	L5	Number of housing units within 0.5 kilometers of a rail station as percentage of all housing units (in region, city, district, or county) (Q26f)
SL4	Adopt and enforce a zoning system that uses control on space such as density and design ("form-based codes") rather than a system based on land use function.	L6	Percentage of residents who agree there is a good mix of building types (e.g., residential housing, shops, office buildings) (Q10a)
SL5	Create a well-connected street network.	L7	Average block length of new rebuilt roads
		L8	Percentage of residents who feel safe crossing at crosswalks (Q27h)
SL6	Provide high-quality green space and attractive public spaces within residential and commercial areas.	L9	Percentage of residents who think the city, district, or county provides access to nature in parks, open spaces, or gardens (Q10c)
		L10	Percentage of districts with under 30 percent open space
		L11	Percentage of residents who think the city, district, or county provides attractive public spaces (Q10d)
GL3	Increase efficiency and cost-effectiveness in the provision of public services and facilities.		
SL7	Create incentives to concentrate development by providing key infrastructure only in designated areas, consistent with compact development.	L12	Average distance to primary school (defined as elementary, middle, and other schools within the nine-year compulsory education system)
		L13	Average distance to community health service center
		L14	Average distance to hospital (general or specialized)
		L15	Average distance to (a) fire stations and (b) police stations
GL4	Reduce the presence of industrial properties in prime residential and commercial areas.		
SL8	Develop a brownfields program that includes remediation standards and clear roles for various agencies.	L16	Number of brownfields sites that are available for redevelopment, according to redevelopment plans, as a share of all brownfields sites in the annual inventory

Goal GL5: Strengthen Measures to Protect Properties and Assets with Historical Importance and Distinctive Local Characteristics

Strategy SL9: Identify and Prioritize Buildings and Neighborhoods with Historical and Cultural Value

Rationale: Protecting buildings and neighborhoods with historic and cultural value from demolition is now widely viewed throughout the world as a critical element of the urban landscape. Buildings with special historic or cultural value provide an important link to the past, preserving the continuity and uniqueness of a neighborhood. They also provide a physical connection between generations and help families carry on traditions from grandparents to grandchildren. Preservation of historic districts can also promote "cultural tourism," as historic sites attract visitors.

Recommended practices: Identifying buildings and neighborhoods to be preserved generally begins with some type of survey by agencies or organizations with specific expertise in history. The criteria by which buildings or neighborhoods might be identified for preservation could include age (structures over a certain age), historic significance (site of a well-known event, the birthplace of a prominent person), "firsts" (that is, the first building of a certain type), rareness (the only example in the city of a certain type of architecture), or, for a neighborhood, having a consistent type of building or some other distinction that relies on the set of buildings and spaces rather than on individual buildings alone. The U.S. National Park Service uses four categories: association with an event, association with a significant person or persons, embodiment of distinct characteristics (such as a period of time or high aesthetic value), and the possibility of yielding important historic information (such as an archeological site) (U.S. National Park Service, no date).

A priority list could be based on the importance of the site. This could be a ranked list or some type of designation, such as high, medium, low. A different criterion could be the degree of threat faced by a site, such that those more threatened sites are designated high priority. Threats might come from development (the site could be demolished to make way for new development), physical condition (the structure is deteriorating to the point where it might collapse or be vulnerable to a disaster such as a storm or fire, or may become prohibitively expensive to renovate), or vandalism (a vacant site that contains valuable items may become a target for thieves). Each year since 1988, the U.S. National Trust for Historic Preservation has named "America's 11 Most Endangered Historic Places" and followed their progress over the years (National Trust for Historic Preservation, 2014).

Indicator:

- L17: Number of conservation units and historical buildings listed on the Historic Preservation Registration List.
  - Explanation: The number of historic and culturally significant buildings is finite. The indicator is simply the number of buildings and neighborhoods that have been designated as being of historic interest and worthy of preservation.
  - Data source and availability: Once criteria are established, the lists can be compiled by individual cities.
  - Frequency: Once collected, can be updated annually based on newly named buildings, or those that no longer exist.

Strategy SL10: Enact and Enforce Historic Preservation Regulations

Rationale: Even with prioritization, it remains important to have regulations in place to protect designated buildings. Regulations must be consistently enforced to be effective.

Recommended practices: In the United States, many cities have designated "historic preservation districts" within which building owners can make only limited modifications to their properties. These are enforced through a local government review process that ensures the proposed changes are consistent with historic features. For example, Charleston, South Carolina, was the first city in the United States to adopt a historic preservation ordinance, in 1931. Special boards staffed with historic preservation experts and others review most proposals for new buildings, renovations, and additions. Guidelines specify that new construction should "respect the historic materials, features, size, scale, proportions, and massing of its setting" (City of Charleston, no date). Where such districts already exist in Charleston, permits for development cannot be issued without the approval of an historic preservation board, and, for major projects, the discussions are generally open to the public so that residents can comment.

Many countries involve nongovernmental organizations in preservation efforts. In the United States, a private organization called the National Trust for Historic Preservation both identifies places to be preserved and provides private funding to their owners to help restore them. In some cases, the National Trust manages the properties itself (National Trust for Historic Preservation, no date). The National Trust also promotes the restoration of traditional "main streets" (the primary commercial streets in cities and towns) as a means of economic development. The United Kingdom has dozens of independent organizations dedicated to preserving historical sites ranging from railroads to war memorials (Heritage Help, no date).

Real estate developers and building owners can be enlisted to preserve old buildings as part of new projects. Vancouver, Canada, provides density bonuses (that is, the developer is allowed to build at a higher density than otherwise allowed) to developers who agree to protect historic buildings (City of Vancouver, no date).

"Adaptive re-use" refers to modifying a building or district whose original purpose is no longer relevant to current preferences for use. Foshan is doing this in its Lingnan Tiandi project, which has preserved old shops for use as modern stores. In Beijing, the 798 Arts Zone is an old factory site that now houses blocks of art galleries. Singapore has promoted several of its older neighborhoods for cultural tourism and has turned an aging traditional group of shops into a museum that showcases life in the 1950s. Dublin, Ireland, and Philadelphia have even transformed former prisons into museums.

Indicator:

- L18: Percentage of residents who think their city, district, or county provides historic preservation of structures or buildings.
  - Explanation: Ideally, indicators for success would involve both quantity and quality of preservation efforts. For quantity, the question of how many buildings with historic or cultural value are under protection is important. The quality of preservation is more difficult to measure on an objective basis.[6] Therefore, we recommend a simple indicator drawn from the survey about resident satisfaction with historic preservation.

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[6] Phillips and Stein (2013) suggest many more indicators dealing with the link between preservation and economic development, but these data would be more difficult to compile.

Table 5.3
Land Use Goal, Strategies, and Indicators for Challenge CL3 (Inadequate Preservation)

CL3	Historic and cultural preservation has been neglected.		
Goal and Strategies		**Proposed Indicators**	
GL5	Strengthen measures to protect properties and assets with historical importance and distinctive local characteristics.		
SL9	Identify and prioritize buildings and neighborhoods with historical and cultural value.	L17	Number of buildings listed on a historic registry
SL10	Enact and enforce historic preservation regulations.	L18	Percentage of residents who think their city, district, or county provides historic preservation of structures or buildings (Q10b)

- Data source and availability: From the survey. The Pingshan survey asked residents "Does (community name) have historic preservation of structures or buildings?"
- Frequency: Survey frequency is recommended every two years.

Table 5.3 summarizes the goal, strategies, and indicators for challenge CL3.

Goal GL6: Reduce Vulnerability to Natural Disasters

Like many coastal areas, the province is vulnerable to several types of natural disasters. With climate change leading to sea level rise and possibly more intense storms, the PRD will need to accelerate its efforts to reduce the potential for damage from major floods. The region is vulnerable to both storm surge and river flooding. This goal may be more important for a subset of cities in the PRD, as risk is not evenly distributed across the region. Other potentially ruinous and expensive disasters are typhoons and earthquakes.

The three strategies suggested below are essentially the same strategy, with slight modifications for each potential threat.

Strategy SL11: Identify and Evaluate Assets at Risk of Flood Damage Through Mapping
Strategy SL12: Identify and Evaluate Assets at Risk of Typhoon Damage Through Mapping
Strategy SL13: Identify and Evaluate Assets at Risk of Earthquake Damage Through Mapping

Rationale: Mapping land that could be inundated by flooding, destroyed by typhoon-force winds, or devastated by earthquakes is the foundational step that can then lead to development of technically credible strategies to save lives, reduce economic losses, shift development to areas less prone to flooding and other disasters, and enable more rapid recovery and rebuilding following storms.

Recommended practices: Nearly all developed countries have well-established hazard mapping programs that require periodic updates to capture changes in land use, the landscape itself, and sea-level rise. These maps identify the geographic boundaries and land assets that are in various zones of the flood plain. Flood plains are typically denoted as those areas with, for example, a 1 percent chance of flooding to a meter or more above the land surface. In the United States, the Federal Emergency Management Agency (FEMA) leads this process. In the Netherlands, flood mapping is carried out by the Directorate-General for Public Works and Water Management. These maps then become the basis for land use planning, zoning, and flood insurance programs.

Once hazard mapping is established, it can be used to assess the number of vulnerable structures within hazardous zones. By *structures*, we mean not only buildings (residential, commercial, and industrial) but also infrastructure (roads and railroads, power plants, water and sewer lines, and so forth). This can be accomplished using a GIS system, possibly supplemented with aerial photography.

The final component of these strategies is to assess the value of structures in these areas, which can in turn help inform decisions about whether certain structures should be moved. For example, if a major road is vulnerable to storm damage or heavy flooding, a city might begin the process of constructing an alternative route through a safer area.

Indicators:

- L19: Number of structures in flood-prone areas
- L21: Number of structures in typhoon-prone areas.
- L23: Number of structures in earthquake-prone areas.
  - Explanation: It is important to survey existing structures as a basis for determining the number of people and buildings at risk.
  - Data source and availability: To the best of our knowledge, this is not currently available. A survey of all structures could be carried out using either GIS mapping or aerial photography, or some combination of both. It might be useful to develop this information on a PRD-wide basis to ensure consistency of definitions.
  - Frequency: Maps should be updated every ten years to capture changes in flood risk. More frequent updates would be desirable, given the rapid rate of development in the PRD, but can be both difficult and costly. Our recommendation for ten years is intended to strike a balance between accuracy and cost.
- L20: Value of assets in flood-prone areas.
- L22: Value of assets in typhoon-prone areas.
- L24: Value of assets in earthquake-prone areas.
  - Explanation: Once the number of structures is established, cities should determine the costs of replacing them. This would then inform decisions about future development as well as whether existing structures should be moved or hardened to reduce risk.
  - Data source and availability: To the best of our knowledge, this is not currently available. Information about development costs should be collected by cities. Responsible city departments should be engaged in discussions about the replacement value of infrastructure. It might be useful to develop this information on a PRD-wide basis to ensure consistency of definitions.
  - Frequency: The cycle would be tied to the mapping cycle.

Table 5.4 summarizes the goal, strategies, and indicators for challenge CL4.

Enabling Strategies

We have also identified two overall supporting strategies whose implementation would significantly increase the likelihood of success of most of the strategies described above.

Table 5.4
Land Use Goals, Strategies, and Indicators for Challenge CL4 (Natural Disasters)

CL4	Current development patterns and processes do not adequately address the need for resilience from natural disasters.		
Goal and Strategies		**Proposed Indicators**	
GL6	Reduce vulnerability to damage from natural disasters.		
SL11	Identify and evaluate assets at risk of flooding through mapping.	L19	Number of structures in flood-prone areas
		L20	Value of assets in flood-prone areas
SL12	Identify and evaluate assets at risk of typhoon damage through mapping.	L21	Number of structures in typhoon-vulnerable areas
		L22	Value of assets in typhoon-vulnerable areas
SL13	Identify and evaluate assets at risk of earthquake damage through mapping.	L23	Number of structures in seismically unsound areas
		L24	Value of assets in earthquake-prone areas

Strategy SL13: GIS-Based Mapping

GIS-based mapping can serve as a source of data for implementing and tracking the success of other strategies. GIS systems are computer-based systems that facilitate the input, storage, manipulation and output of geo-referenced data. Using GIS, one can relate otherwise disparate data on the basis of common geographic location, creating new information from existing data resources. A GIS map of all streets and parcels can be useful in a number of ways. It can provide the basis for traffic models that help planners understand travel patterns and identify where new capacity is needed. It can provide information on travel distances between origins and destinations to help determine whether service provision is distributed evenly. For example, a GIS map may show that residents of a certain neighborhood have to travel much farther to access schools or health clinics than residents of other neighborhoods.

We recommend that ultimately only one map per city be created, but that it include multiple data layers to address questions ranging from average distance to public services to structures in flood plains. Ideally, such maps should be not just created, but also regularly updated. Based on information received from the Beijing University in Shenzhen, all cities have GIS maps of arable land and population, and some have ecological protection zones, but none have information on flood-prone land. Maps should include a specified frequency of updates (for example, every three to five years in the case of road networks).

Strategy SL14: Master Planning Review

Master planning should be undertaken to guide development at a high level. By *master planning*, we mean development of a citywide plan that lays out broad goals for how the city will change over a certain time-frame, along with specifying the associated infrastructure to facilitate those changes and discussing other supporting strategies to achieve those goals.

We recommend that existing master-planning processes be reviewed and assessed for their adequacy in meeting existing and anticipated future challenges. Many of the strategies in this section depend on cities being able to exert control over land use planning and to be "in front" of decisions about land use rather than catching up with development. If planning processes are inadequate because they are too slow, too bureaucratic, require information that cities do not have, or produce decisions that are not effectively enforced, the processes should

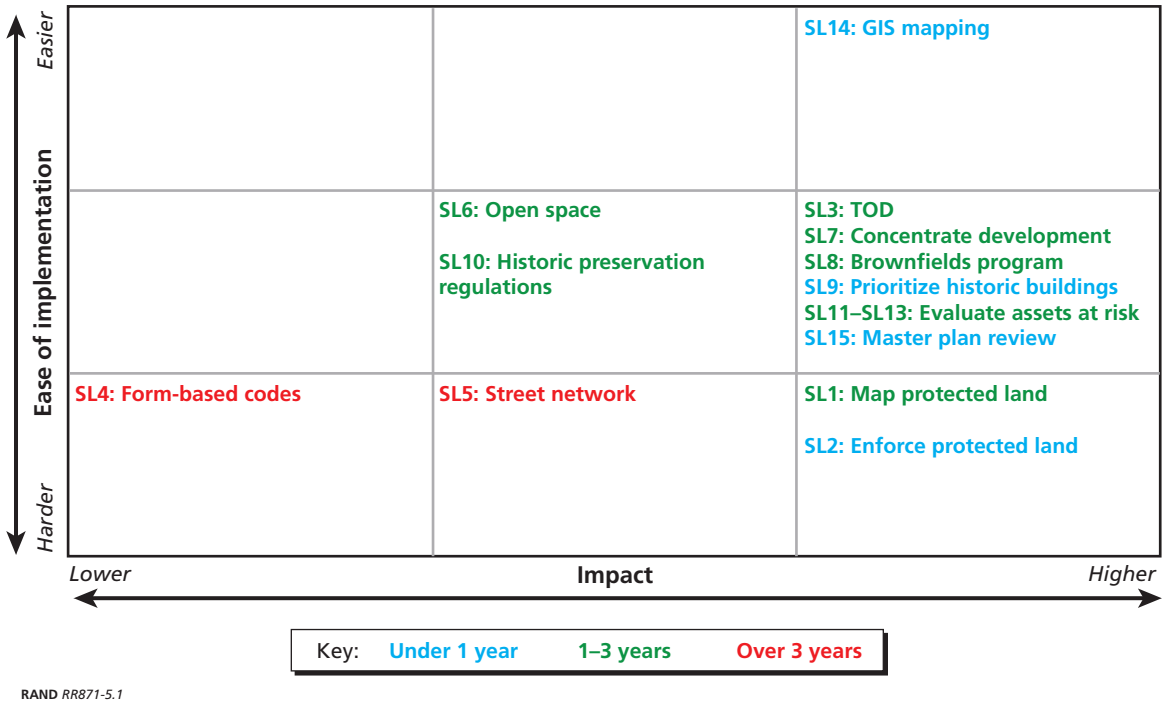
be revised to be more effective. It is difficult to say what these revisions might consist of without understanding why they are currently ineffective. The goal of such an assessment would be to determine whether current land use planning is considered effective, and if not, why.

Priorities for Implementation of Strategies

Figure 5.1 summarizes three important dimensions: the ease or difficulty of implementation, the relative level of impact, and the rough time frame for the proposed strategies. Table E.1 in Appendix E lists the RAND team's view of the underlying assessments associated with implementation of the land use strategies.

The two supporting strategies are both rated as high-impact and fairly easy, as they underlie other strategies and should be relatively straightforward to implement. GIS is ranked as the easiest strategy because it can be done in-house by technical staff; it does not require any regulatory changes or working with other levels of government. The strategies in the lower right quadrant (high-impact but difficult) are those that are very important for achieving higher-density and better-planned development, but that will require changes to development policies and processes. In some cases, such as brownfields, a new program with a set of guidelines and roles will be required.

Figure 5.1
Recommended Priorities for Implementation of Land Use Strategies



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CHAPTER SIX

Transportation

Transportation policy in China requires balancing competing forces. The government would like to see China's automotive industry grow and encourage domestic consumer demand for passenger cars. At the same time, sustainable transportation solutions—including use of non-automotive modes—are needed to address the country's increasing traffic congestion, road safety, and air quality problems. Indeed, transportation challenges and goals are closely tied to land use, environment, housing, and economic development, as summarized in Table 10.1.

As the Pingshan survey results indicated, resident satisfaction with transportation services is tied to mobility: being able to get from one place to another quickly, safely, and comfortably. In this chapter, we recommend policies that seek to reconcile the tension between these forces by focusing on expanding transportation choices to increase mobility while also emphasizing safety and efficiency.

Background

In the early 1990s, China designated the automotive industry as a pillar industry of the national economy. The intended strategies and desired outcomes were documented in automotive industrial policy in 1994 (Holweg, Luo, and Oliver, 2009). The policy made it clear that the development of the automotive industry should rely on the domestic market for private cars. Since that time, automobile production has grown from approximately 2.5 million vehicles in 2004 to over 18 million in 2013 (Statista, 2014). China produced more passenger cars in 2013 than any other country (International Organization of Motor Vehicle Manufacturers, 2013), although foreign brands make up an increasing share of the domestic market, now over 75 percent. The number of registered cars in China increased from around 1 million in 1994 to 7.8 million in 2001, to 32.7 million in 2008, and to 120 million in 2012 (Pan, 2011; "China's Vehicle Population Hits 240 Million as Smog Engulfs Cities," 2013).

This relatively sudden motorization, which includes commercial vehicles, has brought considerable benefits to China, including economic growth, mobility to citizens and commercial entities, and improvements in social welfare. However, it has also created a number of environmental and social challenges. Rapid motorization, together with urbanization, has led to increases in traffic congestion, traffic deaths and injuries, air pollution, noise, and energy consumption. Leaders in PRD cities face the daunting challenges of meeting ever-increasing consumer demand for mobility, while working to reduce vehicle kilometers traveled (VKT), without hampering economic growth.

Challenges and Proposed Goals and Strategies

Challenge CT1: Without High-Quality Public Transit Alternatives, VKT in Privately Owned Cars Per Capita Will Increase and Congestion and Air Pollution Will Worsen

Increasing vehicle ownership will bring considerable benefits to the economies and residents of PRD cities. Indeed, for many individuals, use of a car will be more valuable to them personally than using public transportation. However, the increasing use of those vehicles may be detrimental to the efficient flow of goods and people. The more residents choose to use public transport and nonmotorized options in lieu of private vehicles, the greater the societal, environmental, and economic benefits. But even if high-quality public transit service were available throughout the PRD, public transit is not appropriate for all trips, depending on the origins and destinations, or all people, depending on their age, health, employment, or other characteristics. A range of transportation alternatives, including bicycle-sharing, car-sharing, taxis, and ridesharing options and infrastructure to support walking and cycling, need to be in place to encourage people to travel by modes other than personal vehicle.

Goals and Strategies

We recommend four goals to overcome the challenge of providing a high-quality alternative to driving. The first is to mitigate the need for people to travel by private passenger vehicle. Strategies to further this goal are to (1) enhance the competitiveness of bus and rail through improvements in service coverage and frequency and (2) promote bicycle-sharing, car-sharing, taxi, and dynamic ridesharing services. A second goal is to improve connectivity among transportation modes and among PRD cities. Strategies include (1) developing multimodal transit hubs to enhance transportation connections, choices, and coordination among modes, (2) implementing smart, interoperable ticketing within the PRD to make it easier to use multiple forms of public transit for a single trip, and (3) developing a travel survey that captures inter- and intracity travel flows and mode use to be implemented at regular intervals. The third goal is to create an environment that emphasizes nonmotorized transportation modes. The associated strategy is to connect pedestrian and bicycle greenways and paths to major employment destinations. The fourth goal is to manage parking demand and supply. Three strategies are presented to achieve this goal: (1) instituting a parking pricing system for on-street parking and encourage entrepreneurs to develop smart phone applications that facilitate making payments, (2) encouraging entrepreneurs to develop smartphone applications that provide real-time information on available parking spaces, and (3) enforcing parking regulations and imposing high penalties for illegal parking.

Challenge CT2: Road-Based Freight Transport Is a Major Source of Congestion and Safety Problems

Freight traffic on roads has been increasing rapidly due to the growth in manufacturing in Guangdong. Guangdong has experienced a significant increase in truck traffic over the past decade and a half. According to the World Bank, total freight traffic, defined as tonnage moved by trucks, increased by more than 125 percent between 2000 and 2010 (World Bank, 2011). During the same period, the number of registered trucks grew by nearly 60 percent. This increase in truck traffic, which has positive effects on the economy in terms of moving goods, has had negative effects on congestion and safety. A significant congestion issue is cross-boundary traffic congestion with the Hong Kong Special Administrative Region.

Goal and Strategies

To address the negative effects of road-based freight transport, we recommend one policy goal of reducing interactions between passenger cars and trucks, primarily in urban areas. The two strategies to further this goal are to (1) implement peak-period delivery restrictions in the central business district and other highly congested areas and (2) create freight consolidation centers in urban fringe areas.

Challenge CT3: An Extremely High Number of Deaths and Serious Injuries Are Caused by Everyday Use of the Roads

The rapid expansion of road transportation has led to an increase in road crashes, injuries, and fatalities. Statistics indicate that China's road fatalities include high percentages of pedestrians, motorcycle drivers, and users of nonmotorized vehicles, mainly bicycles (Louma and Sivak, 2012). Guangdong Province not only ranks first among all China's provinces in terms of economic growth, it also ranks highest among all 31 provinces of China in terms of traffic accidents, injuries, and deaths (Zhang, Kelvin, and Xiangpu, 2013).

Goal and Strategies

We propose a goal of reducing deaths and injuries on the roads. One proposed strategy supports this goal: integrate road safety audits (RSAs) into the project development process for new roads and intersections.

Rationale for Strategies, Recommended Practice, and Proposed Indicators

The remainder of this section explains in greater detail the rationale for each strategy, selected best practices, and a discussion of indicators and implementation issues. In some cases, we provide indicators associated directly with the goals themselves; in other cases, we identify indicators for the strategies intended to contribute to achieving the goal.

Goal GT1: Mitigate the Need for People to Travel by Privately Owned Cars

The goal is to create an environment of high quality-public transit service, or other alternatives, so that residents will choose to travel by means other than driving. We recommend one overall indicator for this goal.

Indicator:

- T1: Annual VKT per capita in privately owned cars.
  - Explanation: We recommend VKT per capita (total VKT divided by total population) as an indicator of overall progress toward the goal of mitigating the need for people to travel by private passenger vehicle. The trends in this indicator will be useful in assessing the extent to which travel by car has shifted to public transit or other modes.
  - Data source and availability: VKT data are collected by some cities, but not necessarily published.
  - Frequency: Annual.

Strategy ST1: Enhance Competitiveness of Bus and Rail Through Improvements in Service Coverage and Frequency

Rationale: To be considered high-quality, transit should have the following features: (1) cover a large portion of regional destinations such as business districts, residential communities, major sport and cultural venues, and schools and colleges and (2) be frequent and fast to minimize overall travel time. With better transportation options, some households reduce their vehicle ownership, often avoiding the need for a first or second vehicle; others reduce their automobile use. Such increased willingness to use alternative modes of transportation enables residents to take advantage of financial savings from lower transportation expenditures. In addition, the more residents who use public transit in lieu of driving, the greater the positive impacts on reduced traffic and parking congestion for the rest of society. In addition, the provision of high-quality public transit increases the region's attractiveness to people and firms considering relocation.

Traditionally, public transit has recognized two distinct kinds of passengers. One is called "transit-dependent." The transit-dependent have no car available for trips, either because they cannot afford one or because they cannot drive. These riders have no other choice but to take transit, no matter the quality of the service. The other is called a "choice rider." The choice rider has an automobile available, but on at least some trips he or she chooses to take transit, primarily because it is faster, cheaper, or environmentally friendly. The choice rider is very sensitive to such issues as frequency of the service, where transit goes, the time it takes to travel, cleanliness of the vehicle, and availability of seats. If any of the above are lacking, the choice rider may continue to drive.

Recommended practices: In the United States, as in a number of developed countries, much research has been conducted on the factors that are needed to increase transit ridership, particularly from choice riders. Many researchers categorize these into factors internal to the transit agency (e.g., service quality, fares, safety) and external to public transit agencies (e.g., price of gas, economy, and unemployment). Of the internal factors, service quality upgrades were more significant for increasing ridership than were fare discounts or low pricing of the service (Taylor and Fink, 2003). Such upgrades include greater schedule adherence, an increased number of routes ensuring equitable city coverage, higher service frequency during both peak- and off-peak hours, extended hours of operation at night, etc. Such upgrades would also do much to alleviate the over-crowding that exists on many public transit services in Guangdong Province.

In the United States and other developed countries, rail transit is assumed to attract a higher ridership than does bus, all other factors being equal. This is known in the literature as "rail bias" (Scherer and Dziekan, 2012). We would assume this would be the case in the PRD. But an effective public transport system needs to comprise rail and bus service, with rail lines serving the main corridors and bus service providing feeder routes to rail and more flexible routing. Bus service reliability relies highly on traffic conditions and road quality. Road space can be reallocated to allow buses to travel on a dedicated right-of-way, diminishing some of the effects of "rail bias." Some affordable measures to accomplish this are installing transit priority systems (in which traffic signals at intersections give priority to buses) and queue jump lanes (additional travel lanes on the approach to signalized intersections so that buses are not waiting behind cars). In addition, enhanced traveler information system can complement and further improve the reliability of bus service. Information tools announcing real-time schedule information, delays, and service interruptions help riders react accordingly.

As auto ownership increases in the PRD, local governments will be challenged to attract choice riders to use public transit given its current levels of service. The ease of implementation depends on the type of changes to be made. Some intersection-specific improvements, such as signal timing, might be put into place relatively quickly.

However, improving overall coverage and frequency could necessitate changes in management and operating structures for bus and rail transit that could take a long time to implement. Given that this strategy covers both rail and bus service, it may be important to consider shifting transit management from a single-mode approach—in which separate agencies are responsible for buses and transit—to a more comprehensive, integrated transit management model. This would integrate government or agency functions with different responsibilities and roles into a comprehensive transportation transit planning function. While implementing this strategy is a high priority for the PRD, because of the change to agency structure this strategy may be difficult.

Indicators:

- T2: Percentage commute mode (for driving a car, riding in a car, taxi/ridesharing, bus, rail, high-speed rail, bicycle, and walk).
  - Explanation: We recommend percentage commute mode be used as a measure of the competitiveness of public transit, biking and walking relative to cars as well as satisfaction with the frequency of service for public transit options.
  - Data source and availability: This will be measured by survey by asking whether residents think the city, district, or county provides attractive public spaces. The Pingshan survey asked respondents "How do you travel to work on an average day?"
  - Frequency: Survey frequency is recommended every two years.
- T3: Satisfaction with public transportation service frequency.
- T4: Satisfaction with public transportation service coverage.
  - Explanation: The perception of high-frequency service and widespread coverage is probably as important as the objective measurement. Because increasing service frequency and coverage are expensive, we recommend using satisfaction as an indicator. If riders are satisfied, it would be unnecessary to provide additional service. The coverage question on the survey assesses the convenience of potential destinations on transit, not just the proportion of people who live near transit, as transit must be convenient on both ends of the trip to work well. Dissatisfaction among both riders and nonriders would be included in the values of each of these indicators.
  - Data source and availability: This can be measured via survey. The Pingshan survey asked respondents "Do you agree or disagree that public transport in Pingshan New District is frequent (comes often)?" and "goes where you need it to go?"
  - Frequency: Survey frequency is recommended every two years.

Strategy ST2: Promote Bicycle-Sharing, Car-Sharing, Taxi, and Dynamic Ridesharing Services

Rationale: Bicycle-sharing, car-sharing, taxi, and ridesharing services complement the public transport system by providing on-demand and short-term access to vehicles. Such services separate use from ownership. This is especially important for cars, as research suggests that people who own cars drive far more than people who rent cars (Millard-Ball et al., 2005). These four types of arrangements are described briefly below.

Bicycle-sharing is a system in which bicycles can be rented by both members and the general public for short rides. Bicycles are stored on locked bicycle racks at locations scattered throughout a city. Riders unlock a bicycle on one rack and return it at another rack.

Car-sharing is a service in which members can drive a car for a short period of time, then return it for others to use. It thus provides the convenience of private car use without the costs and hassle (purchase, registration, taxes, parking, maintenance, etc.) of owning a private vehicle. Initially, this market was largely served by rental cars, which were rented to anyone who met certain criteria for several days or weeks depending on the driver's needs. A competing model emerged in the 1960s, under which members of a car-sharing organization could rent cars for much shorter periods of time, such as an hour. This was supported by having the cars parked widely throughout neighborhoods, rather than only in a few parking lots, and increased the convenience for drivers. Such services required prior reservations for a specific car to ensure it was not already in use. Drivers returned the car to its usual parking spot. In the past few years, yet another new model has emerged, enabled by technology, in which drivers can use a mobile app to locate a car, drive it on a one-way trip, and drop it off in any legal parking space. Research has indicted that although car-sharing can increase travel for some users, by reducing the need for households to own more than one vehicle (or any vehicle at all), it tends to reduce overall VKT (Millard-Ball et al., 2005; Martin and Shaheen, 2010).

Taxis provide point-to-point passenger transportation by professional drivers. They are often hailed directly on the street, with fares typically determined by taximeters measuring the distance and the time of travel. They are particularly important for certain segments of the population, such as the elderly, disabled persons who cannot drive, and tourists. In many cities taxi industries supply an important economic development function, providing important employment opportunities particularly for immigrants to a particular region.

Ridesharing, sometimes called carpooling, refers to having more than one person in a car for a single trip, generally from one origin to one destination, or at least with minimal additional driving (e.g., a driver who gives a neighbor a ride and continues to a nearby destination). Depending on the format, the passenger may or may not pay the driver. Ridesharing provides more efficient use of roadway capacity because vehicle occupancy is higher. Dynamic ridesharing, meaning that drivers and passengers locate each other in real time when they are ready to make a trip, can either be offered by individuals who connect with riders using a smartphone app for a trip that they will already be making, such as a trip to work, or be offered by companies who connect drivers with passengers by a smartphone app.

Recommended practices: Bicycle-sharing is fairly new compared with the other modes described here. It has spread to hundreds of cities around the world, including a fair number in China. As of November 2013, China had almost 80 bicycle-sharing systems, including some of the world's largest (Fong, 2013). Eight of the PRD cities have already established systems, and several have more than one (Institute for Development and Transportation Policy, no date).

A recent guide to developing bicycle-sharing services made the following recommendations for a successful system:

> A dense network of stations across the coverage area, with an average spacing of 300 meters between stations; Comfortable, commuter-style bicycles with specially designed parts and sizes that discourage theft and resale; A fully automated locking system that allows users to check bicycles easily in or out of bike-share stations; A wireless tracking system, such as radio-frequency identification devices, that locates where a bicycle is picked up and

> returned and identifies the user; Real-time monitoring of station occupancy rates through wireless communications, such as general packet radio service; Real-time user information through various platforms, including the web, mobile phones and/or on-site terminals; and Pricing structures that incentivize short trips helping to maximize the number of trips per bicycle per day. (Institute for Development and Transportation Policy, 2013)

Car-sharing allows a number of people to use a car at different times without owning it. Because most users do not use the car for long periods of time, one shared car can replace anywhere from nine to 13 personally owned cars (Martin and Shaheen, 2010). Recently, both rental car companies, such as AVIS, which now owns Zipcar, and auto manufacturers, such as Ford, which has Ford2go, have entered the new car-sharing marketplace. Industry analysts expect the worldwide car-sharing market to grow to more than 12 million by 2020, especially as more large companies enter the market (Navigant Research, 2013). In China, car-sharing programs have been introduced by established auto manufacturers such as Daimler AG or by China-based entrepreneurs such as iCarsclub. North America remains the largest car-sharing region, with Europe and North America accounting for 39 percent and 51 percent, respectively, of worldwide car-sharing membership (Shaheen and Cohen, 2013). Practices can be transferred from these countries to encourage the existence of car-sharing programs. Such supportive policies include on-street parking for shared vehicles, providing advertising space and other information outreach, integration with transit, such as providing parking at transit hubs and joint outreach, and planning policies that include car-sharing in new developments.

Most cities regulate commercial taxi services and systems through licensing systems such as (a) restricted access/limitations on numbers of taxi licenses; (b) standardized vehicle specifications and standardized taxi fare systems; and (c) safety and security requirements for both passengers and drivers. While taxis are another way of providing mobility without ownership, they also contribute to traffic congestion and urban air pollution. Best practice for taxi service provision is in the form of "green taxis" that rely on new vehicle technologies (e.g., electric-hybrid vehicles) and information and communications technologies (e.g., global positioning satellite systems) for routing and navigation and credit and debit card readers. Cities such as Washington, D.C., have been implementing reforms to upgrade taxi service to compete with a new generation of car-sharing and ridesharing services (DeBonis, 2013).

Ridesharing, while it has existed as long as cars have, was until recently confined to people who already knew each other. In many American cities, quasi-public organizations have also offered rideshare matching services to pair up drivers and passengers who live and work near each other so they can rideshare during their commute. However, recently a new business model has emerged in which drivers and passengers can use mobile apps to find each other in real time (as opposed to making advance arrangements). To some extent, this has blurred the lines between taxi service and ridesharing. Some of this "real-time ridesharing" has proved controversial due to its lack of regulation, and failure to ensure that drivers were properly licensed, insured, or trained. In the United States, this situation is fluid as cities consider whether the regulations that have long applied to taxi service should be applied equally to various forms of ridesharing. The best practice right now is for the PRD governments to consider how such ridesharing programs can be complementary to taxi and transit, perhaps through stakeholder participation in the development of regulations. By inviting the taxi and transit service providers into the policymaking process, implementation can be improved.

These strategies are high priority since the marketplace for bicycle-sharing, car-sharing, taxis, and ridesharing services is changing quickly in China. The PRD cities should be proactive in developing the necessary policies and regulations. The investment requirement is minimal, since little new infrastructure will be required, so this strategy can be pursued quickly. Policies should be integrated into a comprehensive transportation management model.

Indicator:

- T2: Percentage commute mode (for driving a car, riding in a car, taxi/ridesharing, bus, rail, high-speed rail, bicycle, and walk). Details provided above.

Goal GT2: Improve Connectivity Among Transportation Modes and Among PRD Cities

The goal is to create efficient transportation systems through connectivity of modes of transportation within a city as well as connectivity among PRD cities. This goal of improved connectivity will require a high degree of cooperation among PRD cities and units of local governments.

Strategy ST3: Develop Multimodal Transit Hubs to Enhance Transportation Connections, Choices, and Coordination Among Modes

Rationale: A multimodal transit hub is defined as a physical passenger facility where one or more transit services or other modes can be easily accessed, thus facilitating transfers between modes (Henry and Marsh, 2009). A hub can be a building or a shelter. Effective hubs optimize the use of public transit by increasing accessibility by the maximum number of possible modes and concentrating the maximum development, commercial space, apartments, and facilities around them (thus making it a complementary strategy to increased use of transit-oriented development, as discussed in the land use chapter). Combining a multimodal bus with public services and amenities can help create a more balanced flow of riders, instead of having trains and buses packed in one direction and empty in the other around peak commute times. This helps maximize investments in transit services.

Cyclists and pedestrians can use the hub to access intra- or intercity bus or train service if they live nearby or it is connected to a greenway. Bus passengers and motorists can also use the facilities of the hub and benefit from the intercity railway connection if they can park in the vicinity. Car and bus accessibility further expand the reach of the hub. Taking a train is often more attractive than driving a car, because the transit time can be spent sleeping, working, or meeting. By optimizing the connections among modes, overall travel time can be reduced.

Living in a region connected via multimodal linkages will improve quality of life because it gives residents access to a much broader variety of jobs, cultural events, schools, social groups, and recreational opportunities than can fit in any one district or city of the PRD.

Recommended practices: Transport for London developed best practice guidelines following industry standards to improve the quality of multimodal transport hubs (Transport for London, no date). The guidelines emphasize efficiency (the hub allows seamless transfers between modes or lines), usability (the hub is safe and secure for all passengers regardless of age or disability), understanding (the hub can be navigated intuitively with minimal signage), and quality (the hub is a destination in its own right, an environment in which people are not just passing through but lingering to shop, eat, or relax).

Ideally, hubs would be accessible to transportation services outside of a particular district or city (where appropriate) to maximize connectivity. Best practices would include downplaying intraregional competition and emphasizing coordination in the management and opera-

tion of a hub. In the past in the PRD, competition among local governments was fueled by the decentralization needed to support regional economic growth. Competition between cities, while productive in incentivizing innovation and investment, may also be inefficient in that it may lead to some duplication of infrastructure (OECD, 2010). Some duplicate infrastructure was needed to meet the demands of a continuing growing economy and population, but some major infrastructure facilities may have been over-provided, such as airports. Equally important, a lack of regional coordination has led in some cases to disconnected transportation infrastructure.

The development of multimodal transportation hubs provides opportunities for linking transportation infrastructure across Guangdong and creates synergies to support further economic growth. For example, hubs in the PRD should make PRD cities accessible to each other, as well as to other areas in the province, connecting people who need jobs with companies looking for workers. Such connectivity could serve to mitigate Guangdong Province's internal regional income disparity, which is among the highest of all Chinese provinces (OECD, 2010).

Indicators:

- T5: The number of multimodal transit hubs in the PRD.
  - Explanation: Cities should agree on a common definition of multimodal transit hub and develop an inventory.
  - Data source and availability: Should be available from individual cities.
  - Frequency: Annual.
- T6: Average bus speeds on selected high-use corridors during morning and afternoon peak periods.
  - Explanation: Average bus speeds are a good proxy for the effectiveness of bus services, which play a large role in urban transportation in China. Cities and transit agencies would need to identify several key corridors to measure, as well as a period of time during which to measure (preferably a weekday, and at the same time of day, and the same month each year, so as to have a consistent data set not affected by seasonal variations).
  - Data source and availability: Once corridors are selected, transit agencies should be able to collect this information.
  - Frequency: Annual.

Strategy ST4: Implement Smart, Interoperable Ticketing Within the PRD to Make It Easier to Use Multiple Forms of Public Transit

Rationale: Smart ticketing is a system in which value is stored electronically on a microchip rather than printed on a paper ticket. Interoperable ticketing means that tickets can be used on different operators, different modes, or both.

In addition to the hub concept described above, transit operators should coordinate the ticketing used for their services so that riders can cross service boundaries without time-consuming transfers. This will ensure seamless service and helps make public transit more competitive with driving.

Recommended practices: Public transit operators have been trying to replace paper-based tickets with electronic media for decades as a way to provide seamless, user-friendly public transport. Intelligent transportation system technology now enables electronic pricing and payment options. Ticketing applications can be loaded on smart cards or mobile phones.

Smart ticketing is fairly widespread. For example, in Europe, most countries have a smart ticketing system at least in their capital. In the United Kingdom, the Oyster card is a plastic stored-value smart card that can be used on the London Underground and other transit modes within London, as well as for some intercity train service. The card can be automatically topped up via a credit or debit card to ensure that the rider always has a balance on the card. The card can also be programmed with certain types of discounts (Transport for London, no date-b). Smart ticketing is also fairly widespread in the United States. However, the European systems are not interoperable across country borders (Puhe, Edelmann, and Reichenbach, 2014), and the U.S. systems seldom serve more than one metropolitan region.

Interoperability should be a priority in terms of connectivity with Hong Kong and Macao. Hong Kong uses a smart card known as the Octopus card (launched in 1997). The Octopus card can also be used for payment in many retail shops in Hong Kong. There would be value in Guangdong Province adopting the practice of using the Octopus card technology so as to be interoperable with Hong Kong.

Implementing an interoperable smart ticketing system is complex. Public transit operators and authorities, financial service providers, and telecommunications operators, among others, need to work together to combine their products on a single card or in a single app. This may be especially difficult if there are major differences in fare structures (for example, it may be difficult to integrate a fare system in which every fare costs the same with a system of time-of-day or distance-based fares). Stakeholders need to agree on technical specifications and governance and institutional issues.

Indicators:

- T7: The number of cards sold as a share of number of permanent residents.
  - Explanation: While there are a number of challenges in implementing this system, such as working out new business processes and commercial agreements, this relatively simple indicator can measure how well this strategy is working. It assumes that a smart, interoperable ticketing system exists.
  - Data source and availability: The agency that administers the card should collect this data.
  - Frequency: Annual.

Strategy ST5: Develop a Travel Survey That Captures Inter- and Intracity Travel Flows and Mode Use

Rationale: A travel survey should be implemented at regular intervals (for example, every five years) to provide data as input to travel demand models and strategic transportation plans. Otherwise, transportation plans and investments may be made in the absence of good data about how and where people travel. A travel survey can also provide information on travel times across modes. This travel survey is separate and distinct from the resident satisfaction survey described in Chapter Four and is intended to provide detailed information on individuals' travel modes and preferences.

Recommended practices: American metropolitan planning organizations (regional bodies with responsibility for funding transportation projects) are required to forecast future travel demand. They generally do so based on a travel model, which is generally populated with travel survey data. Surveys usually ask individuals in selected households about all trips they make within a certain period of time (typically one day or several days). The Household Travel

Survey in Sydney, Australia, has been surveying households annually since 1997. The survey relies on face-to-face interviews with 5,000 randomly selected households, of which about 3,500 participate. Respondents are asked about their trips (the origin and destination, purpose, mode, time, and cost), the vehicles they have available, and demographic data that may influence travel patterns (age, sex, employment status, and income) (Transport for NSW, no date). Recently, some agencies have switched from conventional surveys to using GPS to collect similar information, which can be more accurate than asking people to record all of their travel (Wargelin et al., 2012). There are numerous considerations in implementing a survey: selecting respondents, developing questions, choosing an appropriate technology, conducting a pilot survey to determine whether the methods work, creating a repository of data for analysis, and so forth.

Indicator:

- T8: Number of data entries as a consequence of implementation of travel surveys.
  - Explanation: The data themselves demonstrate that the survey has been implemented.
  - Data source and availability: Travel surveys could be conducted by public agencies or private firms working on behalf of public agencies.
  - Frequency: Travel surveys are typically conducted about every five years.

Goal GT3: Create an Environment That Emphasizes Nonmotorized Transportation Modes

Nonmotorized transportation modes, also called *active transportation*, essentially refers to walking and cycling (and all other modes that have wheels but no engine, such as pedicabs). China has a long history of walking and bicycling, and the use of these modes remains high by international standards but has been declining with an increase in the use of personal cars. Shifting travel from personal vehicles to bicycles or walking reduces the number of vehicles competing for limited space on the road network (including public transit vehicles).

In a broader perspective of a multimodal transportation system, nonmotorized travel plays another very important role. Any attempt to encourage mode shifts from personal vehicle to public transit requires good access at both ends of the trip, usually by walking. No matter what mode is used for the long-distance portion of a trip, at some point the traveler must access that mode by walking, even if from a bus or car. Beyond simply helping to advance mobility goals, nonmotorized travel has also become increasingly linked to the achievement of larger social goals, such as the reduction of chronic health problems associated with inactivity. Further, recent research in the United States has also suggested that communities that support walking and bicycling are better able to attract knowledge workers, who serve as the backbone for much of the new economy (Florida, 2002).

Strategy ST6: Connect Pedestrian and Bicycle Greenways and Paths to Major Employment Destinations

Rationale: While the PRD cities have an existing network of bicycle and pedestrian paths, many of them serve recreational purposes exclusively and are not useful for travelers commuting to work. Given the contribution of work trips to congestion, it would be advantageous if cities provided better access to major employment destinations. Depending on the location, worksites could be served with a combination of off- and on-street pedestrian and bicycle pathways.

Recommended practices: Major urban streets within cities, as well as those that serve locations outside of business districts, can be made safer for pedestrians and bicyclists with some physical improvements that reduce conflicts with vehicles. Mehndiratta, Lu, and Fang (2012) discuss some such changes that have been made in Chinese cities. In Liaoning, city planners identified specific areas with a high number of crashes and deaths and concentrated on those intersections and corridors for safety improvements. They then implemented a safe corridor plan with crossings every 300 meters, median separators, and new traffic signals with pedestrian phases so that pedestrians had sufficient time to cross streets. They also enhanced police patrols in the areas to enforce traffic laws. In Guangzhou, major intersections have been "channelized," meaning that the paths for different types of traffic are laid out in such a way to avoid conflicts (for example, turning vehicles may have a distinct lane from through vehicles). Medians have been added to wide streets so that pedestrians and bicycles can cross in two phases. In Wuhan, an intersection with an elevated roadway where traffic moved in a chaotic and unsafe fashion was redesigned with pedestrian medians, islands to separate turning vehicles, and stop lines moved forward to minimize clearance times. The redesigned intersection is safer for nonmotorized traffic while increasing the capacity for vehicles.

Many European cities—even large cities, such as London and Berlin—have extensive infrastructure for nonmotorized vehicles. These include painted bicycle lanes for better visibility, raised crosswalks, cycle tracks and paths that are physically separated from motorized traffic lanes, "bike boxes" at intersections that allow bicyclists to wait in front of cars at intersections, and special bicycle-only traffic signal phases (Fischer et al., 2010). In Berlin, such measures have contributed to impressive use of cycling: In 2008, 1.4 million bicycle trips were made daily (in a city of 3.5 million), for a mode share of 13 percent (Jacobson, 2011).

Such changes require coordination between planners and engineers, as well as safety experts, to ensure that changes to roadways will be beneficial for both drivers and nonmotorized traffic. An analysis of where the most crashes take place is useful to identify the highest-priority corridors and intersections. Such improvements should also consider corridors as part of an interconnected network of streets that are safe for pedestrians and bicyclists, rather than individual streets.

Indicator:

- T2: Percentage commute mode (for driving, car passenger, taxi/ridesharing, bus, rail, high-speed rail, bicycle, and walking). Details provided above.

Goal GT4: Manage Parking Demand and Supply

Parking is an essential component of the transportation system. *Parking management* refers to policies and programs that encourage more efficient use of parking resources through a combination of supply, demand management, and enforcement. Parking management has undergone somewhat of a paradigm shift over the past decades. The old paradigm assumed that parking should be abundant and free at most destinations, with the goal of maximizing supply and minimizing price so that drivers could easily access parking. The new paradigm assumes that providing widespread free parking can encourage greater use of driving than is optimal, and that parking should be managed in tandem with other modes to provide a wide variety of transportation options.

Strategy ST7: Institute a Parking Pricing System for On-Street Parking and Encourage Entrepreneurs to Develop Mobile Apps That Facilitate Making Payments

Rationale: One of the bases of this new paradigm is that on-street parking should be priced in such a way as to encourage frequent turnover of vehicles, while drivers who need long-term parking should be directed to off-street parking. One approach, called "performance-based parking" or "demand-responsive parking," suggests that on-street parking should be managed such that a high proportion (but lower than 100 percent) of parking is used at any given time during the day, which allows for drivers to find parking easily instead of driving around looking for parking (Shoup, 2009).

Fees for on-street parking in most cities have historically been paid through curbside meters, but emerging technologies are making it easier to pay through mobile apps. Having such an app would make parking payments easier, as well as allowing drivers to extend their time if needed. However, this would be coupled with a parking fee structure that makes it increasingly expensive to remain in one spot.

Recommended practices: San Francisco completed a two-year pilot study of demand-responsive pricing. The city designated specific districts in which prices for both on- and off-street parking were set so as to maintain a level of 60 to 80 percent parking occupancy. If occupancy was higher, prices were increased so as to reduce demand; if occupancy was lower, prices were reduced to increase demand. The pilot project also offered several options for payment, including credit cards, parking cards, and pay-by-phone. The pilot found that, compared with nonparticipating districts, the pilot areas increased the amount of time by 31 percent during which parking was maintained at its optimal level of 60–80 percent occupancy, as opposed to just 6 percent in control districts (San Francisco Municipal Transportation Agency, 2014).

Other innovations are the use of smart meters, which accept credit cards, and pay-by-phone technology, which allows drivers to pay for on- and off-street parking with a smartphone and to extend the amount of time without returning to the meter. In surveys conducted as part of the San Francisco pilot, 82 percent of respondents said that it was "somewhat or very easy to pay for parking" once smart meters and pay-by-phone options were available (San Francisco Municipal Transportation Agency, 2014). The pay-by-phone system introduced as part of this pilot was developed by the city.

Several agencies would probably have to work together to develop a similar program. Planning for SFpark required about three years after the decision was made to proceed, including taking an inventory of all parking spaces, setting rates, and installing smart meters and parking sensors. In addition, the pilot required parking enforcement personnel to understand and enforce the program.

Indicator:

- T9: Proportion of paid parking spaces relative to all public parking spaces.
  - Explanation: This indicator shows the extent to which parking is paid as opposed to free. It requires an accurate count of on- and off-street parking spaces that are available to the public.
  - Data source and availability: It is not clear whether data currently exist. It should be the responsibility of a city transportation department to survey existing parking spaces.
  - Frequency: Annual.

Strategy ST8: Encourage Entrepreneurs to Develop Mobile Apps That Provide Real-Time Information on Available Parking Spaces to Make Finding Parking Easier and to Avoid Illegal Parking

Rationale: Looking for a parking space in an area of high parking demand can generate a significant amount of congestion (Shoup, 2009). Providing real-time information about where parking spaces are available could reduce both driver frustration as well as unnecessary circling.

Recommended practices: A number of American cities have introduced smartphone apps that provide real-time information on where parking spaces are available. Pittsburgh's ParkPGH not only provides real-time availability of parking spaces in ten garages, but also predicts parking availability based on past usage. The smartphone apps Parker and Smart Parking both allow drivers to reserve spots in advance. Several apps, including Parking Auction and ParkingMonkey, allow drivers who are leaving a parking space to be paid by fellow app users who want to take that space; however, some cities have ruled this illegal (Jaffe, 2011; Musil, 2014). Such apps rely on the availability of information about parking space availability. Generally, developers do not compile this information themselves, instead relying on information made available by the public sector through sensors that detect the presence of vehicles in parking spaces.

Indicator:

- T10: Satisfaction with parking availability.
  - Explanation: As with other topics that can be measured either objectively or subjectively, we recommend measuring satisfaction as it captures whether the overall system for managing parking is working in ways that meet residents' needs.
  - Data source and availability: The Pingshan survey asked "To what extent is finding parking for automobiles a problem for you in your daily life?"
  - Frequency: Survey frequency is recommended every two years.

Strategy ST9: Enforce Parking Regulations and Impose High Penalties for Illegal Parking in Central Business Districts and Other High-Demand Areas

Rationale: Illegal parking can have high consequences for mobility—blocking or impeding nonmotorized lanes and causing congestion due to double-parking and looking for space. Any type of priced parking requires enforcement to ensure that drivers are paying the required fees. Enforcement includes both issuing tickets to owners of illegally parked vehicles and imposing sanctions on those who do not pay their tickets.

Recommended practices: Several Asian cities have used effective means of enforcement. In Tokyo, individuals wishing to purchase a vehicle must first obtain "proof-of-parking," which demonstrates that they have access to overnight parking. This was not implemented as a measure to reduce car ownership, but rather to cut down on illegal overnight parking. One result of this strategy has been to create markets for privately provided parking near residential areas. Drivers pay monthly fees for access to these lots and garages (Asian Development Bank, 2011).

Several major cities—Tokyo, Singapore, and Seoul—have shifted liability for paying parking tickets from the driver to the vehicle owner. This makes enforcement easier since the parking authority does not need to try to identify the driver; owners can be identified through vehicle registration records (Asian Development Bank, 2011).

Singapore has begun using closed-circuit television (CCTV) cameras in areas with high rates of illegal parking to catch offenders. Ten cameras were installed in April 2014, with another 20 slated for installation by the end of 2014 (Singapore Land Transport Authority, 2014). It is not clear how effective this mechanism will be (Khew and Wee, 2014). Seoul also uses CCTV to monitor parking (Asian Development Bank, 2011).

It is important to have a method in place for ensuring compliance with paying illegal parking fines. In Kuala Lumpur, there is a split in payment rates of parking fines between fines issued by police and fines issued by local governments. The rate of payment of police-issued fines is quite high because vehicle owners cannot renew their road tax without it (a road tax is similar to an annual registration fee; it varies with the type and size of vehicle) (Angloinfo, 2014). Local government fines lack a similar method of enforcement, and consequently payment rates are low (Asian Development Bank, 2011). Implementation can be carried out by police, other local authorities, or contracted out. It should not take long to begin enforcing laws if the laws are in place and the basic infrastructure to pay for parking is already available.

Indicators:

- T11: Number of parking citations issued.
- T12: Percentage of parking citations paid.
  - Explanation: We suggest two indicators here. The first sets a baseline for the extent of the illegal parking problem, and the second measures the effectiveness of enforcement. As noted in the Kuala Lumpur example, the payment rate can vary considerably depending on how payment is enforced.
  - Data source and availability: This should be collected by the agency responsible for parking enforcement.
  - Frequency: Annual (the number of citations issued each year and the percentage that were paid).

Table 6.1 summarizes the goals, strategies, and indicators for challenge CT1.

Goal GT5: Reduce Interactions Between Passenger Cars and Trucks

The share of trucks in fatal and all crashes in China is about four times higher than in the United States (Blower and Woodrooffe, 2012). This may reflect the fact that truck transport is significantly less safe in China, but it probably also stems from the much greater share of trucks in the traffic stream in China than in developed countries. Reducing interactions between passenger cars and trucks can significantly improve traffic conditions and also facilitate free-flow conditions for both passenger cars and trucks.

The primary causes of truck crashes identified in the safety literature are overloading, inattentive driving, speed differentials between vehicles, moving violations, and following too closely (Peeta and Zhou, 2004). With respect to overloading, one study reported that most trucks in China were loaded one to three times more than the design limits, with some loaded up to six times their designed capacity (Gao et al., circa 2005).

Strategy ST10: Implement Peak-Period Delivery Restrictions in the Central Business District and Other Highly Congested Areas

Rationale: Truck traffic contributes to urban congestion, not only because of vehicle movements but also because trucks need several parking spots when making deliveries to sev-

Table 6.1
Transportation Goals, Strategies, and Indicators for Challenge CT1 (Congestion and Air Pollution)

CT1	**Without high-quality public transit alternatives, VKT in privately owned cars per capita will increase and congestion and air pollution will worsen.**		
Goals and Strategies		**Proposed Indicators**	
GT1	Mitigate the need for people to travel by privately owned cars.		
ST1	Enhance the competitiveness of bus and rail through improvements in service coverage and frequency.	T1	Annual VKT per capita in privately owned cars
		T2	Percentage commute mode (for driving a car, riding in a car, taxi/ridesharing, bus, rail, high-speed rail, bicycle, and walk)
		T3	Satisfaction with public transportation service frequency
		T4	Satisfaction with public transportation service coverage
ST2	Promote bicycle-sharing, car-sharing, taxi, and dynamic ride-sharing services.	T2	Same as above
GT2	Improve connectivity among transportation modes and among PRD cities.		
ST3	Develop multimodal transit hubs to enhance transportation connections, choices, and coordination among modes.	T5	Number of multimodal transit hubs
		T6	Average bus speeds on selected high-use corridors during morning and afternoon peak periods
ST4	Implement smart, interoperable ticketing within the region to make it easier to use alternative forms of public transit.	T7	Number of cards sold as a share of number of permanent residents
ST5	Develop a travel survey that captures inter- and intracity travel flows and mode use.	T8	Number of data entries as a consequence of implementation of travel surveys.
GT3	Create an environment that emphasizes nonmotorized transportation modes.		
ST6	Connect pedestrian and bicycle greenways and paths to major employment destinations.	T2	Same as above
GT4	Manage parking demand and supply.		
ST7	Institute a parking pricing system for on-street parking and encourage entrepreneurs to develop a mobile app that facilitates making payments.	T9	Proportion of paid parking spaces relative to all public parking spaces
ST8	Encourage entrepreneurs to develop apps that provide real-time information on available parking spaces to make finding parking easier and to avoid illegal parking.	T10	Satisfaction with parking availability
ST9	Enforce parking regulations and impose high penalties for illegal parking in central business district and other high-demand areas.	T11	Number of parking citations issued
		T12	Percentage of parking citations paid

eral receivers. One way to reduce this congestion is to shift deliveries to off-peak hours, when fewer cars are on the roads and parking is more readily available. This can be accomplished through restrictions on deliveries by truck during peak periods in areas of heavy congestion, coupled with programs to encourage off-peak deliveries.

Recommended practices: New York City conducted a recent pilot program, later expanded into an early implementation phase, of providing incentives to shift deliveries to off-

peak periods. The program, called Off-Hours Delivery (OHD) worked with both carriers[1] and receivers to encourage deliveries to be made between 7:00 p.m. and 6:00 a.m. OHD can be done in two ways: staffed (meaning that receivers have staff available to confirm and take the deliveries) and unstaffed (meaning that the carriers simply drop off the goods without direct contact with the receivers). A recent evaluation of this program found that it has the potential to shift between 20 and 40 percent of all truck deliveries to off-peak hours, which would have a major impact on congestion and emissions. Financial incentives were helpful in persuading receivers to participate in the program; the funding for incentives could be provided through additional tolls. Carriers were able to save money from OHD in several ways: Each driver can make more deliveries, and they accrue fewer parking tickets. Shippers also reported positive experiences with more reliable delivery schedules (Holguín-Veras et al., 2013).

Implementing peak-period delivery restrictions without the type of encouragement New York City provided for overnight deliveries may have negative consequences. In Metro Manila, a ban on daytime travel by large trucks on certain arterials seems to have resulted in a number of undesirable effects, such as increased use of small trucks that also contribute to congestion, delivery delays, possible increased VKT as trucks take more circuitous routes to their destinations, increased costs for trucking firms and customers, and an increase in crashes from drivers working longer hours. Some of these effects have also been observed in other cities that have adopted truck travel bans for similar reasons, including Seoul and Los Angeles (Castro and Kuse, 2005). Other research has found that targeting incentives to receivers, as was done in the New York City pilot, is an effective way to encourage off-peak delivery, especially when receivers are already open during off-peak hours (Federal Highway Administration, 2012).

Indicator:

- T13: Truck volume counts on high-capacity urban roads during peak periods.
  - Explanation: This measures the success of the program in shifting deliveries to off-peak hours. It requires that cities identify roads of interest and conduct truck counts on those.
  - Data source and availability: Data to be collected by city departments of transportation.
  - Frequency: Annual (perhaps using one week per year as a basis for developing an average).

Strategy ST11: Create Freight Consolidation Centers for Freight in Urban Fringe Areas to Reduce the Number of Deliveries to the City Center

Rationale: Urban consolidation centers (UCCs) are designated areas outside of central business districts (CBDs) at which freight is transferred from multiple carriers to a single carrier, who then makes all deliveries to the CBD. These UCCs can reduce the number of trucks entering a CBD, thus also reducing congestion and emissions. In some cases, the carrier for the UCC uses small, low-emissions vehicles to further reduce congestion and emissions.

Recommended practices: The Motomachi shopping street in Yokohama, Japan, has had a UCC since 2004. The impetus for the development came from retailers' associations, who were concerned about the effects of heavy trucks on congestion, emissions, and parking. They

[1] In U.S. freight terminology, a carrier is the company that carries goods from one location to another (e.g., the trucking company). A shipper has goods to ship (e.g., a factory), and a receiver receives the shipment.

approached the city government to request startup funds from a national pilot program for clean urban transportation. The UCC occupies about 330 square meters and handles up to 350,000 parcels per year. It opened six years after it was originally conceived and serves 450 retail stores as well as 820 individual households, all of which receive deliveries directly from the UCC using a fleet of three low-emission compressed natural gas trucks. Most of the funding (95 percent) to operate the center is provided by fees paid by the carriers; the retail associations cover the remainder (Dablanc, 2011).

In London, an office supply company conducted a one-month trial of an "urban microconsolidation center" to make its deliveries to the CBD. This UCC was run by a private firm specializing in green logistics, and it served only one customer. The delivery fleet changed from diesel vans to electric vans and electric freight tricycles. An evaluation of the trial found that the total distance traveled by each parcel within London declined by 20 percent, and total carbon emissions per parcel fell by 54 percent. The electricity supplied to run the vans and tricycles was supplied entirely through renewable sources. These vehicles, being smaller, also consumed less road space and curbside delivery space. Overall, the company's costs decreased, although exact figures were not available. The trial was deemed successful and the company continued to use the UCC (Browne, Allen, and Leonardi, 2011).

UCCs could be set up by private companies that serve several carriers, as in the Yokohama example above, or a single company serving a single carrier, as in the London example, or some other combination. The city may need to provide adequate space for the new facility and ensure that regulations support the use of UCCs.

Indicator:

- T14: Percentage of residents who think congestion from trucks is a problem.
  - Explanation: This indicator is from the survey. Trucks in China do not have a good safety record and also tend to be high polluters (University of Michigan Transportation Research Institute, 2012, p. 59). As with other subjective indicators, it is important to gauge whether policies to reduce the number of trucks on the roads are having an effect on residents' perceptions.
  - Data source and availability: The Pingshan survey asked "To what extent is traffic congestion from freight trucks a problem for you in your daily life?"
  - Frequency: Survey frequency is recommended every two years.

As the evaluation of the trial UCC in London shows, other future indicators could be changes in emissions on a per-parcel basis, or the amount of curbside space used for deliveries. These data would need to be collected and analyzed for a specific project.

Table 6.2 summarizes the goal, strategies, and indicators for challenge CT2.

Goal GT6: Reduce Deaths and Injuries on the Roads

As with GT1, we proposed separate indicators linked directly to the overall goal but not specifically tied to a particular strategy. New strategies could be added over time to address traffic safety.

Indicators:

- T15: Number of traffic deaths per year.
- T16: Number of traffic injuries per year.

Table 6.2
Transportation Goal, Strategies, and Indicators for Challenge CT2 (Road-Based Freight)

CT2	Road-based freight transport is a major source of congestion and safety problems.		
Goal and Strategies		**Proposed Indicators**	
GT5	Reduce interactions between passenger cars and trucks.		
ST10	Implement peak-period delivery restrictions in the central business district and other highly congested areas.	T13	Truck volume counts on high capacity urban roads during peak periods
ST11	Create freight consolidation centers in urban fringe areas to reduce the number of deliveries in the city center.	T14	Percentage of residents who think congestion from trucks is a problem

- Explanation: These are basic measures of traffic safety used widely around the world. Data on traffic injuries and deaths should be collected in accordance with international best practice, such as the data elements included in a recent practitioner manual (Harvey, 2010).
- Data source and availability: It is not clear whether every city collects both measures.
- Frequency: Annual.

Strategy ST12: Integrate Road Safety Audits into the Project Development Process for New Roads and Intersections

Rationale: An RSA is a "formal and independent safety performance review of a road transportation project by an experienced team of safety specialists, addressing the safety of all road users" (Wilson and Lipinski, 2004, quoting a Canadian guide). RSAs are conducted while a road project is still in the planning stages, which maximizes the utility of the study. They can help lead to the construction of roads that are safer than conventional roads from the start, as opposed to more expensive retrofits of existing roads. Studies analyzing the benefit-cost ratio of RSAs have found some in which the benefits outweigh the costs 240 to 1 (all material in this section is drawn from Wilson and Lipinski, 2004, unless otherwise noted). A British study compared 19 projects that had used RSAs to 19 comparable projects that did not and found that the sites using RSAs experienced declines in crashes from 2.08 to 0.83 per year, while the non-RSA site crashes declined by 2.6 to 2.34 crashes per year (cited in Synetics Transportation Consultants Inc. et al., 2006).

Recommended practices: RSAs originated in the United Kingdom in the 1980s. All trunk road highway projects are subject to mandatory RSAs, and all roads that used RSAs are required to have an ongoing monitoring plan. These requirements are formalized in Highways England's 2015 *Design Manual for Roads and Bridges*, which also requires 12- and 36-month crash data. Three stages of audit are required: preliminary design, detailed design, and completion of construction. The requirements also specify minimum levels of experience for team members.

In New Zealand, all projects on the national road network are required to have RSAs unless the project manager believes it is unnecessary; a decision to forgo an RSA must be documented. Transit New Zealand, which is responsible for the national road network, developed its own RSA manual.

RSAs are typically conducted by a small multidisciplinary team (3–5 people) who are not involved with the project to help ensure an independent review. Members are generally safety

specialists, designers, engineers, and in some cases experts on safety for nonmotorized users. They should have access to all pertinent data and documentation about the project (plans, design standards, etc.). The team reviews both written materials (often with the aid of a checklist) as well as conducts a site inspection. After meeting with the project team, they write a final report that identifies any safety deficiencies and makes recommendations. Implementation of the recommendations should be documented as well. The World Bank has suggested that two impediments to implementing RSAs in China are funding and sufficiently trained staff (China and Mongolia Sustainable Development Unit, 2008). Costs in Australia have been estimated at between US$1,000 and US$8,000 per RSA.

Indicator:

- T17: Number of RSAs conducted per year.
  - Explanation: As noted above, RSAs can be collected at various stages. We recommend that this count include only one stage, so that each project that receives as RSA is counted only once. Otherwise it might result in double-counting if different cities require them at different points.
  - Data source and availability: Available from the agencies responsible for conducting RSAs once a program has been implemented.
  - Frequency: Annual.

In the future, once the process is formalized, the effectiveness of RSAs could be measured through some type of benefit-cost analysis that considers the crash profile of roads that have been subject to RSAs.

Table 6.3 summarizes the goal, strategies, and indicators for challenge CT3.

Priorities for Implementation of Strategies

Figure 6.1 summarizes three important dimensions associated with implementation: the ease or difficulty of implementation, the estimated level of impact, and the rough time frame. Table E.2 lists the RAND team's assessment of each of the strategies along the three dimensions.

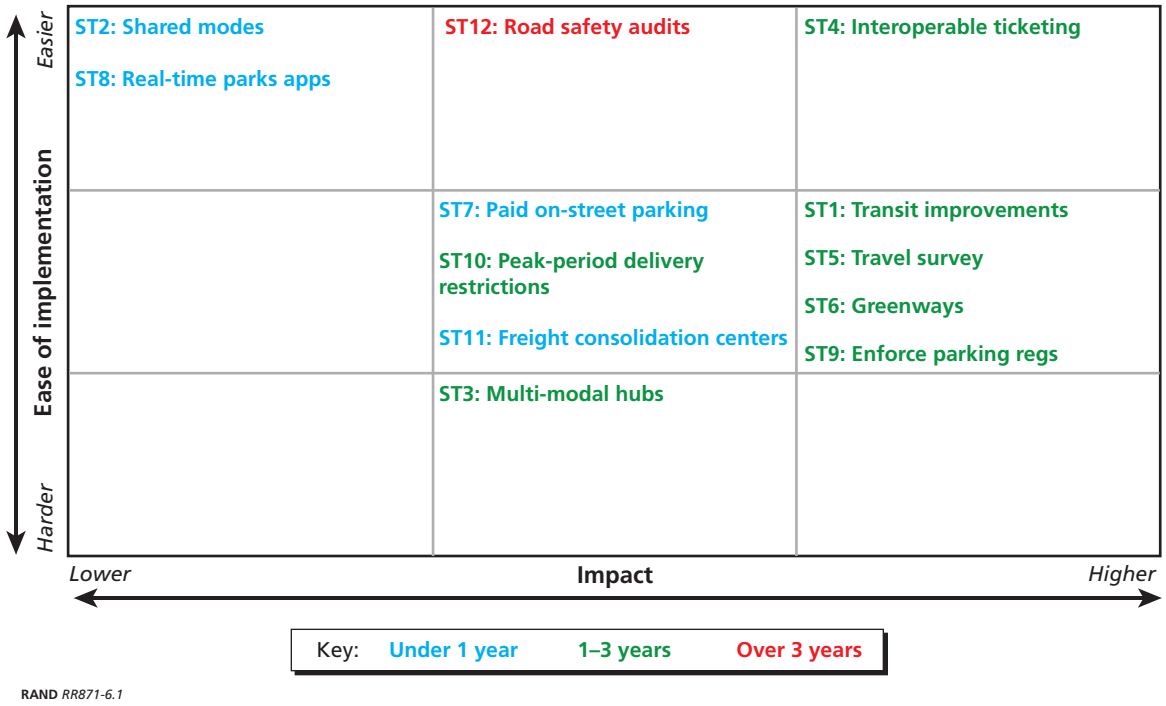
As an example of our reasoning, transit improvements are a top priority, given their importance to residents' preferences, but also because of their importance in improving air quality and reducing greenhouse gas emissions. As another example, we note that the benefit of multi-

Table 6.3
Transportation Goals, Strategies, and Indicators for Challenge CT3 (Traffic Safety)

CT3	An extremely high number of deaths and serious injuries are caused by everyday use of the roads.		
Goals and Strategies		**Proposed Indicators**	
GT6	Reduce deaths and injuries on the roads.		
		T15	Number of traffic deaths per year
		T16	Number of traffic injuries per year
ST12	Integrate RSAs into the project development process for new roads and intersections.	T17	Number of RSAs conducted per year

modal transportation hubs to enhancing connectivity within the PRD is significant, and thus assign it a relatively high priority. However, the institutional issues that might be involved in developing a regional planning structure suggest that this strategy might be difficult to implement. For example, implementation would necessitate the start of a formal system of collaborative regional transportation planning and decisionmaking. Models for such planning not only include the metropolitan planning organization (MPO) model in the United States, in which regional planning commissions are permanent bodies comprised of the leadership from cities or counties in the region, but also models in France and Germany in which regional planning is invoked when needed for particular purposes.

Figure 6.1
Recommended Priorities for Implementation of Transportation Strategies



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CHAPTER SEVEN

Environment

Clean air, water, and soil are major contributors to quality of life in every society. Unchecked, pollution can seriously diminish the health and well-being of residents and degrade the environment. As the PRD's environment improves, the region will become a more attractive place for knowledge workers, innovators, and entrepreneurs to live and work. The challenge for provincial and municipal officials is how to plan, implement, and enforce science-based, cost-effective, and practical actions that can make the greatest difference in the shortest amount of time—and lay a strong foundation for sustaining those gains well into the future.

Improving environmental quality requires several strategies, all based on a strong scientific foundation of environmental modeling and credible monitoring and source data. Strategies also must include building the human capital to effectively implement and enforce the laws and regulations and giving the relevant provincial- and municipal-level agencies responsible for environmental protection the resources needed to do their jobs. Further, strategies intended to improve environmental quality need to be complemented by mutually reinforcing land use, transportation, and other policies whose incentives encourage firms, government at all levels, and individuals to act responsibly and comply with environmental laws and regulations.

In the following sections, we discuss the PRD's top-level environmental challenges, drawing on a growing body of published literature and data. We then identify several goals that address desirable near- and longer-term outcomes, and suggest a set of practical strategies that are within the reach of Guangdong to implement with a good prospect of success.

Background

There are compelling economic and social reasons for heightened focus throughout China and Guangdong on reducing pollution. The World Bank and other authoritative sources (World Bank and Development Research Center of the State Council, 2013) have documented the costs of pollution to the economy. They estimate that China loses around 6.5 percent of GDP from pollution each year as a consequence of illness and death, diminished worker productivity, contaminated food sources, and poor quality of life.

The 12th Five Year Plan and other official statements from the central government (Ministry of Environmental Protection, National Development and Reform Commission, and Ministry of Finance, 2012) emphasize the importance of improving environmental quality throughout China. Similarly, the Guangdong Provincial Government has placed improvements in air and water quality and reduction of land contamination among its top priorities (Guangdong Provincial Government, 2014). For example, regulations are in place to guide

water quality protection activities. There are also special regulations set up to protect the water quality of critical water systems in the region such as *Regulations of Guangdong Province on Water Quality Protection in the Hanjiang River Basin* (Department of Environmental Protection of Guangdong Province, 2001b), the *Regulation of Guangdong Province on the Protection of Water Quality of the Dongjiang River System* (Department of Environmental Protection of Guangdong Province, 2001a), and the *Regulation of Guangdong Province on Water Quality Protection in the Pearl River Delta* (Department of Environmental Protection of Guangdong Province, 1998).

China's recent steps to mandate reduction of coal use in major cities will help improve air quality over time (China State Council, 2013). Further, President Xi Jinping and President Barack Obama's recent announcement at the Asian Pacific Economic Cooperation summit in Beijing regarding commitments of both countries to reduce greenhouse gas emissions may have the further benefit of moving China toward cleaner energy sources (Lander, 2014).

Challenges and Overview of Goals and Strategies

Challenge CE1: Water and Air Pollution and Soil Contamination Are Causing Significant Harm to Human Health and Ecological Resources, and Diminishing Economic Growth

In Guangdong Province, the cost of all types of pollution has not been well quantified, but high levels of air, water, and soil pollution have been documented as Guangdong's manufacturing and population have grown rapidly over the past 30 years. Air quality is the most visible sign of China's and Guangdong's struggle to control pollution from the increasing number of vehicles on the road, the combustion of coal for electricity generation, and manufacturing that continues to emit high levels of pollutants. Air quality is generally poor in the PRD cities, as exemplified by persistently high levels of particulate matter smaller than 2.5 micrometers in diameter ($PM_{2.5}$), perhaps the most damaging air pollutant to the human respiratory system. Most PRD cities had average annual $PM_{2.5}$ concentrations that exceeded China's grade II standard of an annual average of 35μg/m^3; Shenzhen, Zhuhai, and Huizhou's average annual $PM_{2.5}$ concentrations met the national Grade II standard (Guangdong Provincial Environmental Monitoring Centre, 2014).[1] Poor air quality diminishes productivity, imposes a large burden of illness and premature deaths on the regional economy, and also affects the health of ecological systems.

Water quality is also a significant concern in the PRD, and was reflected in expressions of dissatisfaction in some communities surveyed in Pingshan. Most of the heavily polluted sections of rivers in Guangdong Province are those flowing through cities in the PRD along with their tributaries. These include the Longgang River, Pingshan River, Shenzhen River, Lianjiang River, and the Zhanjiang section of Xiao Dongjiang River. According to the *2013 State of Environment in Guangdong Province Report* (2014), among 124 provincial-monitored river cross-sections in Guangdong Province, 78.2 percent were considered good (Class I to III), 10.5 percent were lightly polluted (Class IV), 2.4 percent were considered hazardous (Class V),

[1] Nearly all countries prefer to report air quality indicators as daily averages and number of days exceeding a given standard because health effects are tied to such exposures, not annual averages.

and the remaining 8.9 percent were classified as heavily polluted (sub–Class V) (Department of Environmental Protection of Guangdong Province, 2014).[2]

The magnitude of heavy metal contamination of soil has only recently been publicly documented in Guangdong. In July 2014, the Guangdong Department of Land and Resources disclosed that 28 percent of soil samples collected from various areas of the PRD contained excessive levels of mercury, cadmium, lead, and arsenic, consistent with a 2013 study of soil samples from six different land use types around the PRD (Hu et al., 2013). In the absence of a concerted cleanup effort, former and current industrial sites are likely to remain contaminated throughout the PRD for years to come, not only with heavy metals, but also many organic compounds that are known carcinogens. These sites will continue to be a threat to both surface and groundwater resources and communities living around them.

Challenge CE2: Regulators Have Insufficient Resources and Incentives to Enforce Laws and Standards

An overarching challenge in China that hinders progress in virtually all efforts to improve environmental quality—and quality of life—is the gap between the mandates of the five-year plans and environmental laws promulgated by the central government and the enforcement of those laws at the provincial, municipal, and local levels of government (Beyer, 2006). There are several reasons for this gap between policy and practice. First, China's long-standing emphasis on economic growth and its delegation of responsibility for meeting growth targets as well as implementing environmental policy to the provinces and municipalities have created an inherent conflict in governance (Yee, Tang, and Lo, 2014). Provincial and municipal bureaus of environmental protection tend to be weak relative to other bureaus and departments associated with promoting and enabling economic growth (Marquis, Zhang, and Zhou, 2011). They also generally lack adequate staff and technical tools to match the enormity of the task of identifying, monitoring, and enforcing controls on pollutant sources (Zhao and Nan, 2012). Second, polluters benefit from a lack of transparency and accountability, despite a national law that holds local party officials, as part of their performance reviews, responsible for enforcement of environmental standards (Marquis, Zhang, and Zhou, 2011). Citizens know little about how much factories and other facilities are polluting and what they are discharging into the air, water, and soil. Third, even if citizens knew more about who was doing what, they continue to be limited in their ability to change the situation other than to file complaints. While citizens' lawsuits are now permitted in China, they continue to be very rare (Wang and Gao, 2010). China also lacks a culture of compliance among firms, whether state-owned or private, who are doing the polluting. With few exceptions, these firms tend not to act until compelled to do so; compliance with the 2009 water quality law has been estimated to be no greater than about 25 percent (Tao and Xin, 2014).

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[2] According to the Ministry of Environmental Protection of the People's Republic of China *Environmental Quality Standards for Surface Water* (2002), the water bodies are classified into five levels based on the utilization and protection objectives. Classes I to III are considered applicable to centralized drinking water supply. Class IV is applicable to industrial water use and recreational waters without direct human contact. Class V is applicable to agricultural water use and for general landscape requirements. Sub–Class V is the worst level among the national standards.

Goals and Strategies

We recommend that end-point goals be focused on improving key indicators of environmental quality that will ultimately lead to improved health and well-being of the PRD's residents and ecology:

- Improve water quality in the PRD by reducing unlawful industrial and municipal wastewater discharges into rivers and groundwater.
- Reduce contamination of current and former industrial lands.
- Reduce air pollution from vehicles, major coal-burning power plants, and industrial facilities.

These are the high-level goals for which proven strategies are readily available to implement at the provincial and municipal levels. However, environmental quality cannot be measurably improved without simultaneously increasing enforcement and accountability throughout the environmental protection system in China. For this reason, we recommend three complementary types of strategies:

- Align environmentally friendly land use and transportation strategies to reduce pressure on air and water quality as well as land contamination and ecological resources.
- Publicly disclose information about polluters; their discharges and emissions; and the officials (including heads of bureaus) responsible for issuing permits, monitoring compliance, imposing fines, and shutting down facilities that are in violation with the law.
- Increase incentives to comply with laws and regulations for the individuals and corporations who run the polluting facilities, including state-owned enterprises, and public officials who lead the local Environmental Protection Bureaus.

The first set of strategies related to how land use and transportation goals and strategies align with improvements in environmental quality are discussed in Chapter Five ("Land Use") and Chapter Six ("Transportation"). Measures to encourage more compact development, less fragmentation of ecologically valuable lands, and improved public transportation services to dampen increases in vehicle kilometers traveled by automobile will all contribute to other efforts to reduce pollution.

The second set of strategies relates to transparency and applies across the three major environmental problems of water, soil, and air pollution. To establish a credible enforcement regime, heads of polluting firms need to be persuaded that well-trained permit writers and inspectors will carry out their tasks diligently and with integrity—and that the cost of complying with the law will be less than the cost of polluting and losing face in the eyes of the public. All accountable parties—both regulators and polluters—will be recognized by name on websites, newspapers, and in social media. Hence, the purpose of these strategies is to change the equation from "pollution pays" to "good and lawful environmental practice pays."

The third set of strategies applies within the specific contexts of water, soil, and air pollution but builds on the theme of changing the economic and social cost equation for polluters. For water quality, we recommend that downstream cities, districts, and counties be given the opportunity to share in the fines imposed on upstream polluters, thus giving those places a direct stake in vigorous enforcement. Our recommended second water strategy of improving water quality monitoring of both surface and groundwater is foundational to the success of

the other strategies. To address soil contamination, we recommend two interconnected strategies: a complete and up-to-date annual inventory of all industrial waste sites in the PRD, and the creation of a provincial cleanup fund, whose size is commensurate with the magnitude of the problem, to expedite the removal of hazardous chemicals and waste from these sites. With regard to air quality, China and specifically Guangdong have the right strategies in place, but we recommend that the timetables on implementing these strategies of removing highly polluting vehicles, encouraging the purchase of cleaner vehicles, cleaner transportation fuels, and phase-out of coal use be accelerated to realize their benefits sooner and reduce further costs to health and the economy.

Rationale for Strategies, Recommended Practice, and Proposed Indicators

In this section, we provide brief explanations of the rationale for each strategy along with a summary of international best practices and their applicability in a Chinese context. We then propose indicators associated with goals and strategies.

Goal GE1: Increase Enforcement Capacity and Accountability for Air and Water Pollution and Soil Contamination

Many commentators have documented the "implementation gap" in China (Hon et al., 1995; Kostka, 2014) and the lack of consistent enforcement of existing Chinese laws against polluters and the consequent persistence of excessive levels of emissions from all sources of pollution (World Bank, 2012; OECD, 2006). Indeed, China has adequate laws to protect the environment, but the quality if implementation varies across provinces and municipalities. One of the primary reasons for poor implementation and enforcement is the misalignment of incentives: Pollution "pays" in China. That is, businesses and governments continue to pollute the air, water, and land because they find it in their economic interest to do so. Fines imposed on violators of the law are too small to change behavior. Lack of transparency enables both regulators and polluters to escape the notice of the public that they are not doing their jobs. Another reason is that China is more accustomed to using five-year plans and other directives to bring about change, particularly in the wake of an environmental accident or other disaster, rather than relying on the rule of law and citizens' suits (Young et al., 2015).

Strategy SE1: Increase the Number of Inspections by Trained Inspectors

Rationale: For any type of strategy, whether it is market- or technology-based, sufficient well-trained environmental inspectors are essential to implementing and enforcing existing laws, writing appropriate conditions into discharge and emissions permits for facilities, visiting and becoming familiar with actual performance at each of the facilities covered under regulation. There is no shortcut around this step, although new monitoring technologies may help permit writers and inspectors do their jobs better and more efficiently.

Effective enforcement of environmental regulations requires well-trained inspectors. Local Environmental Protection Bureaus in China are weaker relative to other provincial and municipal government agencies responsible for economic development (Hsu, 2013). Lack of power has led to lack of sufficient resources to enforce environmental laws. In the area of air quality, for example, Zhao and Nan (2012) note:

> The [U.S.] EPA employs 18,760 people, among whom 1,400 are responsible for air-quality management, with corresponding employees for each state, county and city. In California alone, there are 1,273 people in the air-quality management office and 35 air-quality control districts, each with its own management personnel. In comparison, China's Ministry of Environmental Protection has several hundred employees in total, among whom only a small number are responsible for air-pollution management. If environmental management staff were employed in proportion to the population or number of pollution sources, this figure would be on a completely different scale.

While it is not possible to identify a specific number of inspectors that cities in the PRD or the provincial level Environmental Protection Bureau should employ, it is possible to link environmental results with strong and credible enforcement actions. More frequent inspections by well-trained inspectors are a known deterrent to polluters in violation of their permits and significant environmental benefits can be achieved with well-targeted and well-publicized inspections (Shimstack and Ward, 2005; State of Oregon Department of Environmental Quality, 2004).

Recommended practices: The International Network for Environmental Compliance and Enforcement (2015) serves as a clearinghouse for international best practices. Its *Principles for Environmental Compliance and Enforcement Handbook* (2009) provides detailed information on how to structure compliance and enforcement programs, set priorities for inspections, and measure performance and effectiveness of compliance and enforcement programs. As with any type of program, indicators can represent inputs, outputs, and outcomes. Other indicators in this chapter are direct measurements of environmental outcomes. For this strategy, we recommend an input indicator of number of inspections as a simple measure of enforcement activity, a crucial step for Environmental Protection Bureaus at the municipal and provincial level to establish a credible reputation for enforcing the law and being willing to impose penalties or take stronger actions, such as shutting down plants when they are consistently violating the terms of their permits.

Indicators:

- E1: Number of facilities inspected annually by trained inspectors as a percentage of the total number of facilities with permits for air emissions, water discharge, and hazardous chemical storage.
- E2: Number of facilities identified but lacking permits as a share of total number of facilities (permitted and unpermitted).
  - Explanation: For E1, each city should have records of the number of facilities with permits that have been inspected at least once annually by trained inspectors. Because some facilities may be inspected separately for air, water, and hazardous chemical storage, facilities should be counted as having been inspected annually if they received inspections in all three categories of air, water, and land pollution. For indicator E2, each city should also have a list of facilities that are eligible for regulation but for whatever reason lack air emissions and water discharge permits. These facilities will need special attention to bring them into compliance with regulations. E2 represents the share of unpermitted facilities among the total number of facilities subject to regulation.

- Data source and availability: Data for facilities and trained inspectors should be available from each municipal Environmental Protection Bureau as well as the provincial Department of Environmental Protection.
- Frequency: Annual.

Strategy SE2: Increase Incentives for Enforcement

Incentives can come in the form of reward or punishment. This strategy uses both. The Environmental Protection Bureau at the municipal and provincial level should regularly post on the Internet and publish in the newspaper the names of permit writers and inspectors, the facilities they are responsible for inspecting, and the names of the owners of the facilities. In addition, the Environmental Protection Bureau should publish inspection results for each inspector and facility, and publicly recognize the permit writers and inspectors whose facilities show the greatest improvements at their sites (reward). Inadequate performance should be publicized in the same way (punishment).

Rationale: In February of 2013, the Guangdong government announced the "Action Plan for Cleaner Water in Guangdong" with target milestones in 2013, 2015, and 2020 for improved water quality in the province (Department of Environmental Protection of Guangdong Province, 2013). The Guangdong Provincial Government plans to invest around 118.7 billion RMB in seven key water-related projects: (1) integrated water treatment, (2) drinking water safety, (3) water source protection, (4) improvement in efficiency of waste water treatment facilities, (5) water accessibility landscape, (6) water pollutant monitoring, and (7) water protection education campaign. Of this investment, around 40 billion RMB will be allocated for the construction and expansion of major wastewater treatment plants and improving wastewater pipelines and wastewater reclamation and reuse systems. This Action Plan also stipulates that government officials who fail to reduce water pollution in three years will not be promoted for two years, while those who make decisions that result in worsening water quality and those who disrupt enforcement will be removed from their position for further investigation. This is an important step toward greater accountability.

Despite the Action Plan and a recently updated legal framework for permitting (Department of Environmental Protection of Guangdong Province, 2013), fewer than a quarter of eligible facilities actually hold proper permits for their water discharges. (We have been unable to identify a similar permitting rate for air quality and soil contamination). Without a well-functioning permitting system, market-based solutions cannot be properly implemented or enforced. By making public who is responsible for regulating, Environmental Protection Bureaus can increase their effectiveness in driving up compliance rates. This practice is also consistent with the Action Plan and other existing procedures for holding cadres responsible for their performance (Economy, 2014).

Recommended practices: Increasing transparency and accountability in regulation has been shown to be an important ingredient in increasing rates of compliance (Stiglitz, 1999). Under the authority of laws for air, water, and land contamination, the U.S. EPA produces an annual report on all of its enforcement and compliance activities and posts the report on line (EPA, 2014). These kinds of public reports tell citizens what the government is doing to enforce laws and protect public health. Although most U.S. environmental laws were passed over 40 years ago, both state and federal environmental regulators still must actively enforce laws and regulations and ensure full compliance with permits. Publicizing the failure of industrial facility owners to comply with their emissions and discharge permits becomes an embarrassment

for them that can then lead to better behavior. Still, these violators often need to be taken to court before they finally agree to abide by the law.

Consistent with U.S. practice, cities in the PRD region could use the authority of the State Council's *Government Open Information Regulations* (China State Council, 2007) to develop more aggressive environmental information disclosure programs.

Indicators:

- E3: Number of facilities (above a specified size) with up-to-date air, water, and chemical storage permits as a percentage of all facilities (above a specified size) eligible for permitting.
- E4: Percentage of total permitted facilities in full compliance with their permits.
  - Explanation: The first indicator measures how effectively government has been tracking air and water permits. The second indicator measures the extent to which facilities with permits follow the rules, and how well government has been monitoring their compliance.
  - Data source and availability: Data for the first indicator are available. Actual compliance for E2 will require frequent, reliable monitoring data. Such data should be available, but will need to be aggregated by the municipal Environmental Protection Bureaus to an annual sum.
  - Frequency: Annual.

Strategy SE3: Increase Incentives for Compliance

We recommend increasing financial penalties on facility owners for violations of permits, and publicly posting penalties and facility owners' names (alongside the names of the permit writer and inspector responsible for enforcement). Instead of a one-time and relatively small fine as is current practice, fines should be imposed on the facility owner for each day that the facility is out of compliance.

Rationale: Experience over the past two decades has shown that fines imposed on polluters have been too low to change behavior. For example, Guangdong's regulations (Department of Environmental Protection of Guangdong Province, 2014) identify monetary punishment associated with noncompliance: Most one-time penalties have a ceiling of no more than 100,000 RMB. Facility owners have found that paying such modest amounts is more cost-effective than investing in pollution control equipment and changing operating procedures. To change the equation, facility owners must be held personally and publicly accountable for the discharges and emissions coming from their facilities—and fines must be large enough to cause them to alter their behavior. It is important to note that even if market-based approaches such as emissions or discharge "cap and trade" type approaches were implemented, these same kinds of strict and enforceable compliance measures would be needed.

Recommended practices: In the United States and elsewhere, fines are levied on facility owners every day that the facility remains out of compliance with its permit. These fines need to be much higher than is currently the case in China. The new amendments to China's environmental protection law that will come into effect in 2015 include similar provisions that penalties will accumulate for each day the violation continues (Environmental Protection Law of the People's Republic of China, 2014). Cities in the PRD region need to ensure these proposed changes are implemented and enforced. Well-publicized fines, even on a few facilities, will have an impact on those facility owners that are out of compliance but have not yet been

caught. If the penalties are high enough, including the threat of shutdown, facility owners will be more motivated to bring their plants into compliance (Shimstack and Ward, 2005).

Indicator:

- E5: Amount (in RMB) of fines collected per year.
  - Explanation: The amount of fines collected per year includes all pollution-related violations. Until enforcement and compliance practices are better established in the PRD, an increasing trend for this indicator will be a sign of progress toward establishing that the government is serious about enforcing environmental standards. At some later time when compliance rates are much higher, declines in this indicator would be a sign of progress.
  - Data source and availability: Based on Guangdong's provincial Department of Environmental Protection's online data portal, fines collected from individual violations are available. Provincial and local environmental protection bureaus need to compile such data into an annual sum.
  - Frequency: Annual.

Table 7.1 summarizes the strategies and indicators for goal GE1.

Goal GE2: Reduce Unlawful Industrial and Municipal Wastewater Discharges into Rivers and Groundwater

The main sources of water pollution in the PRD are untreated industrial and domestic wastewater and nonpoint sources of pollution, primarily from agricultural lands. Industrial water pollution remains a serious concern throughout China, particularly in Guangdong Province

Table 7.1
Environmental Strategies and Indicators for Goal GE1 (Enforcement)

CE1	**Water and air pollution and soil contamination are causing significant harm to human health and ecological resources, and diminishing economic growth.**		
CE2	**Regulators have insufficient resources and incentives to enforce laws and standards.**		
Goal and Strategies		**Proposed Indicators**	
GE1	Increase enforcement capacity and accountability for air and water pollution and soil contamination.		
SE1	Increase the number of inspections by trained inspectors.	E1	Number of facilities inspected annually by trained inspectors as a percentage of the total number of facilities that have one or more permits for air emissions, water discharge, and hazardous chemical storage.
		E2	Number of facilities identified but lacking permits as a share of total number of facilities (permitted and unpermitted).
SE2	Increase incentives for enforcement.	E3	Number of facilities (above a specified size) with up-to-date air, water, and chemical storage permits as a percentage of all facilities (above a specified size) eligible for permitting
		E4	Percentage of total permitted facilities in full compliance with their permits
SE3	Increase incentives for compliance.	E5	Amount (in RMB) of fines collected per year

and the PRD. Laws and regulations are largely in place. However, there is broad consensus among experts in and outside of China that implementation and enforcement of water pollution discharges from industrial facilities is weak for the reasons cited above: the reluctance of local officials to challenge polluters, lack of adequate staffing, and lack of transparency and accountability.

Current wastewater treatment capacity in the PRD is insufficient to meet current and future demand (World Bank, 2012). Inadequate financing mechanisms are one source of the problem. For example, the Guangzhou Sewage Treatment Company cannot collect its own revenue through tariffs but instead requires allocations from the Guangzhou Municipal Finance Bureau. Funds may not fully cover operations, debt service, and other relevant expenses (Economy, 2003). As a consequence of narrowly drawn boundaries for municipal authorities responsible for sewage treatment, plants have tended to be too small and inefficient to overcome high maintenance costs and capture economies of scale.

Excessive use of fertilizers and subsequent runoff into rivers and seepage into groundwater are major sources of nitrogen and phosphorus, giving rise to excessive aquatic plant growth, depletion of oxygen in water bodies, and subsequent "dead zones" for fish and aquatic invertebrate species. Such diffuse, nonpoint sources of pollution are harder to monitor and control than point sources such as factories. Consequently, enforcement is difficult, particularly because of the relatively small average plot size of farmland.

Because most Chinese cities use basic water purification methods that target microorganisms to treat water before providing it for household use (Gong and Liu, 2013), the quality of drinking water directly reflects the quality of water found in rivers, streams, and groundwater. However, most experts agree that ambient water quality monitoring is inadequate for all assessment and enforcement activities (Zhang et al., 2010). For this reason, we suggest indicators directly linked to this goal that capture actual ambient water quality, monitoring capacity, and resident satisfaction with drinking water quality.

Indicators:

- E6: Percentage of residents who feel that drinking water quality has improved.
- E7: Percentage of residents who are dissatisfied with drinking water quality.
- E8: Number of surface water monitoring stations where Class II water quality standards[3] have been met for 12 consecutive months.
- E9: Number of groundwater well monitoring locations where Class II water quality standards have been met for 12 consecutive months.
  - Explanation: The first two indicators are intended to capture residents' perception of both the recent trends in and current conditions of drinking water quality as they experience them. The latter two indicators are direct measures of water quality compliance at surface and groundwater monitoring stations.
  - Data source and availability: The first two indicators will require residential survey results. The latter two indicators can be compiled using data from the surface and groundwater quality monitoring networks.
  - Frequency: Survey data should be updated every two years, more frequently if possible, to capture changes in contamination that may be affecting the city, district, or county,

[3] Suggested chemical pollutants include: dissolved oxygen, nitrogen, phosphorus, and cadmium. A particular biological species present in a river could also be used (e.g., population of a type of fish).

both positive and negative. Monitoring data are typically collected on a monthly basis for purposes of assessment and compliance, but for purposes of the indicator system, annual averages can be obtained.

Strategy SE4: Allow Cities, Districts, or Counties Downstream of Unlawful Discharges of Sewage and Industrial Wastes to Receive Some Percentage of the Revenue from Fines Imposed on Polluters.

Rationale: National-level wastewater discharge standards have been and continue to be often violated in China generally and in Guangdong Province (Ministry of Environmental Protection of the People's Republic of China, 2002a, 2002b). In the absence of proper incentives, simply requiring municipalities and businesses to meet discharge limits will not necessarily improve water quality. Poor monitoring, weak enforcement, lack of transparency, and inadequate penalties have all contributed to the failure to provide the correct incentives for businesses to reduce pollution.

By gaining access to some portion of revenue from fines, affected downstream jurisdictions will be motivated to hold higher-level officials accountable for strict compliance with laws and permits. In combination with our recommended strategies for increasing transparency and accountability, a strategy to empower downstream jurisdictions to press for more stringent compliance could increase pressure on environmental officials at the municipal level but even more so at the provincial level. Local governments operate at too small of a geographic scale to cope effectively with water pollution whose sources are outside of their jurisdiction. The provincial Environmental Protection Bureau will need to intervene or at least lend its support to local bureaus. For the particular case of municipal wastewater treatment plants, local governments might be more inclined to charge higher fees to users to enable the plant to meet higher standards and avoid high penalties (China Water Risk, 2014).

Recommended practice: In the United States, local governments have used the court system to force upstream polluters to comply with state and federal environmental laws (Cumbler, 2005). This practice forces decisions about pollution to a higher level of government that can take into account the needs of both upstream and downstream jurisdictions and not be influenced by economic pressures at work in the local jurisdiction. In Japan, lawsuits from victims' association of four major pollution-induced diseases against polluters in the 1970s redefined environmental pollution regulation enforcement in Japan (Otsuka et al., 2009). Victims from one of the four lawsuits, the Itai-Itai disease trials, even reached agreement with the polluter that the victim's group has the right to enter and inspect the factories with environmental pollution experts, at the company's expense anytime the victim's group considered it necessary (Kaji, 2012).

Indicator:

- E10: Amount (in RMB) of fines directed to downstream cities, districts, and counties each year.
  - Explanation: This indicator measures the extent to which upstream jurisdictions are improving their compliance, and how much downstream jurisdictions have invested to push for stricter enforcement. Fines would be expected to increase in the early years as local jurisdictions exercise their right to enforce pollution laws upstream, but then decrease as upstream water quality improves.

- Data source and availability: These data will be available once the strategy has been implemented.
- Frequency: Annual.

Strategy SE5: Expand Water Quality Monitoring Networks for Both Surface and Groundwater.

Investments will be required to improve the water quality monitoring system for purposes of assessing the quality of the rivers and groundwater but also to improve the rate of compliance with water pollution discharge permits. This strategy presents an opportunity to stimulate technological innovation and provide market opportunities if the Department of Environmental Protection were to initiate a Guangdong-wide competition to select the most cost-effective water quality monitoring technologies for both surface and groundwater and then initiate deployment.

Rationale: Water quality monitoring and data management are critical to supporting regulation and enforcement. These are weak links in the environmental protection system in China generally and in Guangdong and the PRD in particular (Edgar and Hwang, 2009). Currently, the Guangdong Environmental Information Issuing Platform publishes river and stream water quality at only 41 monitoring stations across the province. No groundwater monitoring station results are available publicly. Groundwater quality statistics appear to be managed by the Geo-Environmental Monitoring Central Station of Guangdong Province. However, the latest groundwater quality information published on this website is from 2003.

Recommended practice: Publicly available water quality monitoring data should include both surface and groundwater. The U.S. Geological Survey, through its National Water Quality Assessment Program and other cooperative water quality monitoring programs with states and local governments, is an international model for its adherence to rigorous data collection and analysis standards and for publishing its results in a form most useful to decisionmakers (U.S. Geological Survey, 2014). In Guangdong, current real-time water quality information only includes that of river and stream water at the 41 monitoring stations, mainly at water treatment plants and reservoirs. Following international best practices of the U.S. Geological Survey, current water monitoring networks need to be built out to include basins, river reaches, and groundwater aquifers where water quality is most vulnerable to high levels of industrial pollution (i.e., Guangzhou and Shenzhen).

Indicators:

- E11: Number of surface water monitoring stations fully operational for 12 consecutive months.
- E12: Number of groundwater well monitoring locations fully operational for 12 consecutive months.
  - Explanation: These two indicators relate directly to government efforts to expand the water monitoring networks to enable better compliance and enforcement and to better inform the public.
  - Data source and availability: Data will be available once this strategy is implemented.
  - Frequency: Annual.

Table 7.2 summarizes the strategies and indicators for goal GE2.

Table 7.2
Environmental Strategies and Indicators for Goal GE2 (Water Quality)

CE1	**Water and air pollution and soil contamination are causing significant harm to human health and ecological resources, and diminishing economic growth.**		
CE2	**Regulators have insufficient resources and incentives to enforce laws and standards.**		
Goal and Strategies		**Proposed Indicators**	
GE2	Reduce unlawful industrial and municipal wastewater discharges into rivers and groundwater.		
		E6	Percentage of residents who feel that drinking water quality has improved
		E7	Percentage of residents who are dissatisfied with drinking water quality
		E8	Number of surface water monitoring stations where Class II water quality standards[a] have been met for 12 consecutive months
		E9	Number of groundwater well monitoring locations where Class II water quality standards have been met for 12 consecutive months
SE4	Allow cities, districts, and counties downstream of unlawful discharge of sewage and industrial waste to receive some percentage of the revenue from fines imposed on polluters.	E10	Amount (in RMB) of fines directed to cities, districts, and counties per year
SE5	Expand water quality monitoring networks for both surface and groundwater.	E11	Number of surface water monitoring stations fully operational for 12 consecutive months
		E12	Number of groundwater well monitoring locations fully operational for 12 consecutive months

[a] Suggested chemical pollutants include: dissolved oxygen, nitrogen, phosphorus, and cadmium. A particular biological species present in a river could also be used (e.g., population of a type of fish).

Goal GE3: Reduce Contamination of Current and Former Industrial Lands

In 2012, Guangzhou invested 190 million RMB to tackle heavy metal pollution in soil and forced 492 polluting enterprises to close. In May 2013, a study by the Guangzhou Food and Drug Administration revealed that nearly half of the 18 rice samples they had tested in a Guangzhou market were found to contain an excessive level of cadmium. Two of the rice manufacturers were located in Dongguan. Soil contamination stories spurred the province to implement a number of measures to address the soil contamination issue, such as the establishment of a soil quality monitoring system by Guangdong's Department of Environmental Protection by 2015. The Guangdong government also released a work plan and technical solutions for pollution remediation of arable land. The related soil treatment plans are currently under review and are expected to come into effect by the end of 2014. These are positive and important steps forward.

Indicator:

- E13: Number of hectares of land requiring major cleanup based on site inventory.
  - Explanation: This indicator is directly tied to the goal and implementation of current policies. It is intended to capture the overall outcome of the additional strategies proposed below.
  - Data source and availability: Data will be available after the following strategies have been implemented.
  - Frequency: Annual.

Strategy SE6: Produce an Annual Inventory of Contaminated Waste Sites in the PRD Region.

We propose a strategy that would improve understanding at the provincial level for the magnitude of the problem of contaminated current and former industrial sites. Responsibility would be with the director-general of the Environmental Protection Bureau of Guangdong Province for producing an annual list of sites with the name of the facility owner and a description of the nature of the contamination. To avoid inappropriate development on contaminated lands and reduce associated health impacts, the PRD's municipal governments need to improve their understanding of the scale of soil contamination problem under their jurisdiction. The first step will be a systematic mapping of all former and current industrial sites and then a site-by-site inspection and monitoring program to build an up-to-date, accurate database of contaminated sites. Oversight of actual cleanup would be conducted by the Environmental Protection Bureaus of the jurisdiction where the site is located, with provincial oversight of progress.

Rationale: The PRD has been home to one of the world's most concentrated regions of industrial growth over the past 40 years, leading to substantial areas of heavily contaminated land (Gao and Kai, 2013). The problem appears to be both widespread and poorly defined. For example, a fertilizer factory site contaminated by heavy metals and petrochemical pollutants was initially chosen for the Asian Game Village in Guangzhou (Gao and Kai, 2013). We were unable to identify any systematic identification and tracking of contaminated sites and their cleanup status in the PRD.

Recommended practices: In the 1970s and 1980s, the United States and European countries began to address their industrial waste site problems after wide press coverage identified many neighborhoods and residents whose drinking water and soil were contaminated by poor industrial waste disposal practices. The United States established a "Superfund" program in which taxes on producers of chemicals funded a program to clean up abandoned waste sites throughout the country. As a first step, the Superfund legislation first mandated the development of a systematic inventory of waste sites for which priorities could later be set.

Indicators:

- E14: Number of contaminated sites identified.
- E15: Number of hectares of land contaminated on the sites identified.
  - Explanation: A survey of past factory relocation needs to be conducted to identify potential contaminated sites. Follow up investigation is required to confirm whether sites under question contain pollutants that exceed safety levels.
  - Data source and availability: Data will be available once this strategy is implemented.
  - Frequency: Annual.

Strategy SE7: Establish Waste Site Cleanup Funds at the Municipal and Provincial Levels to Use to Remediate Contaminated Sites Where the Owner Cannot Be Identified or Found

For contaminated industrial sites with clear ownership, Guangdong already has policies in place to require site cleanup. However, for all the reasons cited previously, enforcement must be strong and consistent at the municipal and provincial levels. If noncompliance with existing site permits persists, ongoing industrial operations should be shut down until the owners demonstrate progress on cleanup and application of best practices in maintaining environmentally responsible practice.

However, there are many contaminated industrial sites for which an owner cannot be identified because the factory may have been shut down. We propose that a special fund be established at the provincial level and then replicated by the PRD municipalities to pay for site assessments and cleanup at the highest priority abandoned waste sites.

Rationale: Between 2004 and 2012, roughly 20,000 hectares of contaminated lands on abandoned industrial sites have been identified as a consequence of factories being relocated from Guangzhou to other parts of China or elsewhere (Gao and Kai, 2013). The lack of clear ownership of these polluted sites makes it difficult to hold anyone accountable and consequently fund remediation. These sites put many residential and commercial districts at risk because of their contamination of drinking water and lands where food crops may be grown. Since such contaminated lands threaten public health, government will need to put together cleanup funds for those sites where no clear owner can be found.

Recommended practice: Beginning decades ago, the United States and other industrialized countries established hazardous waste site cleanup funds to provide the resources needed to clean up sites when the responsible owners or operators of those sites failed to do so or could not be identified. The European Union adopted the "polluter pays" principle of liability for all forms of pollution, including soil pollution, but, in reality, public monies cover on average 35 percent of the costs to remediate most sites (European Union, 2004; EPA, 2009). These cleanup funds have been combined with "brownfields" redevelopment programs, discussed in strategy SL8 in Chapter Five (Land Use). Responsible agencies will need to assess sites, maintain a priority site cleanup list, and develop and implement cleanup plans.

Indicator:

- E16: Expenditures (in RMB) for site cleanup from the provincial and municipal cleanup funds.
  - Explanation: This indicator is a direct measure of provincial and municipal government efforts to clean up contaminated sites that lack clear ownership.
  - Data source and availability: Data will be available once the strategy is implemented.
  - Frequency: Annual.

Table 7.3 summarizes the strategies and indicators for goal GE3.

Goal GE4: Reduce Air Pollution from Stationary and Mobile Sources

At the national level, the State Council has set forth a series of laws and plans to reduce air pollution throughout China. Table 7.4 summarizes China's primary air quality standards measured mostly as average annual concentrations by pollutants (Ministry of Environmental Protection of the People's Republic of China, 2012).

Table 7.3
Environmental Strategies and Indicators for Goal GE3 (Site Cleanup)

CE1	**Water and air pollution and soil contamination are causing significant harm to human health and ecological resources, and diminishing economic growth.**		
CE2	**Regulators have insufficient resources and incentives to enforce laws and standards.**		
Goal and Strategies		**Proposed Indicators**	
GE3	Reduce contamination of current and former industrial lands.		
		E13	Number of hectares requiring major cleanup based on site inventory
SE6	Produce an annual inventory of contaminated waste sites in the PRD region. Assign responsibility to the director-general of the Environmental Protection Bureau for oversight of clean up at sites within the appropriate jurisdiction, and publish a list of sites with the name of the facility owner and a description of the nature of the contamination.	E14	Number of sites identified
		E15	Number of hectares contaminated on the sites identified
SE7	Establish waste site cleanup funds at the municipal and provincial levels to use to remediate contaminated sites where the owner cannot be found.	E16	Expenditures (in RMB) for site cleanup from the provincial and municipal cleanup funds

Table 7.4
Chinese National Primary Ambient Air Quality Standards

		Threshold	
Pollutant	**Measurement Period**	**Class I in μg/m^3**	**Class II in μg/m^3**
Sulfur dioxide (SO_2)	Annual average	20	60
Nitrogen oxides (NO_x)	Annual average	40	40
Carbon monoxide (CO)	24 hours	4	4
Ozone (O_3)	Daily, 8-hour maximum	100	160
Particulate matter (10 microns or less) (PM_{10})	Annual average	40	70
Particulate matter (2.5 microns or less) ($PM_{2.5}$)	Annual average	15	35

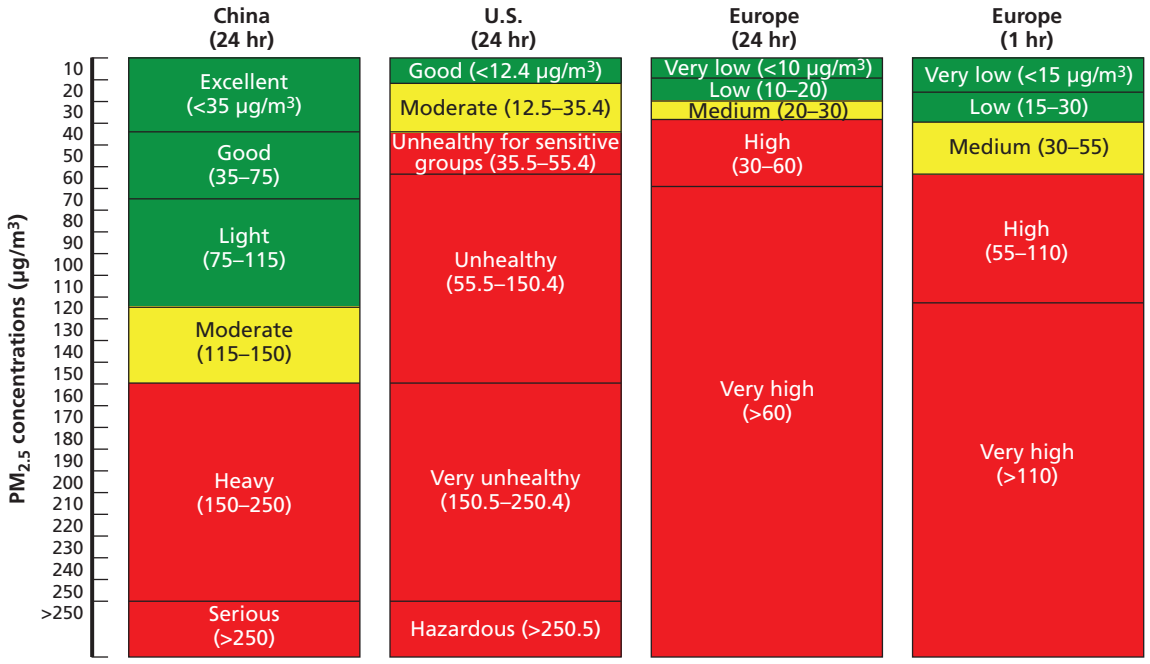
SOURCE: Ministry of Environmental Protection of the People's Republic of China, 2012.

Hong Kong and Guangdong Province have been collaborating to improve regional air quality since 2002. By 2010, significant regional reductions were achieved for sulfur dioxide (SO_2), respirable suspended particulates (RSPs), nitrogen oxides (NO_X), and volatile organic compounds (VOCs) relative to baseline levels in 1997. In November 2012, the Hong Kong–Guangdong Joint Working Group on Sustainable Development and Environmental Protection endorsed a new regional air pollutant emission reduction plan, setting out specific targets for 2015 and target ranges for 2020. The two sides will review progress in 2015 to finalize the targets for 2020.

We recommend a focus on $PM_{2.5}$ and ozone because of the major health impacts associated with these two pollutants and the potential for progress on improving air quality by focusing on reducing these important components of pollution. Ground-level ozone, a major constituent of smog, is not directly emitted from vehicles, power plants, and factories, but rather formed through chemical reactions in the atmosphere of sunlight and mixtures of emitted pollutants such as NO_X, VOCs, sulfur dioxide–based aerosols, and particulates. Particulate matter (PM) includes particles of 10 microns or smaller known as PM_{10}, and the finer and more damaging particles to human respiratory systems known as $PM_{2.5}$. PM is measured in micrograms per cubic meter.

Recommended practice: To reduce the high cost of poor air quality on human health and economic productivity, China, including Guangdong Province, will need to move closer to internationally accepted air quality standards. The World Health Organization and national-level environmental protection agencies have spent decades on research to support their air quality standards. Quantitative measures provide greater transparency and are strongly preferred. Figure 7.1 shows differences in qualitative assessments for $PM_{2.5}$ concentrations averaged over 24-hour periods. What China considers good or light for $PM_{2.5}$ pollution levels are considered to be in the unhealthy, high or very high ranges in the United States and European Union. Because of these differences, we recommend focusing Guangdong's relevant indicator on the actual levels of $PM_{2.5}$ relative to relevant national and international standards, not qualitative assessments.

Figure 7.1
Cross-National Comparison of Air Quality Assessments of $PM_{2.5}$



SOURCE: Andrews, 2014.
NOTE: China, the United States, and Europe all have different color schemes for each grade of air quality, and the above color scheme is a simplification designed by the author.
RAND *RR871-7.1*

Guangdong Province already has a regional air quality monitoring network. However, it may not be up to the challenges ahead. Zhong et al. (2013) have noted that the existing PRD Regional Air Quality Monitoring Network (RAQMN) is inadequate to monitor concentrations of air pollutants that will be covered under the anticipated new air quality standards review. It also lacks the ability to track air toxins for health impact research. Zhong et al. (2013) also suggest adding capability to monitor VOCs to address "regional haze and visibility impairment in the region."

$PM_{2.5}$ and ozone arise from both mobile and stationary emissions sources. However, their actual concentrations in the atmosphere vary by region in sometimes complex ways, depending on the particular geography and weather conditions in a region. Sulfur dioxide, nitrogen oxides, and mercury are other important air pollutants. While the pollutant concentrations can be measured directly in the atmosphere, accurately estimating the relative contribution of individual pollutant sources requires identification of known sources; estimates of emissions from each source and a mathematical model that relates the chemical characteristics, emissions rates, and location of sources to atmospheric concentrations. Such models are essential tools for analyzing the effectiveness of policy measures relative to the costs of those policies and the degree of difficulty in implementing them.

Indicators: We recommend several indicators for this goal and associated strategies:

- E17: Percentage of residents who feel that air quality has improved.
- E18: Percentage of residents dissatisfied with air quality.
  - Explanation: These indicators attempt to track residents' perceptions of past trends and current conditions of air quality in their city, district, or county.
  - Data source and availability: These indicators will require a resident satisfaction survey by cities, districts, or counties.
  - Frequency: Survey data should be updated every two years, more frequently if possible.
- E19: Average daily and annual peak levels of $PM_{2.5}$ (E19a), ozone (E19b), sulfur dioxide (E19c), nitrogen oxides (E19d), and mercury (E19e).
  - Explanation: These indicators reflect direct measurement of key pollutants.
  - Data source and availability: This indicator set will require frequent (preferably continuous) monitoring by the local Environmental Protection Bureau.
  - Frequency: Monitoring data should be collected throughout the year.

Strategy SE8: Accelerate Guangdong's Phase-Out of Coal Use, Especially for Household Heating and Industrial Use, and Coal-Fired Power Plants Serving All PRD Cities

Consistent with the newly released national policy on reduction of coal use and President Xi Jinping's pledge to reduce greenhouse gas emissions over the next 25 years, we propose that Guangdong's planned phase-out of coal use be accelerated for household heating industrial use, and all coal-fired power plants serving all PRD cities.

Rationale: In 2010, Guangdong announced a ban on new and expansion of existing coal-fired power plants in the region (Department of Environmental Protection in Guangdong Province, 2010). Since 2013, following Phase II of the Guangdong Province Pearl River Delta Clean Air Action Plan, many cities in the region have identified "coal-free" zones, mainly within their central business districts, to reduce residential, commercial, and industrial usage. Expansion to the entire PRD region would significantly increase the effectiveness of this strategy, as would strict enforcement. Evidence suggests that new coal-fired power plants are still

being constructed and planned throughout Guangdong, further jeopardizing the health of thousands, particularly children and older people, who are most vulnerable to respiratory illnesses (Greenpeace, 2013). Stretching out the period for reducing coal usage has direct health and economic consequences.

Recommended practices: Industrialized nations around the world have all but eliminated direct residential and industrial coal use, especially for heating and cooking, because of the highly localized pollution levels that emanate from these sources. Guangdong will need to do the same. Retiring old, inefficient, and dirty coal-fired power plants is an equally high priority. Other countries have simultaneously pursued demand reduction programs, energy efficiency, and fuel switching to reduce coal use. Again, Guangdong will need to do the same. Alternative fuel sources will cost more than coal in nearly all instances, but in a wide range of scientific studies carried out in the United States, Europe, and Australia, benefits to the regional and national economy greatly exceed the increased fuel costs. China has the further advantage of making this transition at a time when many alternative technologies are cheaper and better than when first introduced decades ago in other industrialized nations.

Indicators:

- E19: Same as above.
- E20: Annual greenhouse gas emissions reported by type of source (e.g., power plants, industry facilities, residential and commercial buildings, and mobile sources).
  - Explanation: These proposed indicators are direct measurements of air pollution levels. Annual greenhouse gas emissions across all sources will be an essential indicator of progress on both climate change and air quality in the coming years.
  - Data source and availability: Data for the E19 indicators are already available. Accurate data on greenhouse gas emissions for indicator E20 will be difficult to assemble, but can be done incrementally over the next several years.
  - Frequency: Monitoring data should be collected throughout the year to yield the proposed summary indicators specified above.

Strategy SE9: Accelerate Implementation of Green Building Codes and Appliance Efficiency Programs

Rationale: One important and relatively cost-effective component of air pollution and greenhouse gas reduction strategies is reducing energy demand through demand-side management programs with residential, commercial, and industrial users as well as public buildings. The buildings sector consumes about 40 percent of primary energy on average in most industrialized nations (U.S. Department of Energy, 2012; Grözinger et al., 2014).[4] Shenzhen has been considered a frontrunner in China's green building development (Khanna et al., 2014). One of the major contributors to residential building energy use are home appliances, such as refrigerators, washers, and dryers. Appliance efficiency standards have been among the most successful programs in the United States and elsewhere and have spurred substantial technological innovation and reduced household energy demand (Roland-Holst, 2008, Geller et al., 2006).

[4] We do not have recent data for China, but in 2007, approximately 31 percent of China's total energy was estimated to be consumed by the building sector (Eom et al., 2012).

Recommended practices: To facilitate the market transformation toward more efficient buildings and appliances, countries around the world have established numerous policies. The U.S.-based Energy Star and LEED programs, Japan-based Comprehensive Assessment System for Built Environment Efficiency (CASBEE) program, and European Union–based Energy Performance of Buildings Directive (EPBD) are examples of policy instruments in current use. Among them, EPBD is the only mandatory program that requires its member states to develop an energy performance certification framework by a specified deadline (European Commission, 2013). Building on the experiences gained from pilot programs such as the Guangdong Energy Efficiency and Environment Improvement Investment Program, cities in the PRD have the capacity to accelerate the implementation of green building and energy appliance efficiency programs.

Indicator:

- E21: Annual energy consumption per square meter in public (E21a), commercial (E21b), and residential (E21c) buildings.
- E22: Floor area of certified newly constructed green buildings as a share of total floor area of all newly constructed buildings (annual).
  - Explanation: The three sub-indicators in E21 are direct measurements of energy consumption from different types of buildings. By tracking these three building types separately, cities in the PRD region will have a better sense of which building type requires more policy intervention. Floor area of newly constructed buildings meeting green certification standards as a share of total newly constructed floor area is a good measure of increasing the energy-saving value of building stock at the district, county, city, and regional levels.
  - Data source and availability: Data will be available after the strategy has been implemented. Full implementation will require a complete building inventory, but in the early years of the strategy, a sample survey of buildings of different ages and types can be substituted.
  - Frequency: Annual.

Strategy SE10: Accelerate Removal of Highly Polluting Vehicles Through Incentive Payments

China requires highly polluting older vehicles to have yellow license plates. The State Council has called for scrapping all of these yellow-tagged vehicles by the end of 2017 (China State Council, 2013a) with an earlier scrappage deadline of the end of 2015 for the Yangtze River Delta, PRD, and Jing-Jin-Ji Region (Beijing-Tianjin-Hebei). Yellow-tagged vehicles include gasoline-powered vehicles that do not meet the China 1/I standard and diesel vehicles that do not meet the China 3/III standard.[5] In response to the State Council's call for more stringent control of air pollution, in early 2014 the Guangdong Provincial Government released a detailed air quality improvement plan for the period 2014–2017 (Guangdong Provincial Government, 2014). Echoing the State Council targets, the plan emphasizes the need to scrap

[5] China has adopted European Union standards for cars and trucks. The EU has tightened emissions standards over time; each more stringent set of emissions standards has been designated by a number. For example, current emission standards are called Euro 5 (the fifth set of standards). The EU is in the process of introducing Euro 6. China, following the EU, has progressively tightened its emission standards. China's first emission standard, China I, corresponds to Euro I. Overtime, China has introduced China II (Euro II), China III (Euro III), and China IV (Euro IV). (Crane and Mao, 2015)

yellow-tagged vehicles throughout Guangdong Province by the end of 2017, and by the end 2015 for areas within the PRD. We recommend aggressive pursuit of this strategy for the PRD by expanding the Dongguan program, in which incentive payments are made to residents and business owners who turn in their vehicles by a certain date.

Rationale: The five-fold increase in vehicles experienced by China in the space of a decade represents an astounding rate of growth (Shao, Wagner, and Yang, 2014). Unfortunately, the vast majority of vehicles on the road, both passenger cars and trucks, do not comply with China's newest and toughest standards now required for new vehicles. The rate at which older and more polluting vehicles on the road are replaced by newer, low-emission vehicles will determine the timeline for reducing pollution arising from mobile sources. Thus, strategies that accelerate the replacement rate are desirable.

Recommended practice: Many developed countries have used vehicle scrappage programs to promote the replacement of inefficient vehicles and stimulate the automobile industry. In the United States, concerns about air pollution, the increasing age of the vehicle fleet, and new mandates from the 1990 Clean Air Act Amendments encouraged private industries and public agencies led to the adoption of voluntary accelerated vehicle retirement (VAVR) programs (Dill, 2004a). Some programs were even funded by private firms. For example, the oil company Unocal introduced the South Coast Recycled Auto Project that offered $700 to residents in the Los Angeles region for their old vehicles. The company used the program to prove that scrapping older vehicles would be more cost-effective than applying more stringent pollution controls on stationary sources such as oil refineries (Dill, 2004b). This program also introduced the concept of "pollution credits"; Unocal earned emissions reduction credits from the scrappage program to meet emissions standards (Dill, 2004b). Many scrappage programs were introduced during the 2007–2008 global recession in the United States and Europe, with maximum incentives ranging from $1,421 in France to $7,104 in Italy, while the United States, Italy, and France also implemented tougher fuel efficiency and emissions requirements (*The Economist*, 2009). The relative cost-effectiveness of all of these programs depends on a number of factors, including the cars selected for scrappage and other options that may be available to a city to achieve similar emissions reductions (Hahn, 1995).

Currently, Shenzhen, Zhuhai, Dongguan, and Foshan have established subsidy policies to accelerate the phase-out of yellow-tagged vehicles. However, Shenzhen and Foshan's subsidy program also provides a subsidy for those who transfer the yellow-tagged vehicles out of the city instead of scrap them (Foshan Traffic Police, 2013; Shenzhen Traffic Police, 2013). Such subsidies fail to reduce associated pollution emissions by simply moving the polluting vehicles from one location to another place, likely still within the PRD.

Indicator:

- E23: Number of yellow tagged vehicles remaining in use.
  - Explanation: This indicator directly measures the outcome of the strategy proposed above.
  - Data source and availability: Available from the Department of Transportation.
  - Frequency: Annual.

Strategy SE11: Increase the Number of Cleaner Cars Registered

We propose that Guangdong accelerate the pace of replacing the old fleet of cars by offering substantially lower registration fees to buyers of vehicles that meet the China VI pollution control standards.

Rationale: Guangdong and other provincial air pollution reduction action plans call for the development of a cleaner fleet of vehicles running on China's streets. The number of motor vehicles in Guangdong Province grew from 1.7 million to 11 million between 2000 to 2012 (Shao, Wagner, and Yang, 2014). Increasing the share of cleaner vehicles will play an important role in improving regional air quality.

Recommended practice: Accelerated cleaner vehicle adoption programs have been implemented in many countries around the world. They tend to be introduced along with the scrappage program, although design and stated goals vary (International Transport Forum, 2011). Five of the 13 fleet turnover programs introduced in Europe include carbon dioxide (CO_2) emissions thresholds for new car purchases. Italy, Germany, Austria, and Greece also required a minimum Euro 4 standard in new vehicle purchases (IHS, 2010). In contrast, the U.S. CARS program included a fuel efficiency standard instead of a pollutant or CO_2 emissions requirements (International Transport Forum, 2011). The most effective programs were those that accelerated the introduction of more lighter and cleaner vehicles into the fleet (International Transport Forum, 2011). For example, Germany's largest vehicle turnover program actually led to significantly more medium-sized vehicles being purchased through the Umweltprämie program, resulting in smaller emissions reduction impacts in the absence of restrictions on fuel consumption or CO_2 emissions standards (International Transport Forum, 2011).

Indicator:

- E24: Percentage of vehicles registered that meet China VI pollution control standards.
  - Explanation: This indicator is a direct measure of the share of cleaner vehicles on the road. As the standards become more stringent, the indicator will need to be updated accordingly.
  - Data source and availability: Data will be available from the Department of Transportation at the municipal and provincial levels once the strategy is implemented.
  - Frequency: Annual.

Strategy SE12: Accelerate Adoption of Cleaner Vehicle Fuels

In early 2013, China's State Council issued a directive calling for the nationwide introduction of ultralow sulfur fuels (maximum sulfur content of no more than 10 parts per million [ppm]) for gasoline and diesel fuels by the end of 2017 (China State Council, 2013b). As with the yellow-tagged vehicle rule, the State Council accelerated the compliance deadline for the three priority regions including the PRD by the end of 2015. We propose vigorous enforcement of the 10 ppm low sulfur fuel standard to meet the 2015 deadline, with the added incentive of reducing taxes and fees on refineries who can comply with the standard by the deadline.

Rationale: The total population of cars in Guangdong Province is projected to reach over 40 million by 2030, an increase of more than 300 percent over current levels. Aside from the additional congestion these vehicles will cause, their impact on air quality will be profound if measures to replace the highest-polluting vehicles with ultra-low-emissions vehicles, electric vehicles, or other low- or zero-emissions alternatives are not aggressively implemented. Shao, Wagner, and Yang (2014) conducted a scenario analysis examining the cost and benefits associ-

ated with three fuel quality standards implementation dates. Their simulation results indicate that implementation of China V standards can effectively control NO_X emissions in the near term and yield immediate reduction of $PM_{2.5}$ emissions, but the China VI standards will be necessary to curb pollution in the long term due to the anticipated expansion of the vehicle fleet. In terms of costs and benefits, Shao, Wagner, and Yang (2014) show that the introduction of China VI standards could yield a benefit-cost ratio of 2.5 by 2030.

Recommended practice: Advanced emission control technologies function less effectively when sulfur is in the fuel (Blumberg, Walsh, and Pera, 2003). Many industrialized countries have established regulations to reduce sulfur levels in fuels and consequently decrease emissions of smog precursors and other air pollutants. Germany, the United Kingdom, Finland, Switzerland, Belgium, and the Netherlands have provided tax incentives for early adoption of low- and near-zero sulfur fuels (defined as 10 ppm maximum), which led to high market penetration of near-zero-sulfur fuels in the early 2000s (Blumberg, Walsh, and Pera, 2003). In Japan, the Tokyo metropolitan government collaborated with the Petroleum Association of Japan to provide subsidies to enable the early adoption of diesel fuel with less than 50 ppm sulfur content (He, 2013). The effort led to an agreement between the Ministry of International Trade and Industry and industry stakeholders to introduce low sulfur diesel nationwide (He, 2013). Through tax breaks, depreciation allowances, and research funding, 10 ppm near-zero-sulfur fuel was available nationwide by 2005, two years ahead of the original timeline (He, 2013).

Indicator:

- E25: Percentage of fuels sold in Guangdong that meets the new China VI standard.
  - Explanation: This indicator measures the share of cleaner fuels sold in Guangdong. Increasing market share of cleaner fuels will have a direct impact on vehicle emissions levels.
  - Data source and availability: Data are currently available from the Department of Transportation.
  - Frequency: Annual.

Table 7.5 summarizes the strategies and indicators for goal GE4.

Priorities for Implementation of Strategies

Each strategy recommended in this chapter has the potential to improve environmental quality and would make a lasting and substantial improvement in transparency, accountability, and credibility of the regulatory process in Guangdong and the cities of the PRD. In suggesting priorities for implementation in Figure 7.2 (with details provided in Table E.3), we sought to identify those measures whose impact could be felt relatively soon after implementation. As with all of the policy areas, the actual scoring of impact among strategies, ease of implementation, and time frame of implementation should be viewed as a starting point. These assessments will need to be further refined as more analysis is done on potential impacts and implementation details.

With this caveat in mind, we recommend the removal of high-polluting vehicles as quickly as possible. This is a low-risk strategy with immediate air quality benefits. Phasing out coal use

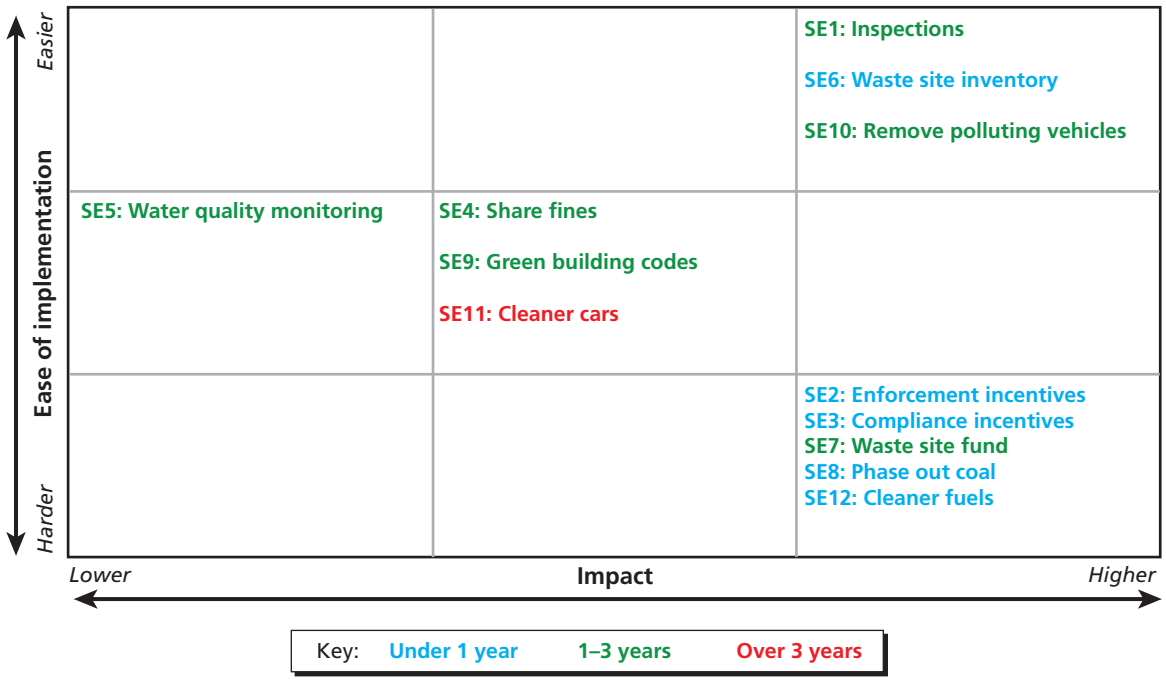
Table 7.5
Environmental Strategies and Indicators GE4 (Air Quality)

CE1	**Water and air pollution and soil contamination are causing significant harm to human health and ecological resources, and diminishing economic growth.**		
CE2	**Regulators have insufficient resources and incentives to enforce laws and standards.**		
Goal and Strategies		**Proposed Indicators**	
GE4	Reduce unlawful emissions from air pollution from stationary and mobile sources.		
		E17	Percentage of residents who feel that air quality has improved
		E18	Percentage of residents dissatisfied with air quality
		E19	Average daily and annual peak levels of $PM_{2.5}$ (E19a), ozone (E19b), sulfur dioxide (E19c), nitrogen oxides (E19d), and mercury (E19e)
SE8	Accelerate Guangdong's phase-out of coal use, especially for household heating and industrial use, and coal-fired power plants serving all PRD cities.	E19	Same as above.
		E20	Annual greenhouse gas emissions reported by type of source (e.g., power plants, industry facilities, residential and commercial buildings, and mobile sources)
SE9	Accelerate the implementation of green building codes and appliance efficiency programs.	E21	Annual energy consumption per square meter in public, commercial, and residential buildings
		E22	Floor area of certified newly constructed green buildings as a share of total floor area of all newly constructed buildings (annual)
SE10	Accelerate removal of highly polluting vehicles through incentive payments.	E23	Number of yellow-tag vehicles remaining in use
SE11	Increase the number of cleaner cars registered.	E24	Percentage of vehicles registered that meet China VI pollution control standards
SE12	Accelerate adoption of cleaner vehicle fuels.	E25	Percentage of fuels sold in Guangdong that meets the new China VI standard

will take longer and be more challenging, but its impact will be larger and more lasting—with the further virtue of being consistent with national air quality and greenhouse gas emissions goals. Sharpening incentives to improve the effectiveness of enforcement and compliance is also at the top of the priority list and will return environmental benefits that residents will notice in the form of cleaner air and water. There is no reason to delay implementation of an industrial waste site inventory and cleanup funds at the provincial and municipal levels. While the impacts of these measures will be more localized to the surrounding residential and commercial areas, these measures will improve quality of life for communities living with the legacy of hazardous chemical wastes.

As Guangdong's leaders seek to foster an innovation-driven economy with cleaner industries and a growing service sector, they have the opportunity of using stricter enforcement of environmental standards and improved air, water, and soil quality as a means of gaining a competitive advantage in terms of quality of life over other provinces. This approach could lead to economic losses if some industrial activity declined as a consequence of strict enforcement of environmental standards, but these losses potentially could be offset by drawing in other businesses that value cleaner air and water for their enterprises and their workers.

Figure 7.2
Recommended Priorities for Implementation of Environmental Strategies



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CHAPTER EIGHT

Housing

This chapter identifies major housing challenges confronting Guangdong's cities and recommends goals to address these challenges, along with strategies and indicators. The goals articulated here are informed by goals previously articulated in government documents for the PRD region and our understanding of the challenges related to housing based on the workshop and other interviews with city officials. Housing policy is closely connected to the other policy areas, as summarized in Table 10.1. For each recommended strategy, we present the rationale for adopting that strategy, a selective review of international practices related to the strategy, and a discussion of possible indicators associated with successful implementation of the strategy.

Background

As in all of China, housing in the PRD was provided primarily by employers until reforms created a more market-based system for housing and ended employment-based housing. These policy changes proceeded in three phases: In 1988, employers were allowed to sell housing they had previously provided free of charge to their employees at low prices; in 1994, the central government created housing assurance programs intended to meet the housing needs of those who did not benefit from those sales programs; and in 1998 the housing assurance programs were expanded.

Due to the ways in which rural and urban land regulations differ, urban residents who purchase homes receive a 70-year housing property right from the city. In contrast, rural residents own land collectively. Much of the housing in rural areas is self-built. The housing stock in urban areas of the PRD region includes units purchased from employers, temporary housing provided by employers to workers (largely in the form of dormitories for factory workers), housing built by real estate developers (most of which is for sale), housing built in "villages in cities" (which is largely rental), and housing built by the government. Homeownership among urban households is approximately 55 percent, the lowest of the heavily urban provinces in China (Pan, 2013). According to the *Guangdong Statistical Yearbook*, in 2012 just over half of urban households lived in commercial houses (54 percent)—defined as those built by private developers—another 23 percent in private apartments acquired when employers sold them to employees, and the balance in employer-provided housing or rental units. Three-quarters of households lived in two- or three-bedroom apartments (Statistics Bureau of Guangdong Province, 2013).

The primary housing challenge in PRD, as in China's urban regions generally, is an insufficient supply of housing relative to demand from lower- and middle-income groups, which drives up housing costs and encourages speculation. Another challenge specific to the PRD is the disparity in access to housing between permanent residents and the floating population. Local governments' reliance on land transfer fees from developers wishing to build housing has meant that new construction of housing has not necessarily been in accordance with a regional master plan, but instead been pursued opportunistically and not always coordinated with other amenities, such as transit and shopping hubs.

Affordability is a major concern. Major urban markets such as Guangzhou have experienced substantial increases in housing prices over the past decade. An analysis in 2010 of the ratio of purchase price of an average for-sale home to average household income found that Shenzhen's ratio was 17.6—the highest of 13 cities analyzed, including Beijing and Shanghai—and Guangzhou's was 10.4. As the analysis pointed out, a ratio between 8 and 12 is considered a great hardship and seriously affects other consumption, while a ratio over 12 would require a household's entire annual earnings to pay for a house (Yi and Jun, 2013).

In response, the central government operates a myriad of housing programs and policies designed to alleviate the housing shortage. The three main government programs are listed in Table 8.1.

Other, smaller government-funded programs included various types of subsidies, public rental housing, and developer-built housing with controlled prices (Huang, 2012), as well as adjustments to the main programs to keep costs down, such as restrictions on maximum square meters per unit (Deng et al., 2011).

While the central government has emphasized these affordable housing programs, they have been hard to implement at the local level because of a misalignment of incentives for both local governments and developers. Local government relies on cash flow from land transfer fees paid by developers of market-rate housing. Land transfer fees are paid up-front by developers to local governments in exchange for the ability to develop a site. In contrast, cities generally provide free or low-cost land to developers to provide affordable housing. In the absence of a widespread property tax that would provide a more stable stream of revenue based on the value of housing units, land transfer fees take on increased importance and some observers (for example, Ding and Song, 2009) think a property tax would be a useful revenue mechanism for local governments.

For a number of reasons, China's urban homeownership rate is high by world standards—Man et al. (2011) calculated it at 84.3 percent for 2010. However, the term *homeownership* is a misnomer, since it is calculated on the basis of the number of residential properties that are privately owned, rather than the number of households who own the home they live in. Also,

Table 8.1
China Housing Assurance Programs

Program Name	Purpose
Economical and Comfortable Housing	Build affordable for-sale units for middle-income households
Housing Provident Fund	Create a savings plan for home-buying
Cheap Rental Housing (CRH)	Construct low-income rental units

SOURCE: Deng et al., 2011.

the count of housing units excludes "informal" housing—meaning housing that is built without government approvals such as permits—namely the housing found in "villages in cities" discussed in Chapter Five. The rate would fall were these homes to be included (Man et al., 2011). Statistics about the number of households who own the home in which they live are not available, so this figure is not directly comparable to those of other countries (Barth, Lea, and Li, 2012).

Low rates of actual homeownership are attributable to a lack of other savings and investment options as well as to cultural preferences. Mortgage financing has also made it easier to purchase homes, but this financial tool is fairly recent. One study found that of Guangzhou residents who had bought a market-priced home between 1998 and 2005, only about one-quarter took out a mortgage loan (Li, 2010). Personal savings and parental contributions were primary sources of funds for home purchases.

Challenges and Overview of Goals and Strategies

In this section, we discuss each challenge and provide an overview of goals to address each challenge, and strategies to achieve the goals. The first of the two challenges focuses on housing solutions for middle-class residents and the second on low-income residents. In keeping with customary Chinese practice in reporting income statistics, we use the definitions in Table 8.2. In referring to "low-income" households, we refer to households earning incomes in the first and second quintile (0–40th percentile) of the income distribution.[1] When referring to "middle-class" households, we refer to households earning incomes within the third quintile (41st–60th percentile) of the income distribution.

The goals focus on affordability and supply of housing units for both low- and middle-income residents. For low-income residents, our goals are related only to rental housing, not for-sale housing, for several reasons. First, the up-front costs and associated maintenance costs of homeownership put homeownership out of reach for most low-income households. Second, countries that have provided subsidies to low-income households to purchase homes—but not to rent—have tended to curtail the rental market (Baird-Zars et al., no date). Third, a well-functioning housing market should include both for-sale and rental housing to provide the largest number of choices. Rental housing provides the greatest flexibility to households, enabling them to more easily move between cities and jobs than those that own housing (Zenou, 2010). Economic growth is not necessarily correlated with high rates of homeownership; for example, high-income countries such as Germany, Sweden, and Switzerland all have more rental than ownership units in their housing stock (Bertaud et al., 2009, Figure 5.2).

Challenge CH1: There Is a Lack of Good-Quality Public Rental Housing and Housing for Purchase for Middle-Income Residents

In light of the shortage of urban housing relative to demand, cities have had a difficult time ensuring that middle-income residents have access to affordable housing. Newly built market units tend toward the higher end of the price range and are therefore unaffordable except by more affluent households.

[1] This is consistent with recent international work on inequality, which suggests that the ratio of the bottom 40 percent of the population to the top 10 percent is a robust indicator of inequality. See Cobham and Sumner (2013) for a discussion.

Table 8.2
Definitions of Household Income Groups

Income Group Name	Definition	Category
Lowest-income households	First decile	Low-income
Poor households	First 5 percent	Low-income
Low-income households	Second decile	Low-income
Lower-middle-income households	Second quintile	Low-income
Middle-income households	Third quintile	Middle class
Upper-middle-income households	Fourth quintile	
High-income households	Ninth decile	
Highest-income households	Tenth decile	

SOURCE: National Bureau of Statistics of China, 2013, Table 11-6.

Goal and Strategy

We recommend a goal of ensuring that reasonably priced housing is available to households at middle-income levels through government intervention. We suggest three strategies to accomplish this: (1) Create incentives for developers to build more affordable rental housing through competitive requests for proposals; (2) limit speculation by levying property taxes on homes; and (3) require a certain percentage of affordable units in transit-oriented development.

Challenge CH2: There Is a Lack of Good-Quality Public Rental Housing for Lower-Income Residents

The challenge in this area is both affordability and availability; that is, many persons live in dormitory-type lodging because rental options are not affordable. Migrant workers, who form a substantial proportion of the population, are not always eligible for housing assurance programs or allowed to purchase housing.

Goal and Strategies

We recommend a goal to increase construction of rental housing that will be affordable to lower-income groups. The strategies to further this goal are to (1) redevelop "villages in cities" using land readjustment techniques, (2) adjust housing assurance programs to allow smaller and lower-cost rental units, (3) provide housing vouchers to low-income residents, and (4) implement and enforce building and amenity standards for rental units.

Rationale for Strategies, Recommended Practice, and Proposed Indicators

In this section, we provide greater detail on the rationale for each strategy, selected international practices, and a discussion of indicators and targets. In some cases, we provide indicators associated directly with the goals themselves; in other cases, we identify indicators for the strategies intended to contribute to achievement of the goal. For some goals and strategies, relevant data are already being collected (in indicator systems such as Happiness Pingshan and in

annual publications, such as the *Guangdong Statistical Yearbook*), and we have noted this where appropriate. However, for most goals and strategies, we recommend additional data collection.

Goal GH1: Ensure That Housing (for Rental and Purchase) Remains Affordable to Households at Medium-Income Levels

For middle-income households, the largest problem seems to be the affordability of homes that are for sale. Prices in housing markets in very large Chinese cities have risen substantially since 2005; average prices are now many times average incomes, making purchases of new homes unaffordable for middle income residents (Man et al., 2011).

One indicator of affordability is the percentage of income spent on housing; the higher the percentage, the less affordable the unit, since it leaves households with fewer resources for other expenditures. There is no single definition of when expenditures on housing are unaffordable, but the United States uses 30 percent of gross income to determine affordability: If a household is paying more than 30 percent of income for housing, the unit is considered unaffordable (Quigley and Raphael, 2004).

A complementary indicator is the housing price-to-income ratio. Unlike the first indicator, which describes the actual proportion of income spent on housing, this second one is a general measure of whether home prices are within reach—regardless of whether the household owns a home or not. The housing price-to-income ratio is the ratio of the median sales price of a housing unit within a geographic area to the median household income for that same geographic area, generally calculated at the city level. The United Nations Human Settlements Programme (UN HABITAT) Global Urban Observatory database suggests that a ratio between 3:1 and 5:1 is acceptable; a ratio over 5:1 is "severely unaffordable." In 2007, of 265 prefecture-level cities in China, 184 were considered "severely unaffordable" with an index above 5. The median for all of these cities was 6.25 (Man et al., 2011). Were the indicator to distinguish between affordability of rental housing price-to-income versus for-sale price-to-income ratio, it could be a useful gauge of general affordability.

Indicators:

- H1: Among middle-income households, share of household income spent on rent or mortgage.
  - Explanation: Of the two potential indicators, this is closer to measuring the important underlying question of what households are actually paying.
  - Data source and availability: Table 10-1 in the *Guangdong Statistical Yearbook* (Statistics Bureau of Guangdong Province, 2013) contains per capita expenditures on residence, but does not appear to include rent or mortgage, only depreciation, building maintenance costs, and property management fees. If this is the case, then these data cannot be used to create this indicator. Instead, the indicator would need to be calculated from two pieces of information: the average household income for middle-class households, and the average monthly rent or mortgage payment. This might be best obtained by survey; the survey tested in Pingshan only included a general question about affordability and would therefore need to be revised.
  - Frequency: Annual.
- H2: Sum of public rental housing units and affordable rental housing units built by private developers as a share of all available housing units.

- Explanation: This indicator will track the overall supply of affordable rental housing units in cities and for the PRD as a whole. It will provide a baseline metric against which the effectiveness of new strategies can be measured, as for example, strategy SH1 described below.
- Data source and availability: Data are available from HURD and cities.
- Frequency: Annual.

Strategy SH1: Create Incentives for Developers to Build More Affordable Rental Housing and Housing for Purchase Through Competitive Requests for Proposals (RFPs) for Below-Market-Price Land

Rationale: The usual development process has thus far generated new construction that is concentrated on high-end apartments ("The Next 6 Billion Square Meters," 2013). To counteract this trend, it would be helpful for local governments to create incentives for developers to build more affordable rental housing units through competitively awarded requests for proposals for below-market-price land. Such projects could be geared to infill development or large parcels adjacent to existing development, consistent with housing master plans. These should be planned and timed to combat housing market volatility and respond to projected demand. A public request for proposal (RFP) process also increases the transparency of developer awards and proposals, since the RFP and the responses would be public record.

Recommended practices: Government agencies often issue requests for proposals on land they own, or land they have assembled, that specify some parameters for development, incentives offered (such as below-market land cost), and exactions required (such as a minimum percentage of affordable units produced) in exchange for the incentives.

As an example, the city of Denver, Colorado, began planning in the late 1980s to decommission Stapleton International Airport and build a new airport on another site. This left a 4,700-acre government-owned site (1,900 hectares) near the city as a development opportunity. The city entered a partnership with a private foundation to create a master plan for future development, which specified mixed-use as well as affordable housing. The affordable housing plan required that 10 percent of for-sale homes and 20 percent of rentals be set-aside for income-qualified occupants. Developers then competed for the right to develop the site on the grounds that they would adhere to the framework. Since the time that the developer was selected in 1998, 4,800 housing units have been built, along with eight schools; 150 businesses are now located on this site (Swetik, 2012).

Such RFPs have also been used by transit agencies to attract development adjacent to stations. Some U.S. transit agencies explicitly include affordable housing in their RFPs on land no longer needed for transit operations (Kniech and Pollack, 2010).

In all instances, incentives for developers to build affordable housing must be designed with trade-offs in mind. Incentives for developers (in this case through below-market-price land) may achieve the increased supply of below-market housing, but at the cost of less revenue to the government from the land sale. To avoid lower-quality construction and homes that are visibly lower-cost within, say, a mixed-income housing development, the government can specify in its RFP selection criteria that housing unit exterior finishes and minimum quality criteria must be uniform across the homes within the development. This imposes greater costs on the developer, and thus a developer typically seeks greater incentives to meet this requirement.

Further, development specifications for below-market-price housing production requires that the government enforce these stipulations via oversight during the construction period

and (depending on the requirements, such as income eligibility rules for tenants) during the operation period. These regulatory requirements pose costs to government for oversight and to developers for compliance. However, these kinds of trade-offs are routine and designed into mixed-income housing solicitations such as are common in the United Kingdom the United States.

Indicator:

- H3: Units built as a result of awards made to private developers through RFPs.
  - Explanation: Counting the number of units is closer to the desired end result—additional housing to meet demand—than counting the number of RFPs or developments. We also suggest that counting units, rather than square meters, is also closer to achieving the goal, because units can vary in size and renters do not control the number of square meters they rent.
  - Data source and availability: This should be available through the construction bureau that issues occupancy permits before the units are made available for rent or sale (U.S. Department of Energy, 2010).
  - Frequency: Annual.

Strategy SH2: Increase Funding Capacity and Reduce Government Reliance on Development Fees by Levying Property Taxes

Rationale: There are several reasons for transitioning to a property tax approach to raising revenues for funding affordable housing and enforcing building codes. The most compelling reason is to reduce incentives of municipal governments to maximize their profits from land sales through development fees as a means of funding government operations. Implementing a property tax system for revenue generation would undermine the pressure for new development and its impacts on the land use priorities, transportation infrastructure, housing, and the environment.

In addition, some Chinese cities have many housing units that have been sold yet remain vacant, even in the face of high demand for housing. This is because more-affluent households often purchase several homes as investment properties, with no intention of living in them or renting them out. A survey conducted in 2013 found that about 22 percent of sold residential units in urban areas were vacant, which amounts to 49 million units across China (Fung, 2014). One motivating factor to keep properties vacant is the fact that many costs are paid up front, with no recurring costs other than loan payments. A property tax would make it more expensive to own vacant housing.

A property tax will increase the cost of housing, although in a manner that would depend on the policy design. For example, a progressive property tax could limit the impact of a new property tax on lower-cost housing. The idea is to reduce the government's reliance on land transfer fees by replacing that revenue source with a modest property tax.

Recommended practices: Most cities in developed countries levy some type of property tax, which is an annual tax on the value of buildings. Property taxes require detailed records about property ownership (or in the case of China, long-term lease rights) as well as an independent valuation. Property taxes have a number of desirable characteristics: They discourage speculation, by increasing the cost of keeping property vacant; the revenues they generate are generally more stable than other types of taxes, such as sales tax or income tax; and they encourage higher-density land uses. In China, they would have the additional benefit of reduc-

ing the reliance of local governments on land transfer fees (Ding and Song, 2009). Among other uses, a portion of the revenues collected from these taxes could be made available to developers to construct additional affordable units. Such taxes might also encourage owners to rent out properties they are not living in, which would help increase the supply of rental housing.

Tax codes can be used to discourage speculation by making it more expensive to purchase several units or to keep a home vacant. Singapore has capital gains taxes on houses sold within three years, as well as a stamp duty on real estate transactions (Phang, 2007). The stamp duty, a type of transaction tax, becomes lower the longer the owner held on to the property, within a four-year period. A sale of a home within one year has a stamp duty of 16 percent of the sales price or market value (whichever is higher), while one held for four years is 4 percent (Inland Revenue Authority of Singapore, 2011).

The United States taxes income from property sales differently depending on whether a residence has been occupied by the owner. A certain amount of the capital gain is excluded from federal taxes provided the owner lived in the house for at least two of the five years preceding the sale (Internal Revenue Service, 2014). The tax treatment is the same regardless of whether the home is vacant or rented out.

If Guangdong or cities in the PRD had property taxes (which have been piloted in China but are not in widespread use), this concept could be modified to provide for higher taxes on vacant homes. A few U.S. cities have imposed taxes specifically on vacant properties to discourage blight and encourage property owners to improve or rent their properties. Washington, D.C., imposes a property tax of $5 per $100 of assessed value on vacant properties and $10 per $100 on blighted properties (Office of Tax and Revenue, District of Columbia, no date). Regular properties are assessed at 85 cents per $100 of value.

Indicator:

- H4: Property tax income received by government.
  - Explanation: This requires that a property tax be implemented and collected.
  - Data source and availability: This would be provided by the agency that is collecting the tax.
  - Frequency: Annual.

Strategy SH3: Require a Certain Percentage of Public Rental Housing Units and Affordable Housing for Purchase in Transit-Oriented Developments

Rationale: Providing affordable units near transit stations helps ensure that transportation options are available to residents, which is especially important for households that cannot afford to own a car. This strategy also supports goal GT1, "Mitigate the need for people to travel by private passenger vehicles." This strategy should also help to mitigate the Challenge CL1 of fragmentation of urban and rural lands and add further strength to the strategy SL3 to promote transit-oriented development near rail stations.

Recommended practice: In the United States, a main source of financing to build affordable housing is the Low Income Housing Tax Credit. Affordable housing programs are administered by individual states and awarded on a competitive basis to developers. A number of states use proximity to transit as one criterion for determining which developers will receive funding. For example, the state of Georgia awards extra points to projects within one-quarter mile (0.4 km) of a rail station connected to the development with roads or bike trails. Ameri-

can cities have also used other federal funding programs to subsidize affordable housing near transit, such as Seattle's leveraging of $4 million in federal funds to build 200 affordable units in four rental housing developments (U.S. Government Accountability Office, 2009).

The San Francisco Bay Area has some of the highest housing costs in the United States. This imposes a particular burden on lower-income households, who spend on average almost two-thirds of their income on combined housing and transportation costs. To address this need, a housing loan fund was created with support from both the public and private sectors to finance the construction of affordable housing units near transit stations. The fund, which was started in 2011, has provided funding to four projects that will include a total of almost 400 affordable units (Bay Area Transit-Oriented Affordable Housing Fund, no date).

Indicator:

- H5: Share of public rental housing units and affordable housing for purchase built in TODs.
  - Explanation: This will provide an indicator of how successful the strategy is in proving affordable housing near transit.
  - Data source and availability: This should be available through a construction bureau that issues occupancy permits before the units are made available for rent or sale. It may also be necessary for an agency to determine whether the units remain affordable, as opposed to reverting to market rates.
  - Frequency: Annual. We suggest this should be a running tally rather than a count of units built in a specific year.

Table 8.3 summarizes the goal, strategies, and indicators for challenge CH1.

Table 8.3
Housing Goals, Strategies, and Indicators for Challenge CH1 (Middle-Income Affordability)

CH1	**There is a lack of good-quality public rental housing and housing for purchase for middle-income residents.**		
Goal and Strategies		**Proposed Indicators**	
GH1	Ensure that housing (for rental and purchase) remains affordable to households at medium-income levels.		
SH1	Create incentives for developers to build more affordable rental housing and housing for purchase through competitive RFPs for below-market-priced land.	H1	Among middle-income households, share of household income spent on rent or mortgage
		H2	Sum of public rental housing units and affordable rental housing units built by private developers as a share of all available housing units
SH2	Increase funding capacity and reduce government reliance on development fees by levying property taxes on homes.	H3	Units built as a result of awards made to private developers through RFPs
SH3	Require a certain percentage of public rental housing units and affordable housing for purchase in TODs.	H4	Property tax income received by government
		H5	Share of public rental housing units and affordable housing for purchase built in TODs

Goal GH2: Encourage Construction of Better-Quality Rental Housing That Is Affordable to Lower-Income Households

Lower-income groups face a severe shortage of affordable rental housing within the PRD. In light of strong demand for housing, developers and city governments have a greater incentive to construct market-rate units, on which they can realize a larger profit than on lower-cost units.

For rental housing, two common measures of affordability are (1) the housing rent-to-income ratio and (2) the percentage of renters paying in excess of a given percentage of income in rent. The first of these is calculated as the ratio of monthly rent to monthly income. The second is the percentage of renters who pay very high percentages of their income in rent. There is no single definition of what this threshold should be, but the United States uses 30 percent in determining affordability; that is, if a renter is paying more than 30 percent of income in rent, the unit is considered unaffordable (Quigley and Raphael, 2004). Researchers in the United States also consider payment of greater than 50 percent of household income on rent to constitute "severe burden." We recommend using the first of these two measures as a yardstick of affordability, as it is comparable to indicator H1. However, the second is helpful in cases of severe shortages such as the PRD experiences, since it gauges the extent of very high housing costs.

Indicator:

- H6: Among lowest to lower-middle income households, share of household income spent on rent or mortgage.
  - Explanation: Of the two potential indicators, this is closer to measuring the important underlying question of what households are actually paying.
  - Data source and availability: It is uncertain whether data to measure this are available. See discussion of indicator H1.
  - Frequency: Annual.

Strategy SH4: Redevelop "Villages in Cities" Using Land Readjustment Techniques

Rationale: Land readjustment is an alternative to eminent domain. Eminent domain is a process by which residents are paid market prices for property that is being forcibly taken by a government entity and from which the owner must vacate. By contrast, under land readjustment methods, the public authority partners with the current residents: Residents are guaranteed to remain in the area and receive a piece of land at the end of the process of similar value to their current holding. The city government can use some of the land in the area to construct low-income housing, through either low-cost construction (and thus low rents), below-market prices for homes (through subsidies to developer), or subsidies to renters of market-rate homes (through a vehicle such as housing vouchers). This might be a particular strategy for villages in cities, which are prime areas for development that could be used instead of displacing current residents.

Recommended practices: Land readjustment originated in Germany, but is quite widely used in Japan, South Korea, and Taiwan. Land readjustment is generally implemented by a local city government, which identifies an area for redevelopment. The process is most widely used in areas with fragmented land parcels and substandard infrastructure. The government negotiates with landowners within the targeted area. The landowners agree to provide some proportion of their land, usually in the range of 10–30 percent, to create new infrastructure (generally roads and public spaces, although some projects have also emphasized commercial

development) in exchange for reaping some of the increase in land value once the new development is completed. In exchange, the government agrees to provide infrastructure as well as return to the landowner a smaller parcel of land, but one that is worth more because of the improvements.

In Korea, for example, the practice started in the 1930s under Japanese colonial rule. By 2001, more than 650 redevelopment areas had been created using land readjustment. The projects have often resulted in large increases in land values. In one major project, Gaepo, land readjustment was implemented with a master plan, providing residents with pedestrian-only walkways, stores, schools, and open space in several neighborhood centers. This project also set aside land for public agencies to build low-income housing (Lee, 2002).

Land readjustment has also been successfully used in China in several areas. In Pujiang (Zhejiang Province), an area of about 40,000 square meters called the Xiajizhai plot was subject to land readjustment after the 132 households applied to the city government. The existing housing was demolished and all households received a new townhouse in the plot. The area was also built up with public open space and better roads (Li and Li, 2007).

Indicator:

- H7: The number of rental units located in villages in cities in which lower-income households pay more than 30 percent of household income in rent.
  - Explanation: This dovetails with the previous indicators H1 and H5 in focusing on lowering the financial burden of housing.
  - Data source and availability: This requires collection of data at the household level to determine the ratio of rent to income. The agency that carries out this strategy would be responsible for data collection.
  - Frequency: Annual.

Other indicators that could be used in the future are the number of "villages in cities" redeveloped this way, or the number of affordable housing rentals created relative to the number of low-income households in a city.

Strategy SH5: Adjust Housing Construction Programs Such as CRH to Allow Developers to Build Low-Cost Rental Units

Rationale: Developers should be encouraged to experiment with building different types of rental units. These could be fairly small-size and very modest in the amenities provided so long as minimum health and safety standards are met, or they could include some shared facilities (such as shared kitchens or bathrooms). Developers could also experiment with new construction techniques, such as modular construction, that make the construction process shorter and less expensive.

Recommended practices: Units constructed under the CRH program area are already limited to 50 square meters, but cities have some flexibility in regulating this program (Deng et al., 2011). Some cities do build even smaller units. New York City, one of the most expensive and high-density cities in the United States, has recently begun several projects to allow new types of apartments with the goals of meeting the city's affordable housing needs. One such project consists of "micro-apartments," which are very small apartments (between 270 and 360 square feet, or 25 to 33 square meters) meant for one- and two-person households. They are designed to maximize space and the feeling of openness through high ceilings, an overhead loft

space, small balconies, built-in storage space, and common areas to encourage the residents to interact (Modular Building Institute, no date).

In Thailand, about three-quarters of affordable units built under the Baan Eua-Arthorn ("home with care") program were 33 square meters (Kojima, 2013). Many micro-apartments that have been built in North America are as small as 100 square feet (9.3 square meters), and have some shared facilities, such as kitchens (Common Ground, 2012).

With regard to lower-cost construction techniques, builders have been experimenting with modular construction, which means that major building components are produced in factories to certain specifications and then assembled on-site. New York City is currently building the world's first modular apartment tower, which will be 32 stories tall and contain 363 rental apartments. This building is being constructed as part of an agreement with the city government to provide affordable housing at a major development site, and is expected to save the developer 15 to 20 percent of typical construction costs, partly due to lower material costs and partly due to shorter construction schedules (Carlyle, 2014).

Indicator:

- H8: The number of newly constructed low-cost units, defined as affordable for the lowest and lower-middle households based on paying no more than 30 percent of income on rent.
  - Explanation: This is an easy way to gauge total construction of new units and is directly related to affordability.
  - Data source and availability: This should be available through the agency that inspects units before they are made available to the public.
  - Frequency: Annual.

Strategy SH6: Provide Housing Vouchers to Low-Income Residents, Where Voucher Payments Are Directly Provided to Landlords After the Unit Is Inspected and Lease Signed

Rationale: A demand-side policy like housing vouchers can complement a supply-side policy (like the construction of subsidized homes) by allowing households to rent a home of their choice so long as the home meets certain health and safety criteria and falls within a rent cap.

Recommended practices: A number of countries have shifted in recent decades from the construction of their own public housing to providing various types of vouchers to assist lower-income households to obtain housing. For example, both Australia and New Zealand provide housing assistance in the form of payments to lower-income households. In Australia, use of Rent Assistance is limited to private rental housing; in New Zealand, Accommodation Supplements can be used for both private and public rental housing, as well as to pay for a mortgage on a house. Eligibility is determined on the basis of income, as well as on the percentage of income the housing spends on housing. Payments are made directly to households, rather than to landlords. In both countries, the programs have been effective in lowering the percentage of households who spend more than 30 percent of their income on housing (Hulse, 2002).

Indicator:

- H9: The percentage of households that receive vouchers who pay more than 30 percent of their income for housing.
  - Explanation: This indicator directly measures whether the voucher program is succeeding in lowering the housing burden on low-income households.

  - Data source and availability: This should be available through the agency that administers the voucher program; it would require information gathered directly from participating households.
  - Frequency: Annual.

Strategy SH7: Implement and Enforce Building and Amenity Standards for All Public Rental Housing Units and Rental Units Built by Private Developers

Rationale: Rental housing stock does not have to be luxurious, but it should meet some minimum standards for size and basic amenities. Otherwise it may fall into disrepair, making it undesirable to live in, and may even constitute a threat to public health if conditions deteriorate below a certain point (for example, a rental building that does not meet safety codes could prove to be a fire hazard). Further, as standards rise in the PRD, residents expect rental housing with private (not shared) kitchens and bathrooms.

Recommended practices: In the United States, cities seldom develop their own building codes, but adopt existing models. The International Code Council is one source of such codes. These "model codes" cover a variety of topics, including fire safety, mechanical systems, and plumbing. Cities generally use these codes to both approve construction plans as well as to issue certificates of occupancy once buildings are completed, as well as at other points. For example, Washington, D.C., requires a certificate of occupancy not only for newly constructed buildings, but also for additions, changes of use, and changes in building loads (Washington, D.C., Department of Consumer and Regulatory Affairs, no date).

The City of Berkeley, California, has an enforcement program specifically for rental housing, the Rental Housing Safety Program. Housing units are exempt the first five years after the certificate of occupancy is issued, but are included afterward. Building owners are required to certify annually that their rental properties continue to meet building codes. City staff inspect a number of rental units each year to verify that the certifications are accurate, and tenants can request inspections if they think their unit is not in compliance. Among the standards the units are required to meet are that doors lock, electrical switches are operational and covered, the unit has smoke and carbon dioxide detectors, windows can open and shut, window bars have a quick-release mechanism inside, plumbing is not leaking, and exits from the building are marked and clear (City of Berkeley, 2013).

Indicator:

- H10: Percentage of rental units that meet standards.
  - Explanation: This should encompass all rental units within a city.
  - Data source and availability: This implies that an agency is responsible for inspecting units for violations of building codes both before it is occupied, as well as at some regular frequency afterward.
  - Frequency: Data should be collected annually, but post-residency inspections could happen less frequently.

Table 8.4 summarizes the goal, strategies, and indicators for challenge CH2.

Table 8.4
Housing Goals, Strategies, and Indicators for Challenge CH2 (Lower-Income Affordability)

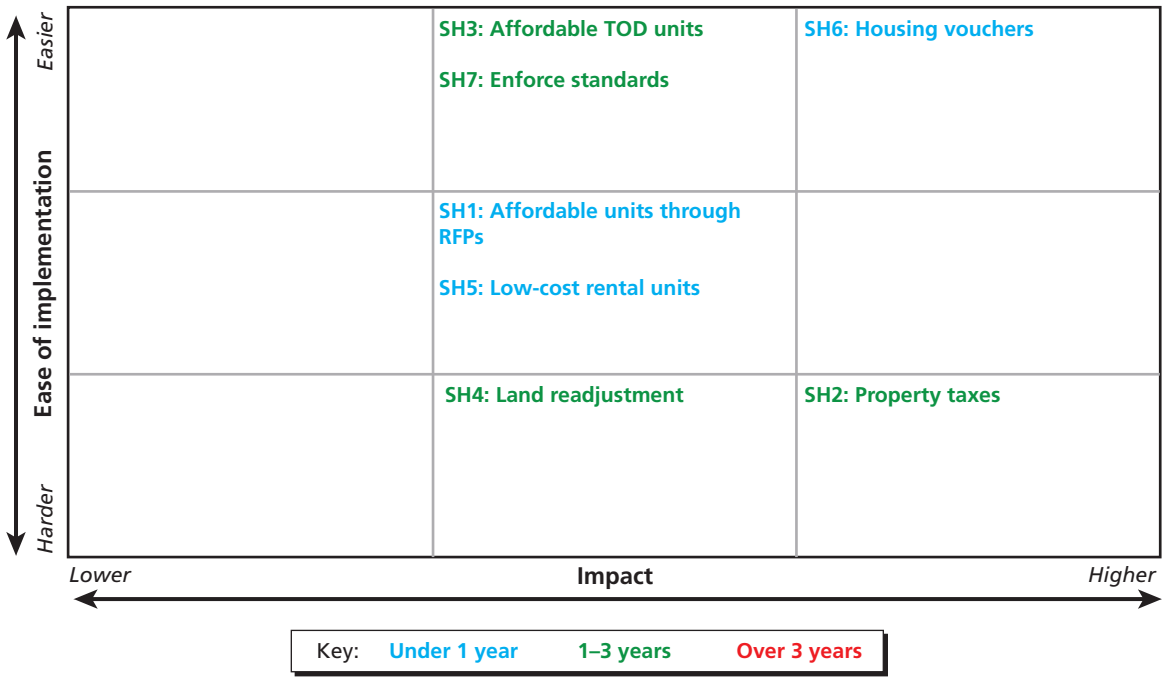
CH2	There is a lack of good-quality public rental housing for lower-income residents.		
Goal and Strategies		**Proposed Indicators**	
GH2	Enhance construction of better-quality rental housing that is affordable to lower-income groups.		
		H6	Among lowest to lower-middle income households, share of household income spent on housing
SH4	Redevelop "villages in cities" using land readjustment techniques.	H7	Number of rental homes located in villages in cities in which lower-income households pay more than 30 percent of household income in rent
SH5	Adjust housing construction programs like CRH to allow developers to build low-cost rental units.	H8	Number of newly constructed low-cost units, defined as affordable to lowest and lower-middle-income households, based on paying no more than 30 percent of income on rent
SH6	Provide housing vouchers to low-income residents, where voucher payments are directly provided to landlords after unit inspected and lease signed.	H9	Percentage of households that receive vouchers who pay more than 30 percent of their income for housing
SH7	Implement and enforce building and amenity standards for all public rental housing units and rental units built by private developers.	H10	Percentage of rental units that meet standards

Priorities for Implementation of Strategies

Following the approach in the previous three chapters, we show in Figure 8.1 the RAND team's first-order assessment of priorities among the strategies along three dimensions: relative level of impact, ease or difficulty of implementation, and the approximate time frame for the proposed strategies. Table E.4 provides our underlying assessments for each of the strategies.

We assign the highest impact to the provision of housing vouchers to low-income residents as one of several strategies to use market forces to increase supply of affordable rental housing. This strategy has been used elsewhere and should be relatively easy to implement. We view the need to limit excessive speculation in the housing market as an important goal and the use of property taxes on residential property as an effective approach, recognizing that this is still a relatively new concept in China and therefore more challenging to implement. The housing strategies vary in the degree of difficulty, but all could be implemented within the next three years.

Figure 8.1
Recommended Priorities for Implementation of Housing Strategies



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CHAPTER NINE

Economic Development

Employment, income, and consumption are basic elements of the quality of life. Each of the other policy areas discussed in the previous chapters has bearing on the speed, direction, and quality of economic development. These interrelationships are summarized in Table 10.1. In this chapter, we briefly discuss the PRD's key economic development challenges, identify policy goals to meet the challenges, and suggest strategies that could improve prospects for growth, consistent with a low-carbon economy. As discussed below, these issues are central to efforts to increase the economic integration of the greater PRD region.

Background

China, Guangdong, and the PRD have enjoyed extraordinary growth in per capita GDP since China began to open up in 1978. However, slower growth since the 2008 financial crisis has led to the recognition of the need for new economic development strategies as well as the need to pay more attention to other dimensions of quality of life beyond GDP. To that end, Vice Premier Wang Yang, former Party Secretary of Guangdong Province, and other leaders identified regional economic integration in the PRD as a top priority, coupled with a growing business service sector and increased economic activity with other parts of China (CPC Guangdong Provincial Committee and Guangdong Provincial People's Government, 2010; People's Government of Guangdong Province, 2009).

Based on *The Outline of the Plan for the Reform and Development of the Pearl River Delta (2008–2020)* ("The Plan for Reform"), Guangdong Province has initiated ambitious steps for cooperation with Hong Kong and Macao Special Administrative Regions. These steps were given firmer shape in the April 7, 2010, *Hong Kong–Guangdong Cooperation Framework Agreement* and the March 6, 2011, *Guangdong-Macao Cooperation Framework Agreement*. Both agreements provide goals, areas of cooperation, specific projects for cooperation, and institutional arrangements.

To implement these agreements, the People's Republic of China at the national level and the Guangdong Provincial Government and Hong Kong and Macao Special Administrative Regions will all have to take measures to further reduce barriers to flows of goods, services, and finance, and their associated flows of people. Current constraints include physical barriers, such as bottlenecks at border crossing points. They also include policy barriers, such as licensing of professionals, such as lawyers and accountants, from Hong Kong and Macao to work in Guangdong, and impediments to the operation of smaller banks and other financial institutions in Guangdong. The key challenge is to remove these barriers while working within

and maintaining China's unique policy of "One Country, Two Systems." Although all jurisdictions within the PRD can gain from closer cooperation, there are also concerns that must be overcome.

Further cooperation and economic integration among Guangdong, Hong Kong, and Macao can foster greater regional economic development and dynamism in the PRD. The OECD (2010) notes that Guangdong's capacity to generate economically valuable knowledge can be increased through cooperation with Hong Kong. Further integration between Guangdong and Hong Kong has the potential to increase growth rates of gross domestic product by one percentage point each year.

In addition to a major focus on economic transition, Premier Xi Jinping has now committed to significantly reducing emissions of carbon dioxide by 2030 in the recently signed agreement with the United States (White House, 2014). China had been taking some steps toward a low-carbon economy. For example, 133 out of 287 prefecture and higher-level cities had received the designation of "low-carbon cities" (Chinese Society for Urban Studies, 2011). Within the PRD region, Shenzhen was selected as one of the national low-carbon pilot cities and has put forward the "Shenzhen Low Carbon Development Medium and Long-Term Plan" (Zhou, He, and Williams, 2012). The National Development and Reform Commission selected Guangdong and Shenzhen for two of seven national pilot carbon trading systems. All of these efforts require accurate tracking of emissions to effectively evaluate program outcomes, a challenge for China and indeed all nations.

Challenges and Overview of Goals and Strategies

Responding to the central government's quest to foster new sources of growth, consistent with a low-carbon economy, the Guangdong provincial government developed a list of implementation guidelines for economic policy (People's Government of Guangdong Province, 2009; CPC Guangdong Provincial Committee and Guangdong Provincial People's Government, 2010). Although these guidelines recognize progress to date, provincial leaders have noted that additional efforts are still required to shift away from the traditional low-cost labor, low-value added export growth model. This is the central economic challenge facing the PRD.

Challenge GD1: Accelerate the Economic Transition by Encouraging More Sales to Other Chinese Provinces, While Seeking New, Low-Carbon Opportunities to Expand the Regional Economy

According to the *Guangdong Provincial Statistical Yearbook* (Statistics Bureau of Guangdong Province, 2014), the rate of growth in total exports from the PRD region has dropped continuously for the past three years. The PRD's export-oriented growth model has been hurt by lower demand from the global market and competition from lower-cost producers in other countries. However, the growth in motor vehicle manufacturing, telecommunications equipment, and other higher-value products has partially offset slower growth in lower-value assembly operations (*Guangdong Statistical Yearbook*, 2014). Many of these more sophisticated products have found domestic markets elsewhere in China. Other countries have been able to maintain economic growth despite declining rates of growth in exports through economic restructuring. The critical step for the PRD region will be to identify new engines of growth by developing

new export markets, expanding sales to China's domestic market, and creating conditions that will enable growth of new industries and services.

Concerns about income inequality add further urgency to the need to accelerate the transition. China's Gini coefficient, a measure of income inequality, is high compared to many other countries, well above 0.45 since the 2000s (Sicular, 2013). In Guangdong Province, the Gini coefficient is somewhat lower than in China as a whole, but still approaches 0.4 (Lei, 2014), indicating severe income inequality within the region, much of which reflects the gap in incomes between urban and rural areas and between the PRD and areas outside the PRD.

Provincial and city leaders have increasingly focused on transitioning to less resource-intensive growth, especially less energy- and carbon-intensive development. Reducing use of fossil fuels would have the combined advantage of improving air and water quality and reducing greenhouse gas emissions. However, accurate and consistent measurement of greenhouse gas emissions and the production of an inventory of sources of greenhouse gases are necessary to market-based and other approaches to carbon reduction strategies.

Goals and Strategies

We recommend three policy goals to address this overarching challenge and seven strategies linked to raising residents' standard of living. The first goal is to raise output and employment by encouraging businesses in Guangdong to sell more to other provinces in China by developing marketing networks to sell the more-sophisticated motor vehicles, telecommunications equipment, and other products whose production has been growing rapidly. To assist firms in the PRD to expand sales to China's domestic market, we propose the following strategies:

- Reduce internal barriers to trade.
- Improve provision of market information on prices, quality, grade, and other product attributes in provinces where PRD businesses are targeting their sales efforts.
- Pilot a preclearance program at the border crossing with Hong Kong–Macao so as to speed cross-border flows of goods and so as to better penetrate China's domestic market.

The second goal is to reduce income inequality by improving access to higher levels of education and developing a labor force with more-sophisticated skills needed for higher wage work. As the structure of the PRD economy changes, the provincial government should improve monitoring and training to meet the demands from emerging industries for a higher-skilled labor force by

- better tracking changes in the PRD labor market
- attracting workers with higher skills to the PRD
- training graduates for work in emerging industries.

The third goal is to implement economic development strategies consistent with reducing emission of greenhouse gases in the PRD while maintaining economic growth in the region. In the land use, transportation, and environment policy areas, we propose several strategies that will yield outcomes that will contribute to reducing emissions of greenhouse gases. These strategies are as follows:

- SL3: Promotion of transit-oriented development
- SL7: Incentives for more compact development

- ST1 to ST6: All six strategies related to improving the efficiency and convenience of public transit, bicycling, and walking
- SE8 to SE12: All five strategies related to improving air quality.

To support these strategies, we recommend an additional strategy here of monitoring and verifying reductions in emissions of carbon dioxide achieved through implementation of the other strategies.

Rationale for Strategies, Recommended Practices, and Proposed Indicators

In this section, we provide brief explanations of the rationale for each strategy along with a summary of international best practices and their applicability in a Chinese context. We then propose indicators associated with goals and strategies.

Goal GD1: Raise Output and Employment by Encouraging Businesses in the PRD to Sell More to Other Regions in Guangdong and Elsewhere in China

Strategy SD1: Reduce Internal Barriers to Trade

Rationale: For the past several decades, Guangdong has imported more from other provinces than it has sold to them (Xu and Li, 2012). Expanding sales to these provinces involves providing more information to businesses in the PRD, which has traditionally focused on exports. It also would mean strengthening links between Hong Kong–based distributors and the PRD to facilitate sales into China's domestic market and thereby encouraging the development of the wholesale and distribution system in the PRD.

Lower logistics costs would contribute to expanding sales of goods and services produced in the PRD to the rest of China. Logistics costs for China in 2013 were $164.7 billion (RMB10.2 trillion), accounting for 18.0 percent of GDP, more than double that of America (8.5 percent) (China Federation of Logistics and Purchasing, 2014). Due to high internal transportation costs, many distributors of lower-value goods do not ship goods to other provinces.

Recommended practices: Substandard transportation infrastructure is a major barrier to trade and supply chain efficiency, and hinders the free flow of goods across regions (World Economic Forum, 2013). To better integrate the regional market in the 1990s, the European Union began construction of the Trans-European Transport Network (TEN-T) (European Commission, 2013). The Structural Fund and the Cohesion Fund were launched to enable less developed European Union members to catch up. The Guangdong provincial government could work with the national government and other provincial governments to reduce cross-border highway tolls between provinces. Investments in road, rail, and port facilities should be made to improve interprovincial transportation infrastructure.

Indicator:

- D1: Annual number of shipping containers (in 20-foot-equivalent units, or TEUs) to other regions.
  - Explanation: By measuring the volume of goods distributed through containers or trucks to other provinces, we will know whether interprovincial distribution is affordable and efficient.

- Data source and availability: No existing data available yet. The transportation or commerce bureau should start collecting such data, preferably by destination provinces.
- Frequency: Annual.

Strategy SD2: Improve Provision of Market Information on Prices, Quality, Grade, and Other Product Attributes in Provinces Where PRD Businesses Are Targeting Their Sales Efforts

Rationale: Wholesale markets in the PRD that have focused on sales to other regional markets in China have generally been less developed than wholesale markets focused on exports. Many small manufacturing enterprises in the PRD rely on wholesalers, fairs, and well-developed Internet systems to provide information on potential orders. Many of these links and much of this information are less developed for the domestic Chinese market.

Recommended practices: While many national and local trade agencies focus on exporting local products to international markets, PRD cities can draw lessons from efforts that aim to support access to domestic markets for a specific sector, such as agriculture. The U.S. Department of Agriculture's Agricultural Marketing Service has provided market information such as price and sales data to farmers for 100 years (U.S. Department of Agriculture, 2014). Daily market news as well as periodic industrial analysis reports are provided through the Internet, in printed reports, or through the phone.

The Guangdong provincial government could work with the municipal governments, wholesalers, and manufacturers to develop a provincial clearing house for information on prices and sales in other provinces by product type. Provincial and prefecture level commerce bureaus could consider duplicating the model of the Canton Fair (China Import and Export Fair, 2012) to introduce PRD products to domestic buyers. Provincial and municipal governments should also work with local wholesalers, manufacturers, and market support companies to arrange specialized fairs, marketing brochures, and marketing trips to leverage marketing experience gained from international trade to increase access to domestic customers.

Indicator:

- D2: Annual growth rate in sales value adjusted for inflation, by province from base year.
  - Explanation: Annual growth rate in sales value is a direct measure of trade volume between Guangdong and other provinces in China. Tracking this growth rate by province can reveal which provincial markets are expanding or shrinking for Guangdong and the PRD.
  - Data source and availability: These data may be available from the Provincial Commerce Bureau.
  - Frequency: Annual.

Strategy SD3: Pilot a Preclearance Program at Border Crossing with Hong Kong–Macao

Rationale: The purpose of this strategy is to speed cross-border flows of goods and enable goods coming into Guangdong to more efficiently penetrate China's domestic market. Efficiency in logistics is an important enabler of increasing economic activity and is particularly important to the PRD as it seeks to broaden its reach into markets in other regions of China. Historically, there has been a wide gap between southbound and northbound truck traffic, with southbound traffic dominating (Wong, Siu, and Choi, 2005). For the PRD to increase its volume of trade with other provinces, it will need to reduce logistics costs by substan-

tially improving logistics operations and increase northbound traffic from the Hong Kong–Shenzhen corridor.

Recommended practices: The United States and Canada have a long-standing preclearance program called the NEXUS trusted travelers program, and recently the United States and Ireland initiated a program as well. In 2011, the United Sates and Canada implemented a pre-inspection program for U.S.-bound commercial truck cargo along the Pacific Highway in Surrey, British Columbia.[1] U.S. Customs and Border Protection officers pre-inspected roughly 3,500 commercial trucks carrying cargo in Canada. This enabled the trucks to make only a rolling stop at the inspection booth on the U.S. side (White House, 2013). Phase II of the truck cargo pre-inspection pilot has been launched in 2014 at the Peace Bridge crossing between Fort Erie, Ontario and Buffalo, New York (U.S. Department of Homeland Security, 2014). As another example, full implementation of the Single Window Initiative, through which each country's importers can electronically file all information to fulfill customs and other regulations without duplication, is expected to start in 2016 (White House, 2013).

Guangdong and Hong Kong already have some of the elements in place, such as the Green Lane initiative, in which cross-boundary trucks use a dedicated Green Lane and are tracked by an electronic truck surveillance system using GPS and e-seal (Hong Kong Shipper's Council, no date). Mainland China–bound trucks unload their laden container at the Shenzhen International Logistics Center, after which goods are passed to a truck to continue on their route to the mainland. This practice has reduced wait times at the Huang Gang checkpoint that tends to be congested (Tradelink, 2007).

Indicator:

- D3: Wait times of goods traffic (trucks) when crossing Shenzhen (border with Hong Kong) and Zhuhai (border with Macao).
  - Explanation: Wait times of commercial vehicles at the border is a direct measure of how efficiently goods move between Hong Kong–Macao and PRD cities.
  - Data source and availability: Data should be available from border authorities.
  - Frequency: Annual.

Goal GD2: Reduce Income Inequality by Improving Access to Higher Levels of Education and Developing a Labor Force with More Sophisticated Skills Needed for Higher-Wage Work, Especially Skills Required for Emerging Industries

Strategy SD4: Improve the Tracking of Changes in the PRD Labor Market

Rationale: To effectively assess local economic conditions and be more agile in setting policy, the provincial and municipal governments need to be able to track and identify labor market trends by job and worker categories in a more timely fashion. By tracking the number of jobs created and lost by sector, PRD leadership will have a better grasp of the economic changes taking place in the cities. Particularly because the PRD region is so focused on economic transition, obtaining such information is critical for monitoring labor demand in the subsectors of the broader industry and service sectors that are expanding.

Recommended practices: Current labor market statistics track jobs created but not numbers of separations or labor turnover. We recommend that the provincial and municipal

[1] The program was initiated under the auspices of the Beyond the Boarder Declaration and the launch of the Canada–United States Regulatory Cooperation Council.

statistics bureaus start collecting data on job openings, hires, and separations from representative samples of businesses, government, and other hiring institutions within the region. This recommendation is based on current practices by the statistical offices of all the members of the OECD (OECD, 2014). The OECD led a data collection effort named DynEmp Express to compile a cross-country database of firm level data on employment dynamics (Criscuolo, Gal, and Menon, 2014). In the United States, the Bureau of Labor Statistics conducts a monthly Job Openings and Labor Turnover Survey (JOLTS) with a sample of 16,000 public and private U.S. businesses within all nonagricultural industries for the 50 states and the District of Columbia (U.S. Bureau of Labor Statistics, 2014). During the first six months in the sample, respondents are called by interviewers who enter data directly into a computer; respondents then can enter their data through touchstone data entry phones (U.S. Bureau of Labor Statistics, 2010). The U.S. Bureau of Labor Statistics also collects job gains and loss data through the Business Employment Dynamics database. These data are compiled through the Quarterly Census of Employment and Wages records that are submitted to the states by employers. While the JOLTS data measure hires and separations that happen to the individual worker, the Business Employment Dynamics data measure job changes at the establishment level (U.S. Bureau of Labor Statistics, 2004).

Indicators:

- D4: Annual number of new jobs created.
  - Explanation: Annual number of new jobs measures how many positions of what skill level are created in each sector over a year, indicating whether and to what extent a sector is expanding.
  - Data source and availability: The *Provincial Statistical Yearbook* indicates data for this indicator are available.
  - Frequency: Annual.
- D5: Annual number of jobs lost.
  - Explanation: Annual number of jobs lost measures how many positions have been eliminated within each sector over a year, indicating whether and to what extent a sector is shrinking.
  - Data source and availability: These data are currently unavailable.
  - Frequency: Annual.

Strategy SD5: Attract Workers with Higher Skills to the PRD

Rationale: The transition to higher-value-added industries will require changes in the labor force to meet demands for new and higher educational levels required for service and high-technnology businesses in contrast to those needed by labor-intensive industries. Based on our pilot survey at Pingshan New District in Shenzhen, 50 percent of residents' education level in that district is junior secondary education; only 4 percent of those interviewed had a full-time job in research and development/high-tech industry.

Recommended practices: In the Pingshan survey, workers with more-sophisticated skills have higher expectations for improved public services, lower pollution levels, and a good work-life balance. Chapters Five through Eight offer many strategies aimed at improving the quality of life in the PRD that would make it more attractive to more-skilled and better-educated workers. Here we recommend a strategy of recruitment and improved information exchange between PRD-based "new economy" and service-sector firms and educational insti-

tutions both within the PRD and elsewhere in China about both job opportunities and quality of life in the PRD.

Since many cities in the PRD region are working toward transitioning their industrial base to less labor- and energy-intensive activity, there may be advantages to the region as a whole to launch joint marketing campaigns rather than compete against one another. Such a strategy has been implemented in the Baltic Sea Region under an initiative that aims to increase the competitiveness of the region as a whole by branding it as a unified area, namely the One Baltic Sea Region (ONE BSR) and focusing on retention of talent (Ketels and Summa, 2014). However, the best strategies to attract higher-skilled workers will be the ones that produce visible signs of improvement in the quality of life as demonstrated by the indicator system recommended for development in this study.

Indicators:

- D6: Number of workers in key areas: assembly (D6a), high tech (D6b), and business services (D6c).
  - Explanation: Tracking the distribution of workers across sectors in conjunction with surveys of business labor demand will enable PRD policymakers to better target recruiting plans.
  - Data source and availability: Data on number of workers are available, but these data need to be disaggregated to provide more depth of understanding about supply and demand across sectors and skill levels.
  - Frequency: Annual.
- D7: Percentage of residents satisfied with their job situation.
  - Explanation: The percentage of residents satisfied with their job situation is a subjective indicator of well-being. Increases in this indicator over time would be a positive sign that a growing number of residents are matched to jobs that meet their personal expectations of rewarding work.
  - Data source and availability: These data can be collected through the resident survey.
  - Frequency: Every two years.

Strategy SD6: Train Graduates for Work in Emerging Industries

Rationale: The labor force of the PRD region will need to adjust to meet the changing needs for skills. However, the provincial and municipal governments will wish to ensure that poorer, less-well-educated citizens are prepared to take advantage of new opportunities offered by the transition by providing more opportunities for retraining and adult education. High regional income inequality can partly be attributed to inequality in opportunities for education. A World Bank study assessing income inequality in Guangdong Province found that those residents with only primary school or junior secondary education are 96 percent and 19 percent, respectively, more likely to be poor than those with a high school education (World Bank, 2011).

Recommended practices: The private sector, often with the cooperation of the government, can take the lead in attracting and retaining skilled workers. In the Philippines, the Filipino Technical Education and Skill Development Authority (TESDA) collaborated with employers prior to curriculum design to ensure programs produced graduates with the skills necessary to succeed in the private sector. Such close engagement with employers also increased the value of TESDA certification in the labor market because of its effect on enhancing trust

among employers (INSEAD, 2013). To build a highly skilled workforce, the provincial and municipal governments in the PRD region could play a role in coordinating and advising providers of education and training on how to better meet the needs of lower-income, less-educated workers. Curriculum design and course offerings should reflect the skills needed for advancing industrial development envisioned by regional governments.

Indicator:

- D8: Number of graduates from local vocational-technical schools in relevant fields.
  - Explanation: By *relevant field*, we mean those areas of expertise required by the emerging industries. Tracking the number of technical graduates in these fields will improve understanding among policymakers and business leaders about labor supply and gaps in supply that will need to be filled.
  - Data source and availability: The total number of technical graduates is available, but data will need to be disaggregated by technical field.
  - Frequency: Annual.

GD3: Implement Low-Carbon Economic Development Strategies

Strategy SD7: Improve Monitoring and Verification of Emissions Reductions Resulting from Low-Carbon Development Strategies Introduced in the Other Policy Areas [SL3, SL7, ST1–ST6, SE8–SE12]

Rationale: In the discussion of Challenge GD1 earlier in this chapter, we list the particular strategies in land use, transportation, and the environment that will lead to reduced greenhouse gas emissions. However, to evaluate the effectiveness of these strategies, Guangdong will need to strengthen its measurement of actual emissions to then track reductions over time as strategies are implemented. The creation of pilot trading systems for emissions caps in Guangdong Province as a whole and Shenzhen in particular will require that emissions be verified to assess compliance.

Recommended practices: The provincial and municipal governments in the PRD will need to establish a rigorous program for collecting, monitoring, recording, and verifying greenhouse gas emissions. Well-established practices for how to implement and operate such a monitoring system can be found in the United States and among the European Union member states of Germany and Italy (Falconer et al., 2012).

Indicator:

- D9: Energy intensity of relevant sectors/areas: transportation (D9a), industry (D9b), and waste water treatment (D9c).
  - Explanation: These indicators measure sector-specific energy intensity. They provide a clearer picture of which activities within the region require more policy intervention.
  - Data source and availability: These data are available from local bureaus of environmental protection.
  - Frequency: Annual.

Table 9.1 summarizes the goal, strategies, and indicators for challenge CD1.

Table 9.1
Economic Development Goal, Strategies, and Indicators for Challenge CD1 (Transition and Expansion)

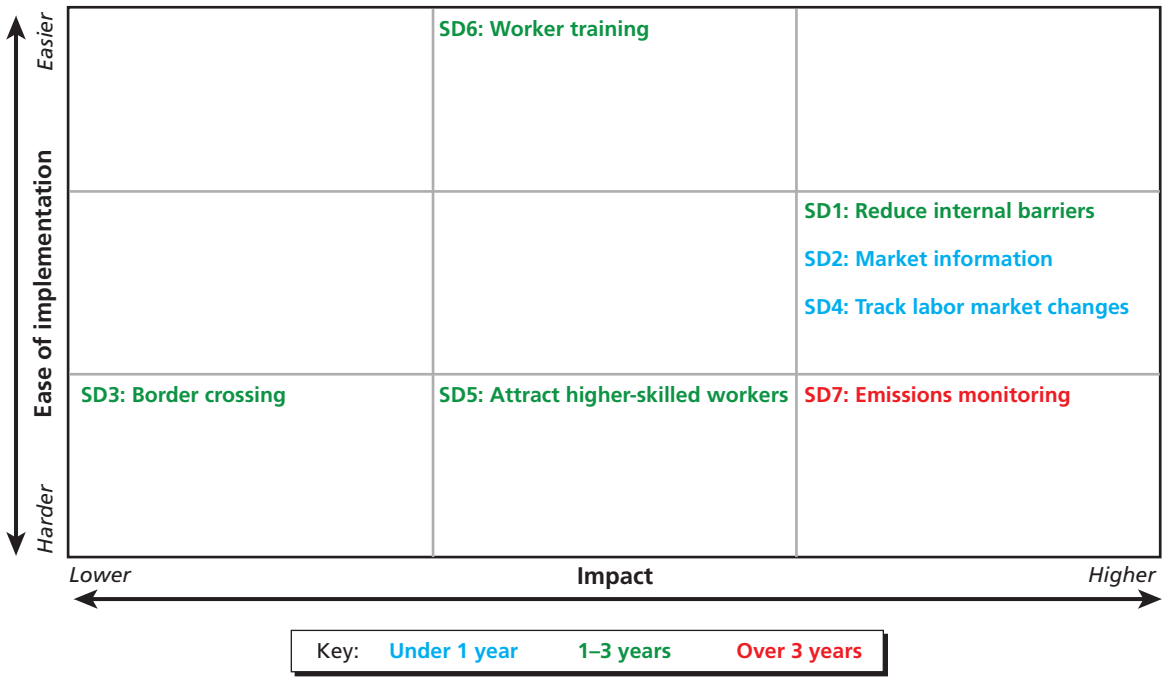
CD1	**Accelerate the economic transition by encouraging more sales to other Chinese provinces, while seeking new, low-carbon opportunities to expand the regional economy.**		
Goal and Strategies		**Proposed Indicators**	
GD1	Raise output and employment by encouraging businesses in the PRD to sell more to other regions in Guangdong and elsewhere in China.		
SD1	Reduce internal barriers to trade.	D1	Annual number of shipping containers (in TEUs) to other regions
SD2	Improve provision of market information on prices, quality, grade, and other product attributes in provinces where PRD businesses are targeting their sales efforts.	D2	Annual growth rate in sales value, by province from base year
SD3	Pilot a preclearance program at a border crossing with Hong Kong–Macao.	D3	Wait times of goods traffic (trucks) when crossing Shenzhen (border with Hong Kong) and Zhuhai (border with Macao)
GD2	Reduce income inequality by improving access to higher levels of education and developing a labor force with more sophisticated skills needed for higher-wage work.		
SD4	Improve the tracking of changes in the PRD labor market.	D4	Number of new jobs created
		D5	Number of jobs lost
SD5	Attract workers with higher skills to the PRD.	D6	Number of workers in key areas: assembly (D6a), high tech (D6b), and services (D6c)[a]
		D7	Percentage of residents satisfied with their job situation
SD6	Train graduates for work in emerging industries.	D8	Number of graduates from local vocational-technical schools in relevant fields
GD3	Implement low-carbon economic development strategies.		
SD7	Improve monitoring and verification of emissions reductions resulting from low-carbon development strategies [SL3, SL7, ST1–ST6, SE8–SE12].	D9	Energy intensity of relevant sectors/areas: transportation (D9a), industry (D9b), and waste water treatment (D9c)

[a] According to the *Chinese Urban Statistics Yearbook* industries list, we consider the assembly sector to include the manufacturing industry; the high-tech sector to include the following industries: information, computer services, and software, and scientific research; and the services sector to include the following industries: finance and real estate services; health care and social welfare; transport, storage, and postal services; hotels and restaurants; and environment and public facilities management.

Priorities for Implementation of Strategies

Some of the strategies recommended in this chapter will require cooperation among several departments, making their implementation more challenging. Figure 9.1 summarizes our judgment about the relative order of impact and degree of difficulty among the economic development strategies. Table E.5 provides the listing of our underlying assessments. We view the reduction of trade barriers and the provision of improved market information as top priorities and relatively easy to implement. We assigned the strategy of attracting higher-skill workers a lower priority only because its success will depend on the success of other strategies in the other policy areas. Increasing the efficiency of freight transport through border crossings

Figure 9.1
Recommended Priorities for Implementation of Economic Development Strategies



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is important, but it will be difficult to implement and may have less overall impact than the other strategies.

CHAPTER TEN

Implementation of the Indicator System and Strategies

We have sought to develop a workable indicator system that would be closely associated with policy strategies aimed at improving the quality of life in the PRD and facilitating improved cooperation and regional integration with Hong Kong and Macao. However, we wish to emphasize, as noted in Chapter Three as well, that the nine prefecture-level cities of the PRD are varied. Hence, the selection of the proposed strategies and indicators will need to be tailored to meet the circumstances and priority goals of each city, district, and county. Not all strategies and indicators will be applicable or useful to every city within the PRD.

Across the five policy areas, we have identified 12 challenges, and proposed a hierarchy of 21 goals, 53 strategies, and 85 indicators to address those challenges. Implementation of the indicator system will need to be staged over several years as strategies are initiated and data collected. While year-over-year consistency will be a mark of strength, it is also the case that the indicator system as a whole will also require periodic review and updating to keep it fresh and relevant to the PRD's challenges. In this chapter, we discuss issues related to implementation and recommend approaches to oversight and management of the indicator system to ensure its utility and sustainability over time at reasonable cost relative to the benefits of having such a measurement system in place.

Integration Across Policy Areas

Successful implementation of strategies and collection of indicators will require close cooperation across departments and bureaus at multiple levels of government. As can be seen in Table 10.1, most of the goals relate to more than one policy area. For example, land use goals will affect transportation, environmental, housing, and economic development strategies. Strategies, however, have different geographic scope and will need to be customized for the cities, districts, and counties where they will be implemented.

Each strategy will require its own team for coordination across departments and levels of government. We discuss roles of each level of government and management issues in the next several sections.

Recommended Roles for Government

As a general matter, the Guangdong Provincial Government Departments of Housing and Urban-Rural Development, Transportation, Environmental Protection, Land and Resources,

Table 10.1
Interrelationships Among Goals Across the Five Policy Areas

Goals	Land Use	Transportation	Environment	Housing	Economic Development
Land Use					
GL1: Increase the contiguity of urban and rural land.	√	√	√		√
GL2: Increase density of residential space and employment opportunities through provision of high-quality compact development.	√	√	√	√	√
GL3: Increase efficiency and cost-effectiveness in the provision of public services and facilities.	√				√
GL4: Reduce the presence of industrial properties in prime residential and commercial areas.	√		√	√	√
GL5: Strengthen measures to protect properties and assets with historical importance and distinctive local characteristics.	√				√
GL6: Reduce vulnerability to damage from natural disasters.	√	√	√	√	√
Transportation					
GT1: Mitigate the need for people to travel by privately owned cars.	√	√	√	√	√
GT2: Improve connectivity among transportation modes and among PRD cities.	√	√			√
GT3: Create an environment that emphasizes nonmotorized transportation modes.	√	√	√	√	
GT4: Manage parking demand and supply.		√			
GT5: Reduce interactions between passenger cars and trucks.		√			
GT6: Reduce deaths and injuries on the roads.		√			
Environment					
GE1: Increase enforcement capacity and accountability.			√		√
GE2: Reduce unlawful industrial and municipal wastewater discharges into rivers and groundwater.	√		√		√
GE3: Reduce contamination of current and former industrial lands.	√		√		√

Table 10.1—Continued

Goals	Land Use	Transportation	Environment	Housing	Economic Development
GE4: Reduce air pollution from stationary and mobile sources.		√	√		√
Housing					
GH1: Ensure that housing (for rental and purchase) remains affordable to households at medium-income levels.				√	√
GH2: Enhance construction of better-quality rental housing that is affordable to lower-income groups.				√	√
Economic Development					
GD1: Raise output and employment by encouraging businesses in the PRD to sell more to other regions in Guangdong and elsewhere in China.					√
GD2: Reduce income inequality by improving access to higher levels of education and developing a labor force with more sophisticated skills needed for higher-wage work.					√
GD3: Implement low-carbon economic development strategies.	√	√	√	√	√

and other key provincial departments, and their counterparts at the city, district, and county levels will play key roles in the implementation and management of the proposed indicator system. For many of the strategies, the municipal governments of the nine cities of the PRD have been delegated the authority by the central and provincial governments to play the leading role, but they will be working closely with governments at the city, district, and county levels to coordinate the design and implementation of these strategies. In some of these cases, the provincial government's role will be primarily technical support and oversight to the cities.

Within each policy area, we recommend the level of government that should have the lead for each of the strategies described in Chapters Five through Nine. Our recommendations are based on our professional judgment of the governmental and geographic level that can be most effective in implementing the particular strategy and on our understanding of current delegation of authorities. For example, we recommend that the provincial government assume greater authority for environmental enforcement and compliance, while continuing to work in close cooperation with cities, districts, and counties. Ultimately, the Guangdong Provincial Government and city governments will need to make these delegation decisions.

For Tables 10.2–10.6, we use the same terminology:

- Lead: The lead level of government is responsible for the design, implementation, management, and operations in support of the strategy and associated indicators; works in close partnership with the co-leads in all functions, and cooperatively with others.

- Co-lead: The co-lead level of government is a critical partner with the lead in the design, implementation, management, and operations in support of the strategy.
- Oversight: The purpose of the oversight role is to ensure consistency in application and enforcement of the strategy across the PRD.
- Technical support: The purpose of the technical support role is to provide a cost-effective source of information and guidance to cities, districts, and counties in their lead and co-lead roles.
- Cooperative: The cooperative role is to advise and help implement strategies led by the cities or province.
- No role: For strategies that are highly local in nature (such as parking meters), the provincial government does not have a direct role.

Land Use

Land use decisions are historically within the control of city governments, not only in the PRD and China generally but throughout the world. However, there are certain functions that are more appropriately led at a higher level of government. In Table 10.2, we summarize our recommended roles for each level of government for each of the strategies. For example, the mapping functions in strategies SL1 and SL11–SL13 would be most efficiently and effectively accomplished at the provincial level, given the need for consistency and coordination across the entire PRD region and Guangdong Province. As another example, strategies SL7 and SL8 relate to major development decisions that have implications for competitiveness among the cities, and for that reason, we recommend that the provincial government take the lead role in their implementation.

Transportation

As summarized in Table 10.3, lead responsibility for implementing the transportation strategies is divided between the provincial government and city governments. We recommend a provincial lead for those strategies that have a regional orientation and that involve linkages among the cities. These include strategies ST3, ST4, and ST11 that are intended to enhance regional connectivity and mobility. Strategy ST5 to develop a specialized travel survey will need to be led by the provincial government but with a close partnership with the cities. Technical development of a mobile application for parking, strategy ST8, would be most efficiently handled at the provincial level with actual implementation then carried out by the cities.

Environment

As summarized in Table 10.4, we recommend that the provincial government play the leading role in implementation of all of the strategies, with the city governments serving as close partners in each step of planning and implementation. We make this recommendation because the PRD and Guangdong Province more generally needs to present a strong and consistent model of compliance assistance and enforcement to all industrial sources, whether state-owned or private, that environmental standards for water, soil, and air. Without this unified regional approach, industries can place cities in competition with one another at the expense of environmental quality.

Table 10.2
Recommended Roles in Implementation of Land Use Strategies for Each Level of Government

Strategy	Province	City	District/ County
SL1: Map ecological protection zones and agricultural land based on productivity.	Lead	Cooperative	Cooperative
SL2: Enforce limits on development of more valuable ecological and agricultural lands.	Oversight	Lead	Cooperative
SL3: Promote transit-oriented development near rail stations (both intercity and urban rail).	Technical support	Lead	Co-lead
SL4: Adopt and enforce a zoning system that uses control on space such as density and design ("form-based codes") rather than a system based on land use function.	Technical support	Lead	Co-lead
SL5: Create a well-connected street network.	Technical support	Lead	Co-lead
SL6: Provide high-quality green space and attractive public spaces within residential and commercial areas.	Technical support	Lead	Co-lead
SL7: Create incentives to concentrate development by providing key infrastructure only in designated areas, consistent with compact development.	Lead	Co-lead	Cooperative
SL8: Develop a brownfields program that includes remediation standards and clear roles for various agencies.	Lead	Co-lead	Cooperative
SL9: Identify and prioritize buildings and neighborhoods with historical and cultural value.	Technical support	Lead	Co-lead
SL10: Enact and enforce historic preservation regulations.	Oversight Technical support	Lead	Co-lead
SL11: Identify and evaluate assets at risk of flooding through mapping.	Lead	Co-lead	Cooperative
SL12: Identify and evaluate assets at risk of typhoon damage through mapping.	Lead	Co-lead	Cooperative
SL13: Identify and evaluate assets at risk of earthquake damage through mapping.	Lead	Co-lead	Cooperative
SL14: GIS mapping	Technical support	Lead	Co-lead
SL15: Master planning review	Technical support	Lead	Co-lead

Housing

Table 10.5 summarizes the government roles for the strategies related to housing. We recommend provincial leadership on three strategies (SH2, SH3, and SH5) because of their important implications for the PRD as a whole as it strives to improve the availability of affordable housing throughout the region. In all strategies, the cities have either a lead or co-lead role, given their leadership on land use issues. Districts and counties also have co-lead roles in strategies SH4 (redevelopment of "villages in cities"), SH6 (housing vouchers), and SH7 (implementation and enforcement of building quality standards).

Economic Development

Table 10.6 summarizes the government roles for the strategies related to economic development. The provincial government is in the best position to lead all of the economic develop-

Table 10.3
Recommended Roles in Implementation of Transportation Strategies for Each Level of Government

Strategy	Province	City	District/ County
ST1: Enhance the competitiveness of bus and rail through improvements in service coverage and frequency.	Technical support	Lead	Cooperative
ST2: Promote bicycle-sharing, car-sharing, taxi, and dynamic ridesharing services.	Technical support	Lead	Cooperative
ST3: Develop multimodal transit hubs to enhance transportation connections, choices, and coordination among modes.	Lead	Co-lead	Cooperative
ST4: Implement smart, interoperable ticketing within the region to make it easier to use alternative forms of public transit.	Lead	Co-lead	Cooperative
ST5: Develop a travel survey that captures inter- and intra-city travel flows and mode use.	Lead	Co-lead	Cooperative
ST6: Connect pedestrian and bicycle greenways and paths to major employment destinations.	Technical support	Lead	Co-lead
ST7: Institute a parking pricing system for on-street parking and encourage entrepreneurs to develop a mobile app that facilitates making payments.	Technical support	Lead	Cooperative
ST8: Encourage multiple entrepreneurs to develop mobile apps that provide real-time information on available parking spaces to make finding parking easier and to avoid illegal parking.	Lead	Co-lead	Cooperative
ST9: Enforce parking regulations and impose high penalties for illegal parking in central business district and other high-demand areas.	No role	Lead	Co-lead
ST10: Implement peak-period delivery restrictions in the central business district and other highly congested areas.	Technical support	Lead	Co-lead
ST11: Create freight consolidation centers in urban fringe areas to reduce the number of deliveries in city center.	Lead	Co-lead	Cooperative
ST12: Integrate RSAs into the project development process for new roads and intersections.	Technical support	Lead	Cooperative

ment strategies, given their regional scope and broader implications for regional economic integration within the PRD including Guangdong Province, Hong Kong, and Macao. Strategies SD5 and SD6 related to worker training will require a close partnership between the provincial government and cities of the PRD. Strategy SD7 (monitoring and verification of greenhouse gas emissions reductions) will be particularly challenging and require provincial leadership with strong participation by the cities.

Limits of the Indicator System

The indicator system is a set of individual indicators linked to attainment of multiple goals, and not intended to lead to the creation of an overall index that somehow condenses the individual indicators into a single score. We strongly advise against this approach. First, weighting of the individual indicators in a composite score is itself a subjective judgment that may greatly

Table 10.4
Recommended Roles in Implementation of Environmental Strategies for Each Level of Government

Strategy	Province	City	District/ County
SE1: Increase the number of inspections by trained inspectors.	Lead	Co-lead	Cooperative
SE2: Increase incentives for enforcement.	Lead	Co-lead	Cooperative
SE3: Increase incentives for compliance.	Lead	Co-lead	Cooperative
SE4: Allow cities, districts, and counties downstream of unlawful discharge of sewage and industrial waste to receive some percentage of the revenue from fines imposed on polluters.	Lead	Co-lead	Cooperative
SE5: Expand water quality monitoring networks for both surface and groundwater.	Lead	Co-lead	Cooperative
SE6: Produce an annual inventory of contaminated waste sites in the PRD region.	Lead	Co-lead	Cooperative
SE7: Establish waste site cleanup funds at the municipal and provincial levels to use to remediate contaminated sites where the owner cannot be found.	Lead	Co-lead	Cooperative
SE8: Accelerate Guangdong's phase-out of coal use, especially for household heating and industrial use, and coal-fired power plants serving all PRD cities.	Lead	Co-lead	Cooperative
SE9: Accelerate the implementation of green building codes and appliance efficiency programs.	Lead	Co-lead	Cooperative
SE10: Accelerate removal of highly polluting vehicles through incentive payments.	Lead	Cooperative	Cooperative
SE11: Increase the number of cleaner cars registered.	Lead	Cooperative	Cooperative
SE12: Accelerate adoption of cleaner vehicle fuels.	Lead	Cooperative	Cooperative

change the overall score depending on how weights are selected. Second, the proposed indicator system is not intended for use as a means of ranking areas, but rather as a tool for assessing the effectiveness of policies. Because the purpose of this system is to closely link indicators to specific policy goals and strategies, each indicator needs to stand on its own in support of evaluation of the effectiveness of strategies and achievement of goals.

We have included both subjective and objective indicators for several reasons. First, quality of life is by its nature a matter of human perception, albeit informed by the objective reality of conditions in the surrounding environment. Second, residents' perceptions of quality of life are important to provincial and municipal leaders as they set forth policy and implement programs intended to improve quality. They are a valuable complement to objective indicators. Third, objective indicators have the obvious advantage of technical consistency and standardization across geographic areas. However, changes in objective indicators may take some time to be noticed or perceived by residents, and therefore may serve as a leading indicator of residents' perceptions of improvements in quality of life.

Table 10.5
Recommended Roles in Implementation of Housing Strategies for Each Level of Government

Strategy	Province	City	District/ County
SH1: Create incentives for developers to build more affordable rental housing and housing for purchase through competitive requests for proposals (RFPs) for below-market priced land.	Oversight Technical support	Co-lead	Cooperative
SH2: Increase funding capacity and reduce government reliance on development fees by levying property taxes on homes.	Lead	Co-lead	Cooperative
SH3: Require a certain percentage of public rental housing units and affordable housing for purchase in TODs.	Lead	Co-lead	Cooperative
SH4: Redevelop "villages in cities" using land readjustment techniques.	Oversight Technical support	Lead	Co-lead
SH5: Adjust housing construction programs like CRH to allow developers to build low-cost rental units.	Lead	Co-lead	Cooperative
SH6: Provide housing vouchers to low-income residents, where voucher payments are directly provided to landlords after unit inspected and lease signed.	Oversight Technical support	Lead	Co-lead
SH7: Implement and enforce building and amenity standards for all public rental housing units and rental units built by private developers.	Oversight Technical support	Lead	Co-lead

Table 10.6
Recommended Roles in Implementation of Economic Development Strategies for Each Level of Government

Strategy	Province	City	District/ County
SD1: Reduce internal barriers to trade.	Lead	Cooperative	Cooperative
SD2: Improve provision of market information on prices, quality, grade, and other product attributes in provinces where PRD businesses are targeting their sales efforts.	Lead	Cooperative	Cooperative
SD3: Pilot a preclearance program at border crossing with Hong Kong–Macao.	Lead	Cooperative	Cooperative
SD4: Improve the tracking of changes in the PRD labor market.	Lead	Cooperative	Cooperative
SD5: Attract workers with higher skills to the PRD.	Lead	Co-lead	Cooperative
SD6: Train graduates for work in emerging industries.	Lead	Co-lead	Cooperative
SD7: Improve monitoring and verification of emissions reductions resulting from low-carbon development strategies introduced in the other policy areas (SL3, SL7, ST1–ST6, SE8–SE12).	Lead	Co-lead	Cooperative

Strategies and Priority Setting

In Chapter Three, we noted the limitations of our evaluation of strategies and that caveat bears repetition and expansion in the context of implementation. The study focused on the development of a wide-ranging quality of life indicator system and the recommendation of accompanying strategies that would help move the PRD and Guangdong Province along a path of progress across each of the five policy areas.

Each of the strategies discussed in this study will require further analysis prior to implementation. In some cases, our recommendations either build on or accelerate policy strategies already in place. This is particularly true for some of the proposed strategies to improve air quality. RAND did not conduct a detailed policy analysis of alternative strategies to evaluate their relative benefits and costs. We strongly recommend that the respective departments at the provincial level in collaboration with their counterparts in municipal governments undertake such comparative analyses to ensure that public resources are efficiently and effectively allocated. In addition, by agreement with HURD prior to the initiation of the project, we focused on land use and transportation and therefore devoted fewer project resources to the development of strategies for the environment, housing, and economic development areas. This lighter treatment is reflected in the fewer number of strategies and less detail on international practices.

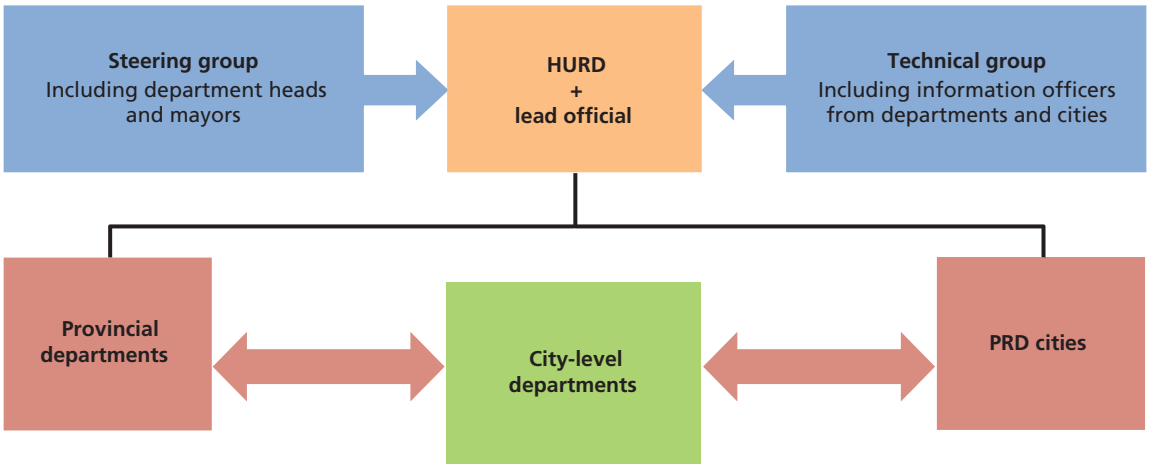
With these limitations in mind, we have recommended, in the closing sections of Chapters Five through Nine, starting with strategies that are both high impact and relatively easy to implement within each policy area. Early success is important in building both implementation capacity and evidence of progress while also laying the groundwork for the more difficult strategies. We advise turning to some of the moderately difficult but still higher-impact strategies that may need more lead time, consultation, or technical assistance to implement. The next tranche of strategies could be relatively easy even though of relatively lower impact to help maintain momentum and take advantage of "low hanging fruit." Finally, for the higher-impact but more challenging strategies requiring more time, analysis, and consultation, we advise the establishment of special multi-agency working groups or other similar processes to begin charting a path toward implementation.

Proposed Management Structure for Implementation

The indicator system cuts across five major policy areas and many departments at the provincial and municipal levels. Centralized oversight and accountability for the overall system will be essential to its success, although responsibility for data collection and implementation of strategies will need to be widely diffused. Figure 10.1 offers a suggested management structure that reconciles the need for both high-level leadership and coordination across provincial departments and with cities and their respective departments.

The Guangdong Provincial Government has designated HURD as the lead implementer of the indicator system. We recommend that the Director-General of HURD name a senior official to be the lead official of the province-wide indicator system. Because so much of the data gathering will need to take place across multiple departments at both the provincial and municipal levels, the designation of a single individual with responsibility for overall implementation will improve both the focus and the efficiency of decisionmaking.

Figure 10.1
Recommended Management Structure for the Indicator System



The lead official would chair a steering group of officials from each of the provincial-level departments and mayors' offices of the nine cities. The steering group will provide important guidance and support to HURD for implementation of individual strategies across the departments at the provincial and municipal levels. We also recommend that the director-general of HURD name a chief information officer (CIO) who would chair a technical group of CIOs and information technology and database systems experts from each of the provincial-level bureaus and mayors' offices. These technical leads will ensure smooth, timely, and accurate uploading of indicator data from provincial departments and counterpart departments in cities. As shown in Figure 10.1, the departments at the city level will be key data gathers and will need to work in close coordination with their counterpart department at the provincial level to ensure consistency with provincial-level guidance on indicators, and also work closely with their own mayors' offices and other city-level departments.

The first task of the lead official will be to develop a detailed business plan that includes a description of roles and responsibilities of the various departments, the sequence of management activities to enable implementation, the timing of building the database structure, the plan for sequencing the collection of baseline indicators across the PRD, and the timing and plans for launching the highest-priority strategies. Implementation of strategies will need to be carefully coordinated and consistent with existing policy and budget-setting procedures and practices in place at the provincial and municipal levels. From this base of information, the lead official in consultation with the departments would develop an implementation budget that includes both startup and annual maintenance costs.

Each strategy at the provincial and city level would have a public official whose job performance is tied to timely and effective implementation. Each responsible provincial level official will add context and details to the implementation plan and budget developed by the lead official in consultation with city officials.

Data Availability

Availability of data to populate the indicator system has been a primary concern throughout the project. There are obvious advantages of relying on data that already exist. They are easy, cheap, and accessible. However, there are also advantages to using the development of the indicator system and implementation of new strategies as a spur to collect new or better data that will provide more direct, meaningful feedback on progress toward goals. We have sought to strike a balance between available data and "aspirational" data that will emerge as new strategies are implemented.

Our assessment of data availability for the indicators falls into one of four categories:

1. Objective indicators (not from GIS): These data already exist and are available in the required format.
2. Objective indicators available in GIS: These data exist in some cities but not all.
3. Objective indicators available after implementation: Data for strategies that have not yet been implemented but that will be available in the future.
4. Subjective indicators available through a resident satisfaction survey: These data can be readily collected through future surveys.

Table 10.7 summarizes our classification. In consultation with our local partners, we have ascertained that non-GIS data for 33 of the 85 indicators are already being collected at the provincial or municipal level; GIS data will be required for eight land use indicators, some of which may already be available in cities; data for 30 indicators will be available following implementation of a proposed strategy. Tables D.1–D.5 in Appendix D provide the details regarding availability of each of the individual indicators. Table D.6 summarizes the classifications across all of the indicators.

In the early months of implementation, HURD and local partners will be leading in the full assessment of the availability of baseline data and its subsequent collection and incorporation into the indicator system's master database.

Table 10.7
Assessment of Data Availability for Proposed Indicators

	Objective Indicators (Not GIS) Available Now	Objective Indicators Available in GIS	Objective Indicators Available After Implementation of Strategy	Subjective Indicators Available After Survey	Total by Policy Area
Land use	2	8	10	5	24
Transportation	7	0	5	5	17
Environment	15	0	6	4	25
Housing	2	0	8	0	10
Economic development	7	0	1	1	9
Total by category	33	8	30	15	85

Database Management and Visualization Tools

We recommend that all indicator data be stored in a relational database that will enable easy linkage to geographic information systems coverage files of political boundaries, census data, and other relevant information.[1] The database should be available government-wide and should be made available to the general public after full testing. This can be done through the use of a password-protected cloud-based server and website portal. Transparency will be an important component of the data quality assurance process and a driver in improving performance across the entire spectrum of indicators.

The CIO would be responsible for maintaining the database and associated software and putting protocols in place to enable uploading of data from multiple sources at any time. The CIO would also develop protocols for maintaining newly uploaded data in a temporary file until data quality procedures are applied and the data are cleared for inclusion in the online, publicly available database.

Visualization of data will be an important tool for communicating the content of the indicator system to decisionmakers and to the public and is integral to increasing transparency. For this reason, we recommend that effort be made to embed the relational database within a flexible and easy-to-use visualization software platform. Such a platform will enable easy display and comparison of indicators using graphics rather than tabular data. Visualizations also will enable efficient analysis of patterns and trends in the data, permit the quick building of figures and tables for reports across the various government entities that will be populating the indicator system, and support decisionmaking throughout interactive graphics.

Sustainment of the Indicator System

The success of the indicator system will be judged by its ability to focus public resources on improving conditions in the PRD that lead to both the perception and reality of a better quality of life for all of the region's residents. Beyond the difficulties of actually collecting the data to populate the indicators, there are two fundamental challenges for the provincial government. First, sustained resources will be required to maintain and expand the indicator system, as needed. For this reason, it is important that the business plan developed by the lead administrator take a realistic view of the costs of data collection and find ways to leverage funds already being spent on data to gain efficiencies and save costs. For example, resident satisfaction surveys at the city level would be valuable to individual districts as well as provincial departments; costs can be shared.

A second challenge is to instruct and demonstrate for mid- and higher-level officials throughout all levels of government the use of indicators to guide development, monitoring, and evaluation of policy strategies. Policy analysis in advance of implementation can save money and yield better outcomes. Through its organization and provision of data, the indicator system is a key contributor to the policy analysis process. As with the first challenge of sustained resources, this challenge will require sustained attention from Guangdong's top leadership to ensure the long-term success of the effort.

[1] There are many relational database software packages available including Oracle, Microsoft Access, SQLite, and MySQL. RAND does not make product recommendations or endorsements.

CHAPTER ELEVEN

Conclusions

The Guangdong provincial government directed HURD to lead the development and implementation of a quality of life indicator system for the PRD, including the pilot testing of a resident satisfaction survey in the Pingshan New District of Shenzhen. At HURD's request, RAND undertook the task of developing a conceptual framework for the indicator system and recommendations on strategies in five policy areas that would contribute collectively to the improvement of quality of life in the PRD. As part of our original agreement, we focused our efforts primarily on land use and transportation.

We selected strategies after an initial phase of research to identify the primary challenges facing the PRD in the years ahead and goals consistent with meeting those challenges. In some cases, national, provincial, and municipal leaders had already set appropriate goals. In other cases, we proposed statements of goals that were consistent with the mutually agreed on challenges. We then identified both objective and subjective indicators that would support the assessment of progress toward or attainment of goals as well as the evaluation of the performance of individual strategies.

Several common themes emerged as we first separately developed the strategies in each of the policy areas to be responsive to the challenges in the PRD, and then stepped back to consider the proposed strategies as a whole. We chose strategies that would

- increase transparency and accountability in regulation
- increase compliance with regulations by improving the effectiveness of incentives
- expand access to public services and quality improvements
- increase pace of improvements in public services and the environment
- improve data and analysis to better guide decisionmaking
- reduce pollution and improve health and safety.

All of these themes are important, but their ordering above reflects our sense of the priority in sequencing their implementation. Justification for government intervention in each of these policy areas is strongest on grounds of correcting for market failures, such as the discharge of pollutants in the process of manufacturing goods and generating economic value. Economists call pollution an *externality*, meaning that its costs are borne by surrounding communities, not the factory owner. Environmental regulation is a means of internalizing the externality of pollution. Similarly, land use policies are intended to protect valuable ecological, agricultural, or culturally significant lands that developers or government officials would otherwise develop for their own economic gain or to secure additional revenue for their city. In these examples and many others, the regulation of economic activity must be done with integrity, fairness, con-

sistency, and a strong scientific basis. Transparency and accountability in regulation increase public confidence and enable improvements in public services and quality of life.

There are two sides to improving the regulation of economic activity: compliance and enforcement. Effective incentives means that officials and business owners, whether of private or state-owned enterprises, are motivated to follow a policy or regulation because they will be rewarded for doing so, or at a minimum, penalized at a level sufficiently high to discourage noncompliance. Another way of expressing this idea is to say that the incentives are aligned with expected rational behavior of those targeted for action. For example, when fines and penalties are too low, business owners or land developers often find that it is more profitable to pay those fines (if noncompliance is even detected) than paying the costs for pollution control or affordable housing built to standards. The equation for compliance needs to change in the PRD to bring about good behavior among those being regulated; otherwise, innovation in regulation or other types of policy cannot be successful.

Some of our proposed strategies address the need for improvements in public services. The Pingshan Resident Satisfaction Survey provided a number of examples of how public services could be improved to meet residents' expectations and improve their view of their own communities. Increasing the convenience and the experience of public transportation ranked high on the list among those surveyed. Improving access to green space, improving water quality, preserving ecologically valuable lands, and expanding cultural opportunities within walking distance all were valued highly by residents. Although environmental policy was not one of the two areas of primary focus in this study, we wish to underscore the centrality of improving air, water, and soil quality throughout the PRD as major contributors to residents' perceptions of quality of life in the region.

Building a culture of evidence-based policymaking throughout the PRD could be the most important legacy of this indicator system. The process of choosing indicators first requires a careful analysis of the pathway to desired outcomes in each of the policy areas. Getting to desired outcomes sometimes requires a number of intermediate steps. For example, cleaner air and cleaner water are the *outputs* of environmental regulation. Better human and ecological health are the *outcomes* of having cleaner air and water. However, getting to these outputs and outcomes requires all the necessary ingredients (*inputs*) for successful environmental regulation: adequate staffing, incentives for compliance, strong and consistent enforcement, and a solid scientific basis for regulation and monitoring. For this reason, across all policy areas, we emphasize the need for investing in strategically designed data collection and conducting analysis to assess policy strategies before, during, and after implementation. Indicators that are viewed as accurate and grounded in sound data collection methods will lend credibility to claims of improving quality of life in the PRD. It is an investment worth making.

The ability to attract higher-skill workers to the PRD will be enhanced if, over time, the PRD develops a reputation inside and outside of China as having made great strides in each of the policy areas addressed in this study. An indicator system is only one of many management tools that governments have to work with, but it can become a powerful tool if it can be seen as a credible representation of progress toward meeting challenges facing the PRD region and a reliable and trusted means of demonstrating that policy strategies are contributing to achievement of Guangdong's long-term goals of a better life for all residents.

APPENDIX A

Pingshan Survey Interviews, by Community

Table A.1
Number of Interviewees in Communities of Pingshan New District

Community	Township	Total Population[a]	% of Total Population	Target # of Interviews/ Actual # of Interviews	% of Total Targeted Interviews
Grand total		691,157	100.0	1,822/1,869	100.0
Xiuxin	Kengzi	61,440	8.9	96/98	5.3
Longtian	Kengzi	48,461	7.0	96/97	5.3
Jinsha	Kengzi	38,679	5.6	96/76	5.3
Laokeng	Kengzi	25,076	3.6	75/84	4.2
Shatian	Kengzi	22,739	3.3	75/96	4.2
Kengzi	Kengzi	9,483	1.4	50/50	2.8
Liulian	Pingshan	58,617	8.5	96/94	5.3
Jiangling	Pingshan	51,694	7.5	96/52	5.3
Biling	Pingshan	49,316	7.1	96/95	5.3
Zhukeng	Pingshan	48,121	6.9	96/98	5.3
Shijing	Pingshan	37,235	5.4	96/107	5.3
Pinghuan	Pingshan	36,260	5.2	94/101	5.2
Shatang	Pingshan	35,825	5.2	93/103	5.2
Liuhe	Pingshan	34,985	5.1	91/75	5.1
Nanbu	Pingshan	31,573	4.6	75/98	4.2
Shahu	Pingshan	25,345	3.7	75/49	4.2
Pingshan	Pingshan	23,156	3.3	75/96	4.2
Tangken	Pingshan	17,724	2.6	75/75	4.2
Heping	Pingshan	15,259	2.2	75/75	4.2
Tiantou	Pingshan	10,756	1.6	50/74	2.8
Tianxin	Pingshan	7,305	1.1	50/75	2.8
Maluan	Pingshan	1,465	0.2	50/50	2.8
Jingui	Pingshan	643	0.1	50/51	2.8

[a] Population data current at the time of the survey in July 2014. Pingshan's population has since declined from about 700,000 to 600,000.

APPENDIX B

Pingshan Survey Questions and Aggregated Response Frequencies

N = 1,869

1. Resident Status Type:

Original	3%
Registered, Not Original	2%
Floating	95%

2. Gender:

Male	58%
Female	42%

3. Age

18–24 years	23%
25–34 years	42%
35–44 years	22%
45–54 years	11%
55–65 years	2%
65+ years	<1%

4. In this survey we are interested in opinions about quality of life. By quality of life, we mean the quality of the conditions in which you live, such as having access to transportation choices, jobs, housing, and green space; having adequate opportunities for recreation and leisure time; living in a pleasant, safe community, being able to breathe clean air or drink clean water. So thinking about overall quality of life right now in Pingshan New District, do you think it is …

Very good	5%

Good	43%
Average	48%
Poor	3%
Very poor	<1%
DON'T KNOW (DK)	0%

5. Thinking about the future, do you think overall quality of life in Pingshan New District will…

Improve a lot	13%
Improve a little	72%
Stay the same	8%
Get a little worse	2%
Get a lot worse	<1%
DK	4%

6. For you answer to Q5, what is the main reason you think that?

New district with good development potential	34%
Economy will continue to grow	35%
Improved living enviroment	24%
There will be new planning	14%
Abundant natural resources	1%
Population will shrink	2%
New development may worsen the natural environment	2%
Lack of planning	3%
Other	6%
DK	6%

7. How important is it to you that Pingshan New District preserves . . .Is it very important, somewhat important, unimportant, or very unimportant to you?

	Very Important	Somewhat Important	Neither	Unimportant	Very Unimportant	Don't Know
a. Ecological land (mountain, water resource)	61	34	3	1	<1	1
b. Agricultural land	30	38	16	8	<1	7
c. Community, cultural heritage	38	38	12	5	<1	6

Next, I'm going to ask you questions about the specific community you live in.

8. How much do you agree or disagree with the following statement, "Today, I like the way [COMMUNITY NAME] looks and feels"? Do you…

Strongly disagree	1%
Disagree	8%
Neither agree nor disagree	43%
Agree	45%
Strongly agree	2%
DK	<1%

9. For Q8, What is the main reason you think that?

Career advancement potential	9%
Good public safety	25%
Good living enviroment	31%
Friendly neighbors	8%
Convenient transportation	10%
Lack of good urban design and management	11%
Lack of leisure and entertainment	11%
Lack of public space and park	10%
Lack of planning	<1%
Lack of public transportation	7%
Economic downturn in community	2%

Other	11%
DK	3%

10. Next I will read a few statements about the land utilization characteristics in [COMMUNITY NAME]. Please think about [COMMUNITY NAME] as it is right now. A. Tell me whether you strongly agree, agree, disagree or strongly disagree with each of these statements? B. Do you feel it is important?

[COMMUNITY NAME] has…

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Don't Know	Yes	No	Don't Know
a. A good mix of housing, shops, and other types of buildings	3	44	37	12	1	3	90	5	5
b. Historic preservation of structures or buildings	4	35	20	24	1	16	81	11	8
c. Access to nature in parks, open spaces, or garden	11	56	15	15	2	1	94	3	3
d. Attractive public spaces (social place like public square or park)	8	47	21	20	3	1	93	4	3
e. A sense of community (people support each other, friendly, helpful)	15	54	21	7	<1	2	94	3	3
f. A safe environment (low crime	18	54	17	9	1	1	97	1	2
g. Access to transportation options other than driving a private car	7	59	22	8	1	3	90	6	4

11. How much do you currently walk around your neighborhood for pleasure?

Daily	34%
Several times a week	23%
About once a week	17%
About once a month	6%
Not at all	20%
DK	<1%

12. IF Q11 = Not at all, about once a month: Why don't you walk around for pleasure more often? IDENTIFY ALL THAT APPLY.

Lack of time	68%
The weather	2%
Poor air quality	3%
Fears for personal security (from people)	<1%
Fears for safety (from vehicles)	<1%
Lack of knowledge of walking environment	2%
Lack of motivation in general	18%
City blocks are too long and spread apart	1%
Lack of tree canopy or shade	3%
Lack of benches for resting	4%
No sidewalks or sidewalks are of poor quality	4%
Too small (nothing interesting to see)	6%
Other	5%
DK	<1%

13. Thinking about [COMMUNITY NAME], are you very satisfied, somewhat satisfied, neither satisfied or dissatisfied, somewhat dissatisfied, or very dissatisfied with …

	Very Satisfied	Somewhat Satisfied	Neither	Somewhat Dissatisfied	Very Dissatisfied	Don't Know
a. The air quality	9	59	9	20	3	<1
b. The quality of drinking water	6	57	10	22	4	1
c. Local government efforts to preserve the environment	6	48	14	19	3	10
d. Frequency of home garbage collection	9	63	7	17	4	<1
e. Frequency of collection of garbage generated from commercial places near your home	5	55	12	18	3	7

14. In your opinion, has the quality of the air in [COMMUNITY NAME]

Improved a lot	2%
Improved a little	34%
Stayed the same	52%
Gotten a little worse	8%
Gotten a lot worse	2%
DK	2%

15. In your opinion, has the quality of the drinking water in [COMMUNITY NAME]

Improved a lot	1%
Improved a little	25%
Stayed the same	62%
Gotten a little worse	7%
Gotten a lot worse	2%
DK	3%

16. Do you or someone in your family suffer from asthma or other respiratory illnesses?

Yes	8%
No	89%
DK	3%

17. How safe against natural disasters like flooding do you feel in [COMMUNITY NAME]?

Very safe	10%
Safe	74%
Unsafe	12%
Very unsafe	2%
DK	2%

18. Do you own or rent the residence you live in?

Own	7%
Rent	84%
Do not own but do not pay rent	9%
Prefer not to say	<1%

19. What type of residence is this?

Individual housing for own use	<1%
Rental built by village	79%
Commercial real estate	3%
Government housing	<1%
Dorm room for factory	16%
Other	<1%

20. Thinking about the building you live in right now, are you very satisfied, somewhat satisfied, neither satisfied or dissatisfied, somewhat dissatisfied, or very dissatisfied with …

	Very Satisfied	Somewhat Satisfied	Neither	Somewhat Dissatisfied	Very Dissatisfied	Don't Know
a. Amount of living space	10	57	13	18	2	0
b. Quality of construction	6	61	13	16	1	3
c. The bathroom facilities	6	60	12	18	3	<1

21. Do you feel that where you live right now is affordable on your salary?

Yes	89%
No	10%
DK	1%

22. Is the impact from noise to your life a …

Serious problem	18%
Moderate problem	21%
Minor problem	41%
Not a problem at all	19%
DK	<1%

23. IF Q22=serious or moderate problem, ASK: What is the source of the noise problem? [CIRCLE ALL THAT APPLY]

Neighbor	21%
Street vendors	22%
Loud speakers from commercial business	21%
Factory manufacturing	21%
Traffic	33%
Construction	16%
Old people dancing and playing music	4%
Other	2%
DK	<1%

24. How satisfied or dissatisfied are you with the diversity of housing options available to you? Are you…

Very dissatisfied	2%
Dissatisfied	12%
Neither satisfied or dissatisfied	54%
Satisfied	23%
Very satisfied	2%
DK	7%

25. How satisfied or dissatisfied are you with the availability of good housing that is affordable? Are you…

Very dissatisfied	4%
Dissatisfied	19%
Neither satisfied or dissatisfied	50%
Satisfied	22%
Very satisfied	2%
DK	3%

26. To which of the following can you walk from your current residence in 10 minutes? ASK B ONLY IF “YES” (2): And, are you satisfied with the quality of the….

	Yes	No	Don’t Know	Satisfied	Not Satisfied
a. Public library or cultural building	24	66	10	76	24
b. Leisure, recreation, or sports facility	56	38	6	78	22
c. Doctors, health clinic	64	33	3	74	26
d. Children’s school	56	35	9	88	12
e. Park, open, or green space	57	40	3	79	21
f. Bus stop or station	91	9	<1	80	20
g. Grocery store or market	85	13	1	79	21

27. To what extent is each of the following transportation issues a problem for you in your daily life? A. Is it a serious problem, moderate problem, minor problem or not a problem at all?

	Serious Problem	Moderate Problem	Minor Problem	Not a Problem at All	Don't Know
a. Traffic congestion from too many cars on the road	18	30	37	14	<1
b. Traffic congestion from freight trucks	15	26	40	16	3
c. Safety in driving due to sharing road with trucks	22	31	32	12	3
d. Lack of metro (subway) service to reach downtown Shenzhen	38	37	19	3	3
e. Lack of rail service to reach other cities in PRD	28	34	25	6	7
f. Road condition for biking is unsafe	18	30	41	8	3
g. Finding secure parking for bicycles	18	33	37	9	3
h. Safety in crossing the street at pedestrian crosswalks	26	30	35	8	<1
i. Lack of connectivity in various transportation options (bus, rail, cycling)	15	35	40	7	3
j. Dangerous driving by others including drunk driving and speeding	38	18	23	9	12

28. Local government is promoting greenway construction (dedicated bike lane or walk path with green landscaping). Do you use the greenway for any of the following trip purposes? CIRCLE ALL THAT APPLY

Travel to work	45%
Travel to school	7%
Travel for leisure and sports	37%
Travel for shopping	11%
Or is it not used at all?	18%
Other	2%
DK	5%

29. How satisfied are you with the availability of traffic safety education by local government?

Very satisfied	6%
Somewhat satisfied	34%
Neither satisfied nor dissatisfied	38%
Somewhat dissatisfied	11%
Very dissatisfied	3%
DK	8%

30. And, what methods do you use to get necessary information about the local government programs? CIRCLE ALL THAT APPLY

Internet	43%
TV	36%
Radio	3%
Public poster	16%
Flyer	4%
Newspaper	4%
Word of mouth (other people)	10%
In-person at government department	5%
Text message	5%
Other	4%
DK	11%

31. How important is it for you to own your own car?

Very important	27%
Somewhat important	28%
Neither important nor unimportant	28%
Unimportant	14%
Very unimportant	2%
DK	<1%

32. If important: Why is that?

Commute convenience	10%
More convenient for daily life	89%
Status	1%
Other	<1%
DK	0%

33. How many passenger cars does your household own?

0	76%
1	21%
2+	3%

34. IF Q33>0, ASK: To what extent is finding parking for automobiles a problem for you in your daily life?

Serious problem	31%
Moderate problem	22%
Minor problem	31%
Not a problem at all	15%
DK	<1%

35. IF Q33>0, ASK: To what extent is the cost you pay to park an automobile a problem for you in your daily life?

Serious problem	13%
Moderate problem	23%
Minor problem	38%
Not a problem at all	24%
DK	2%

36. Thinking about public transport in Pingshan New District, based on your experiences and perceptions, do you agree or disagree with the following:

Public transport in Pingshan New District is…

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Don't Know
a. Affordable	14	61	19	4	<1	2
b. Frequent (comes often)	7	49	24	14	3	2
c. Goes where you need it to go	6	53	26	11	2	2
d. A slow way to travel because of number of transfers required	12	40	28	16	1	3

37. Which of the following best describes your current employment status?

Fully employed worker	79%
Not fully employed worker	9%
Not employed	11%
Prefer not to say	1%

38. IF employed: What type of job do you have? Response categories will not be read—interviewer just select closest to respondent's answer.

Farming, fishing, mining	0%
Manufacture	58%
Electric power, gas, and water	1%
Construction	3%
Transport, storage, and postal services	2%
Information, computer services, and software	3%
Wholesale and retail stores	11%
Hotels, restaurants	5%
Finance, real estate services	2%
Scientific research	1%

Environment and public facilities management	1%
Resident services and other services	8%
Education	1%
Health care, social welfare	1%
Culture, sports, and recreation	1%
Public administration and social organizations	1%
Other	1%

39. IF employed: How do you travel to work on an average day? CIRCLE ALL THAT APPLY

Drive car	8%	
Passenger in car	1%	
Carsharing, ridesharing, taxi serivce	<1%	
Bus, Bus Rapid Transit		10%
Light rail, commuter train, metro	<1%	
High speed rail	<1%	
Cycle	32%	
Walk	55%	
Other	2%	

40. IF employed: Where is the location of your work?

Your community	81%
Elsewhere in Pingshan New District	15%
Shenzhen	3%
Some other location	1%

41. If employed: ASK: How long do you spend traveling to and from work on an average day? [RECORD ANSWER IN MINUTES]

To Work:_____

<11 min	65%
11–20 min	23%
21–30 min	9%
31–59 min	2%
>60 min	2%

From Work:_____

<11 min	64%
11–20 min	23%
21–30 min	9%%
31–59 min	2%
>60 min	2%

42. If employed: ASK: How satisfied or dissatisfied are you with the balance between your work and other aspects of your life such as time with family or leisure?

Very dissatisfied	3%
Dissatisfied	13%
Neither satisfied or dissatisfied	39%
Satisfied	40%
Very satisfied	5%

43. If employed, ASK: Which of the following best describes how well your total income meets your everyday needs for things such as housing, food, clothing and other necessities?

Have more than enough money	7%
Enough money	44%
Just enough money	36%
Not enough money	8%
Prefer not to answer	5%

44. If employed: ASK: On the whole, are you very satisfied, somewhat satisfied, neither satisfied or dissatisfied, somewhat dissatisfied, or very dissatisfied with . . .

	Very Satisfied	Somewhat Satisfied	Neither	Somewhat Dissatisfied	Very Dissatisfied	Don't Know
a. Your personal job situation	8	45	38	8	1	<1
b. The length of time it takes for you to travel to work	16	52	23	7	2	<1
c. The financial situation of your household	3	28	47	18	3	<1

I just have a few more questions.

45. Currently how many persons live in your household, including yourself? By household we mean people who live in the same dwelling as you.

1	17%
2	31%
3	20%
4	17%
5+	15%

46. How many of these persons are age 18 and older [driving age]?

1	19%
2	53%
3	14%
4	8%
5+	6%

47. What is the highest grade you have achieved?

Less than primary education	2%
Primary education	8%
Junior secondary education	41%
Senior secondary education	23%
Specialized secondary education	12%
Tertiary education	14%

APPENDIX C

Summary of Findings from Pingshan Resident Satisfaction Survey

In this appendix, we present a narrative summary of findings from the Pingshan Resident Satisfaction Survey. This summary is not intended to be a complete presentation of survey results, but rather an overview of the observations we found most salient with respect to the development of targeted policy strategies and indicator system. As noted in Chapter Four, the survey has a sampling error of plus or minus 10 percent with a 95 percent confidence interval. With this level of imprecision, readers are cautioned to not infer statistical significance to small differences between groups and categories. The full survey data set from the survey can be acquired in tabular form on request to HURD.

Views on Overall Quality of Life

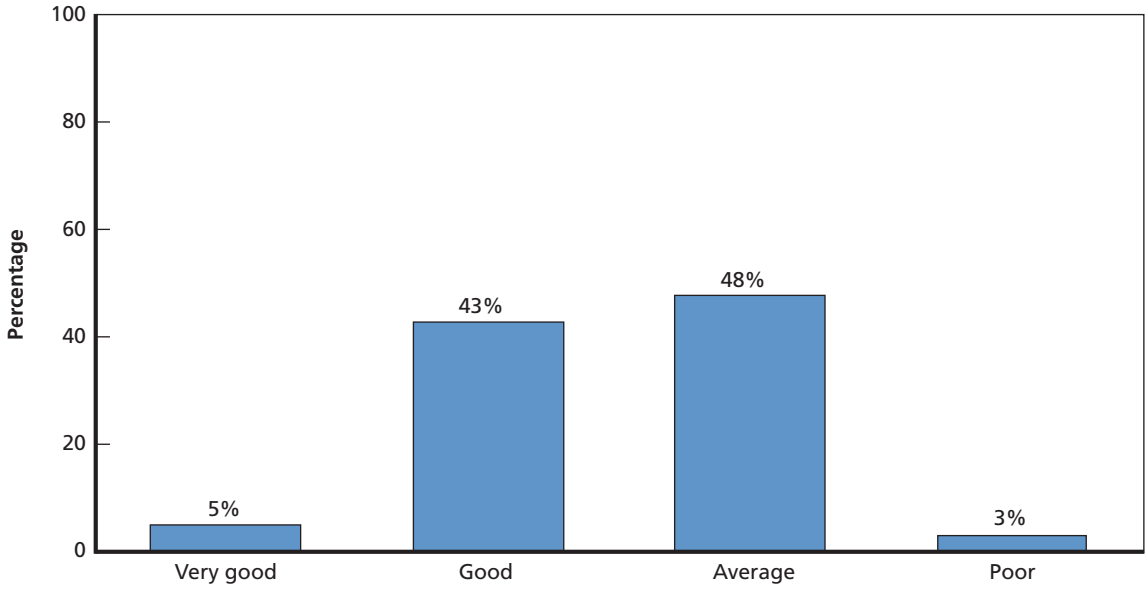
Individuals' perceptions of quality of life are shaped by a wide range of attributes of their communities and surrounding environment. These attributes may include access to convenient and affordable transportation choices, good jobs, affordable and attractive housing, and accessibility to green space; adequate opportunities for recreation and leisure time; pleasant, safe communities; and clean air or clean drinking water. As summarized in Figures C.1a and C.1b, most respondents thought that quality of life in Pingshan New District is good (43 percent) or average (48 percent). A small number thought that overall quality of life is very good, and even fewer thought it was poor. Middle-age residents (between 45 and 65 years old) appeared to be more positive about current quality of life than those younger or older.

The vast majority of respondents believe that in the future (no date specified) quality of life in Pingshan will improve a little (72 percent) or improve a lot (13 percent). They based their general optimism on beliefs that the district has good development potential, the economy will grow, and overall living conditions will improve. Few respondents (3 percent) who think that overall quality of life is good or average now feel that it will get worse in the future. More than half of the respondents who said that overall quality of life is poor now believe that it will improve in the future.

Land Use

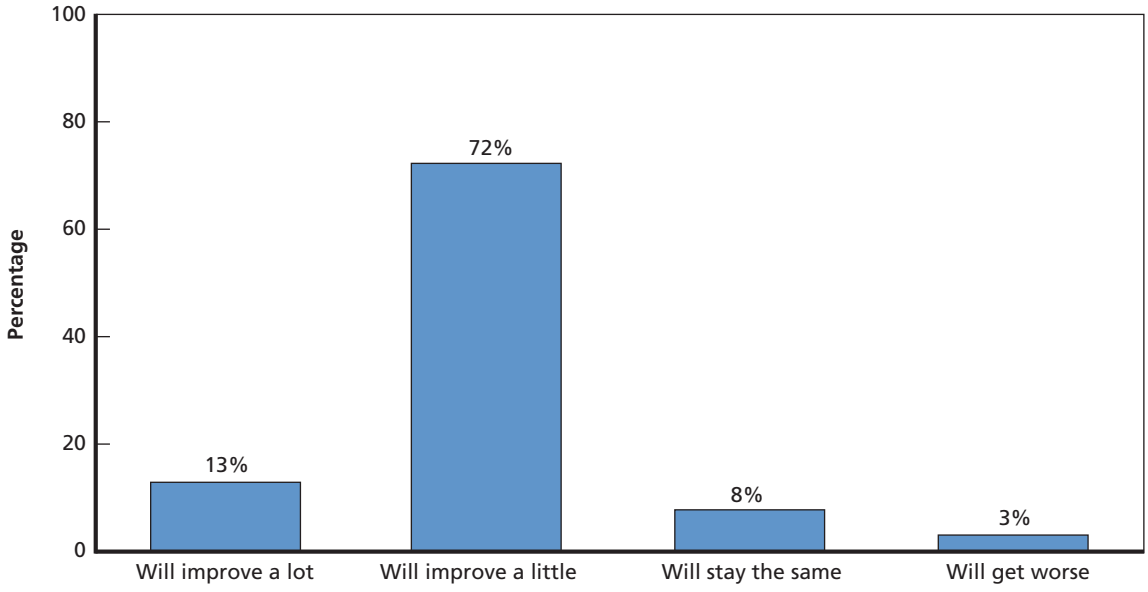
Land use refers to the management and modification of the natural environment to accommodate development and the built environment. Government plays an important role in setting and implementing policies to preserve and protect valuable habitat for various species,

Figure C.1a
Views About Current Quality of Life



RAND *RR871-C.1a*

Figure C.1b
Views About Future Quality of Life



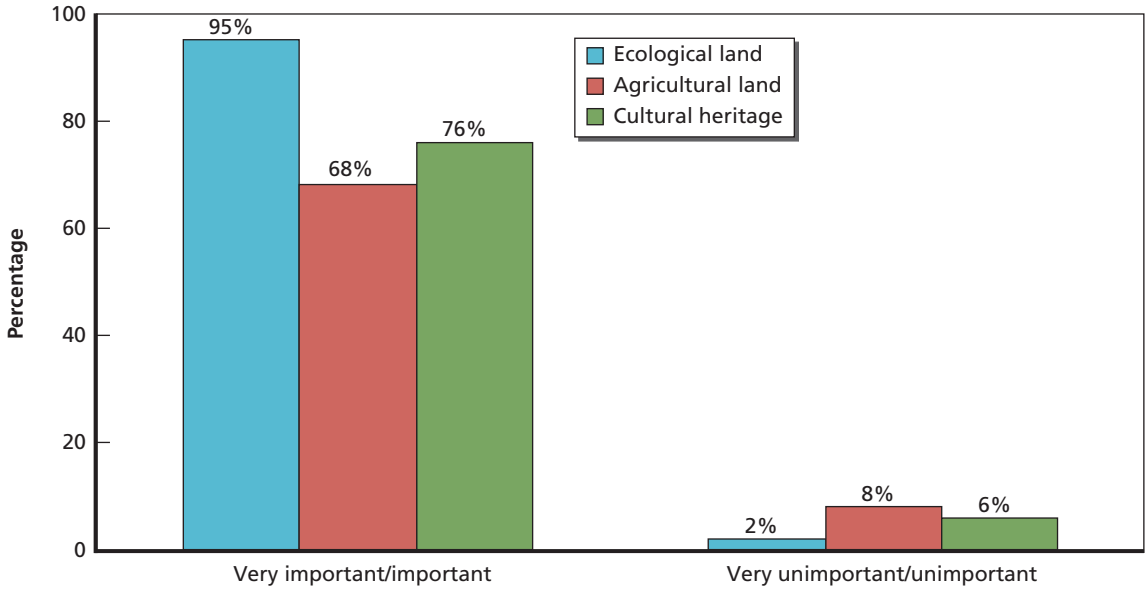
RAND *RR871-C.1b*

fertile agricultural lands, and lands with cultural and historical significance. As summarized in Figure C.2, preservation of ecological land was considered important to more residents (95 percent) than the preservation of cultural heritage (76 percent) or agricultural land (68 percent). In fact, nearly two-thirds of residents (61 percent) considered preservation of ecological land to be "very" important, compared with less than half as many who considered the preservation of agricultural land (30 percent) and cultural heritage (38 percent) to be very important. Dissatisfaction with the current level of land preservation was strongest among the better educated.

Many respondents agreed (46 percent), though not strongly, that they like the way their community looks and feels right now (Figure C.3), while others (43 percent) had no strong feelings about this one way or another. Respondents viewed particular land utilization characteristics as beneficial for a community. Respondents rated access to nature (94 percent), a sense of community (neighborliness) (94 percent), and attractive public space (93 percent) as important (Figure C.4). Yet, in comparison to the desirability of those characteristics that nearly all of those surveyed expressed, only 57 percent of respondents felt that their community had access to nature; 69 percent felt their communities had a sense of community; and 55 percent of respondents felt their communities had attractive public spaces.

Mixed-use development was considered desirable, but most respondents said that their communities lacked such development. Fewer than half (47 percent) felt that their communities had a good mix of housing, shops, and other types of buildings, but this was important to 90 percent of residents. Nine out of ten residents also thought access to transportation was important, but nearly two-thirds of them thought that their community had this characteristic. About 40 percent of respondents felt that their communities were doing a good job of preserving historic buildings and structures; more than twice (81 percent) felt this was important to them.

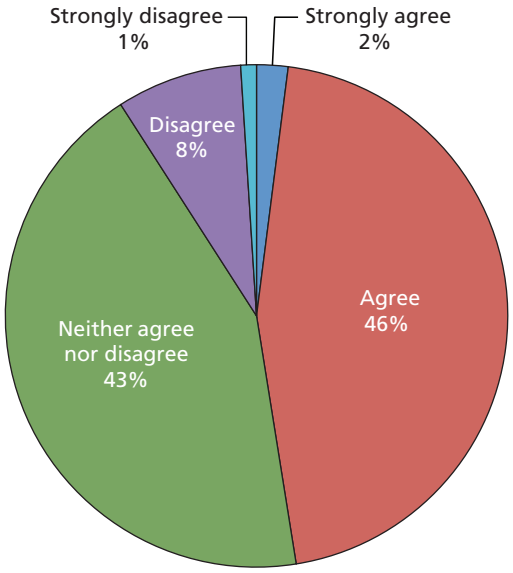
Figure C.2
Importance of Protecting Ecological Agricultural Land and Cultural Heritage Resources



NOTE: Does not add to 100 percent because responses for "neither important or unimportant" and "don't know" are not shown.

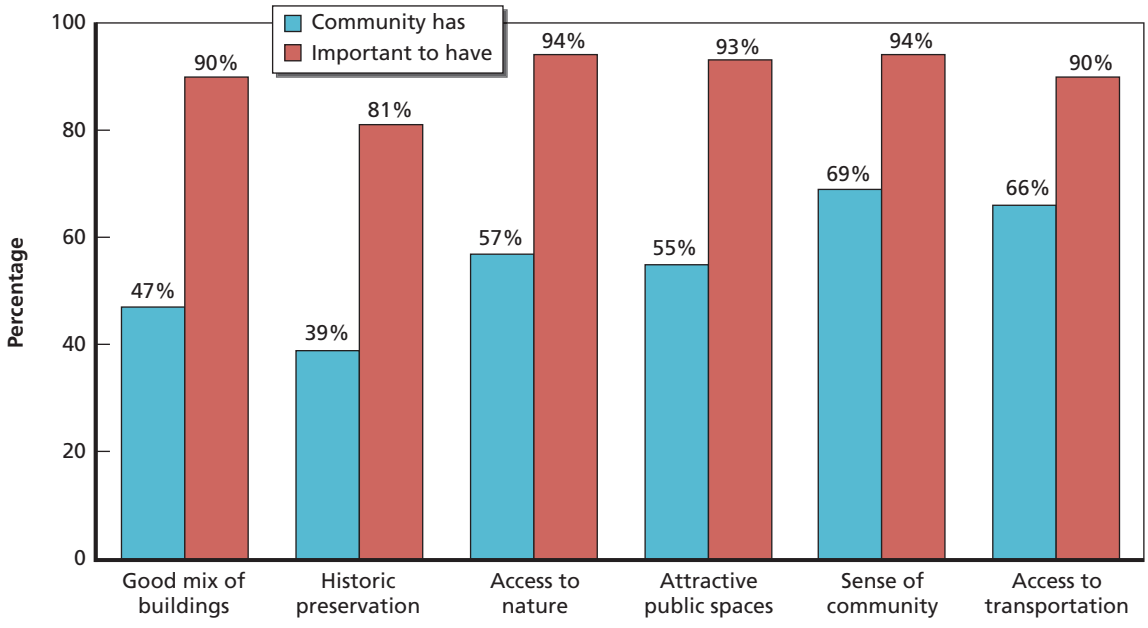
RAND *RR871-C.2*

Figure C.3
Satisfaction with the Look and Feel of Communities



RAND *RR871-C.3*

Figure C.4
Importance of Selected Land Use Characteristics



RAND *RR871-C.4*

Livable communities are frequently associated with walkable communities (Smith, Nelischer, and Perkins, 1997; Raphael et al., 2001). More than half of the residents surveyed walk around their communities on a daily basis (34 percent) or several times a week (23 percent). Those that do not walk around their communities as frequently cited "lack of time" as the most frequent (68 percent) reason.

Transportation

Less than one-fourth of all respondents (24 percent) reported that their household owned one or more passenger cars, but 40 percent of residents age 55 or older own cars, as do 42 percent of the better educated. Registered residents have the highest percentage of car ownership (71 percent), more than three times of those who are floating population (22 percent). Those who reported owning a vehicle were asked about parking issues; availability of parking was more of a concern than was the cost of parking. Just over half of the respondents with cars (53 percent) said that finding parking was a serious or moderate problem, compared with 36 percent who said that the cost of parking was a serious or moderate problem.

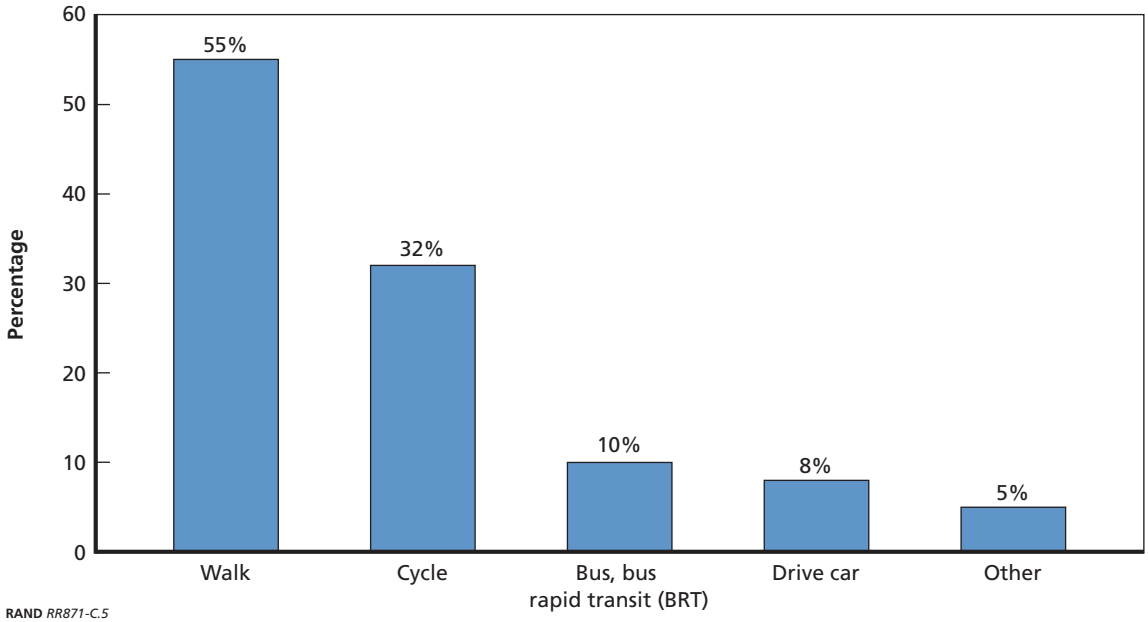
Whether they own a car or not, most respondents said it was very important (27 percent) or somewhat (28 percent) important to own a car. Most respondents (89 percent) said that owning a car would be more convenient for daily life. Only 10 percent said it would be more convenient for their commute to work. The explanation for this may be that most people surveyed worked in their communities and either walked (55 percent) or cycled (32 percent) to work (Figure C.5). About 10 percent take the bus or bus rapid transit, and 8 percent drive to work.

Only about 15 percent of the residents utilize more than one commute mode. Because people tend to walk or bike to work, their commutes were short. Most spent less than 11 minutes (65 percent) or less than 20 minutes (23 percent) traveling to work. Given the relatively short commutes, it is not surprising that few (9 percent) were dissatisfied with the length of time it takes to travel to work, and 68 percent were very and/or somewhat satisfied.

Connectivity to Shenzhen and other cities in the PRD was the top-rated transportation challenge among all of the residents surveyed in Pingshan (Figure C.6). Three out of four respondents (75 percent) said that the lack of metro services to downtown Shenzhen was a serious (38 percent) or moderate (37 percent) problem. Three out of five respondents (62 percent) also thought that lack of rail service to reach other cities in the PRD was a serious (28 percent) or moderate (34 percent) problem.

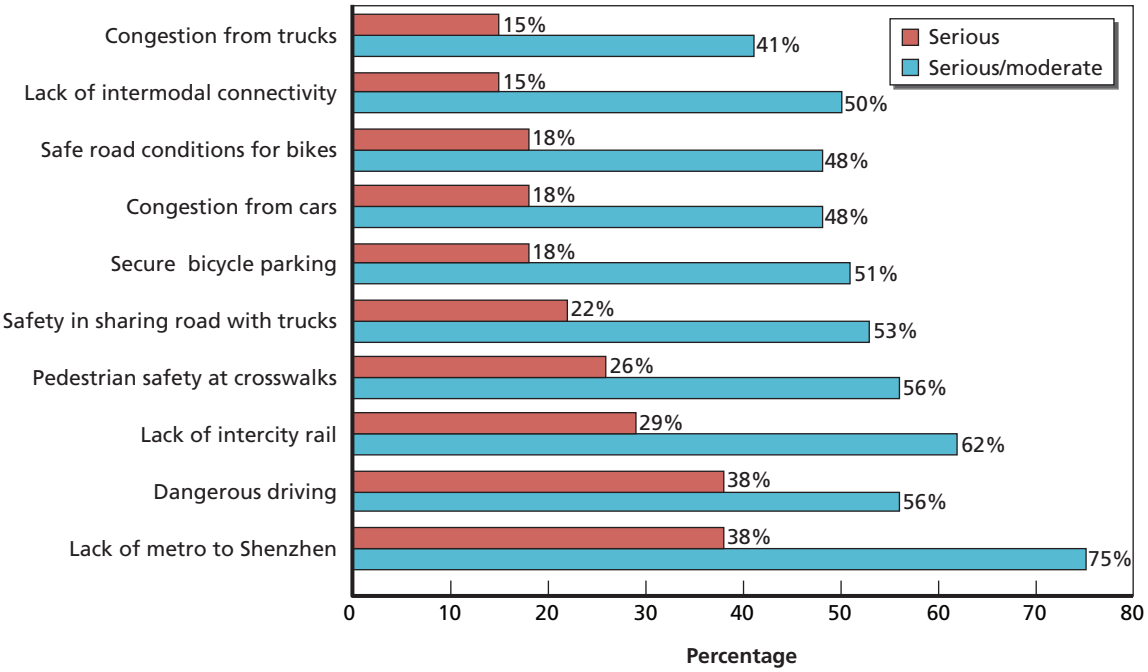
Road traffic safety was also a key issue, as indicated in Figure C.6. Dangerous driving by others, including drunk driving and speeding, was considered a serious or moderate problem by 56 percent. A majority (53 percent) also thought safety in driving due to sharing of the road with trucks was a serious or moderate problem. Pedestrian safety at crosswalks was identified as a serious or moderate problem by 56 percent. About 40 percent were satisfied with the availability of traffic safety education by local government, 14 percent were dissatisfied, and 46 percent were neutral—neither satisfied nor dissatisfied—or gave a "don't know" response. Respondents were asked how they received traffic safety information. Internet (43 percent) and TV (36 percent) were mentioned most frequently, followed by public poster (16 percent) and word of mouth from others (10 percent).

Figure C.5
Mode of Transportation to Work



RAND *RR871-C.5*

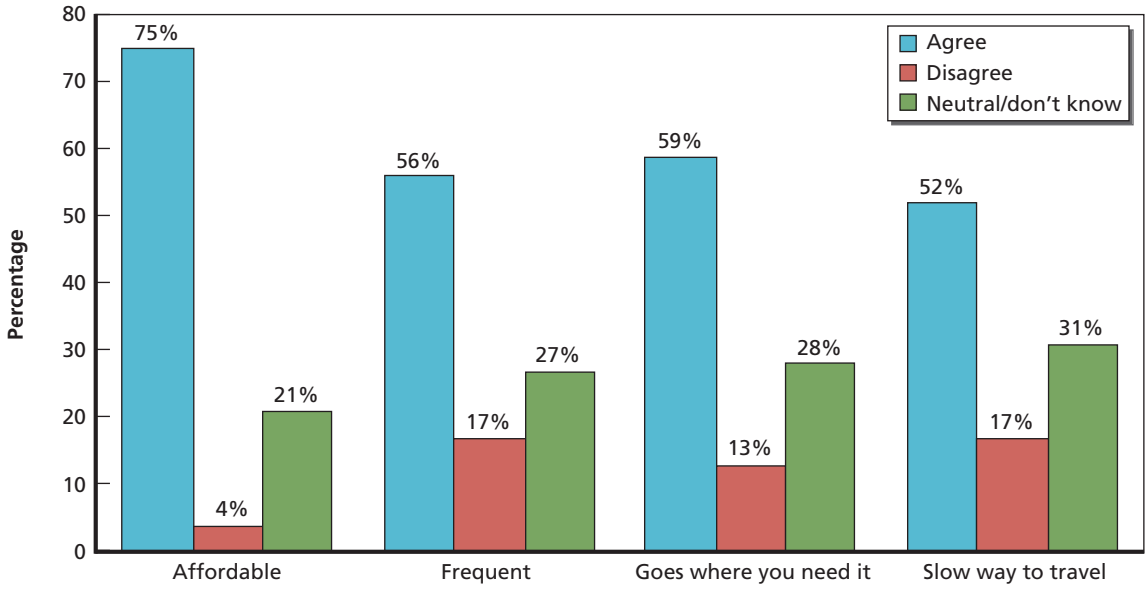
Figure C.6
Transportation Problems Encountered in Daily Life



NOTE: Does not add to100 percent because multiple responses were allowed.

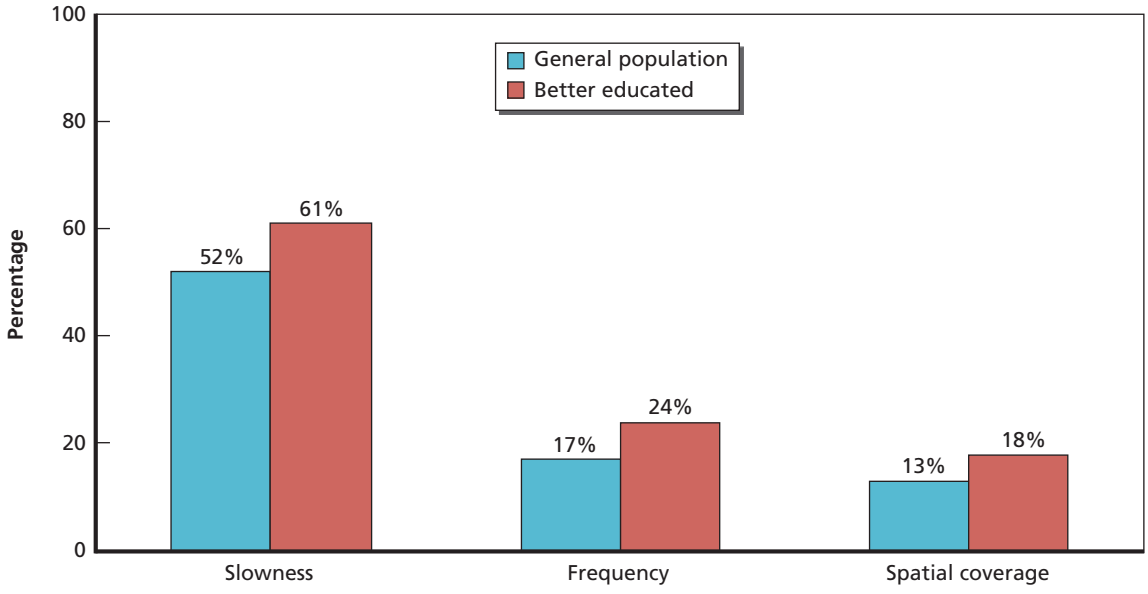
RAND *RR871-C.6*

Figure C.7
Views of Public Transportation in Pingshan New District



RAND *RR871-C.7*

Figure C.8
Dissatisfaction with Public Transportation



RAND *RR871-C.8*

The connectivity issue also surfaced in a set of questions regarding public transport in Pingshan New District, in which a majority (52 percent) said that public transport was a slow way to travel because of the number of transfers required (Figure C.7). Nonetheless, a majority felt that public transport was affordable (75 percent), frequent (56 percent), and goes where they need it to go (59 percent). Respondents with higher education levels, especially those with a tertiary level of education, tended to be more dissatisfied than the survey population in total with the frequency (24 percent), coverage (18 percent), and particularly the slowness (61 percent) of public transport (Figure C.8).

Congestion (from car or truck traffic) did not rise to the top of serious transportation issues, as noted in Figure C.6, most likely due to the fact that auto ownership is still relatively low. Likewise, unsafe road conditions for biking were not at the top of the list of problems, although bike security did register as a concern for just over half of the respondents. The presence of greenways (i.e., dedicated bike lanes or walk paths with green landscaping) may be a reason why bike safety was less of a concern. We asked respondents about their use of the greenways, given that local government is promoting greenway construction. On a question in which multiple responses were permitted, we found that the most prevalent uses of greenways were travel to work (45 percent) and travel for leisure or sports (37 percent). Only 18 percent said that they did not use the greenways at all.

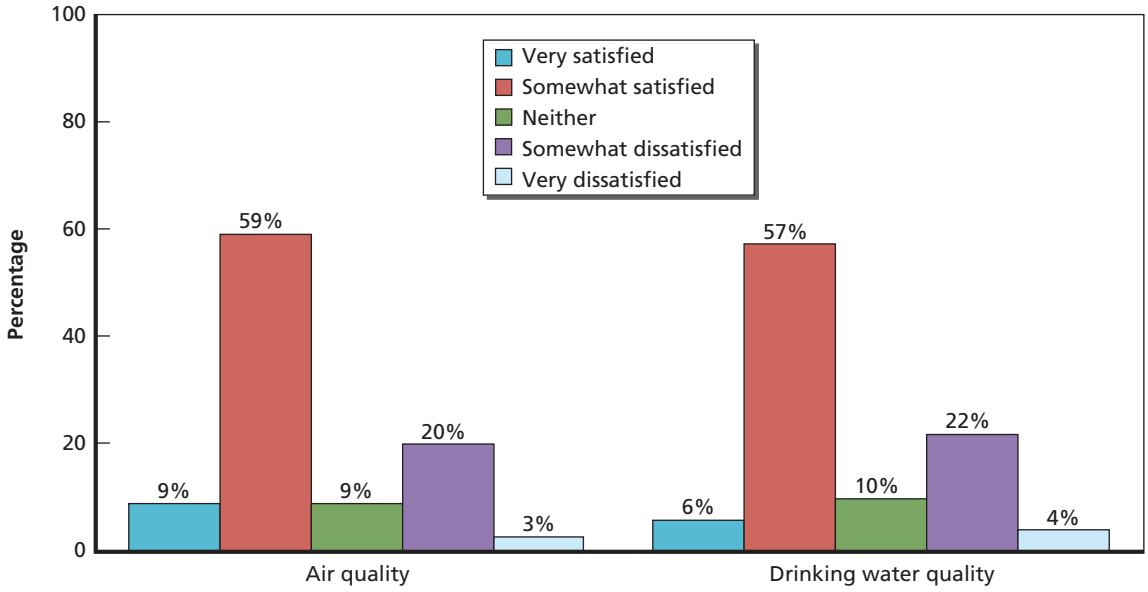
Environment

Most respondents are somewhat satisfied with air and drinking water quality, but almost a quarter are not (Figure C.9). In general, respondents who are most dissatisfied with air and water quality also tend to have obtained higher levels of education, especially those with specialized secondary and tertiary education level (Figure C.10). It is worth noting that 8 percent of all residents surveyed affirmed that a family member suffered from asthma or other respiratory illness. However, these general observations may not be true for particular communities where dissatisfaction with environmental quality is particularly high. Respondents who were dissatisfied with air quality are more likely to live in the Shabo, Heping, Jiangling, Pingshan, Pinghuan, and Xiuxin communities. Respondents in Heping, Pingshan, Pinghuan, and Xiuxin are more likely than those in other communities to be dissatisfied with water quality (Figures C.11 and C.12).

Between 60 and 70 percent of respondents believe that air quality, water quality, and environmental preservation efforts have either stayed the same or gotten worse. However, as shown in Figure C.13, 36 percent of respondents think that air quality has improved, and 26 percent think that drinking water quality has improved over the recent past. About 10 percent of residents feel that air quality has gotten worse, and 9 percent feel that water quality has gotten worse. A higher percentage of residents surveyed from Liuhe, Tiantou, Jiangling, and Shijing think the quality of air in their community has gotten worse compared with other communities. Residents who think drinking water quality has gotten worse are more likely to live in Tiantou, Shijing, and Tianxin.

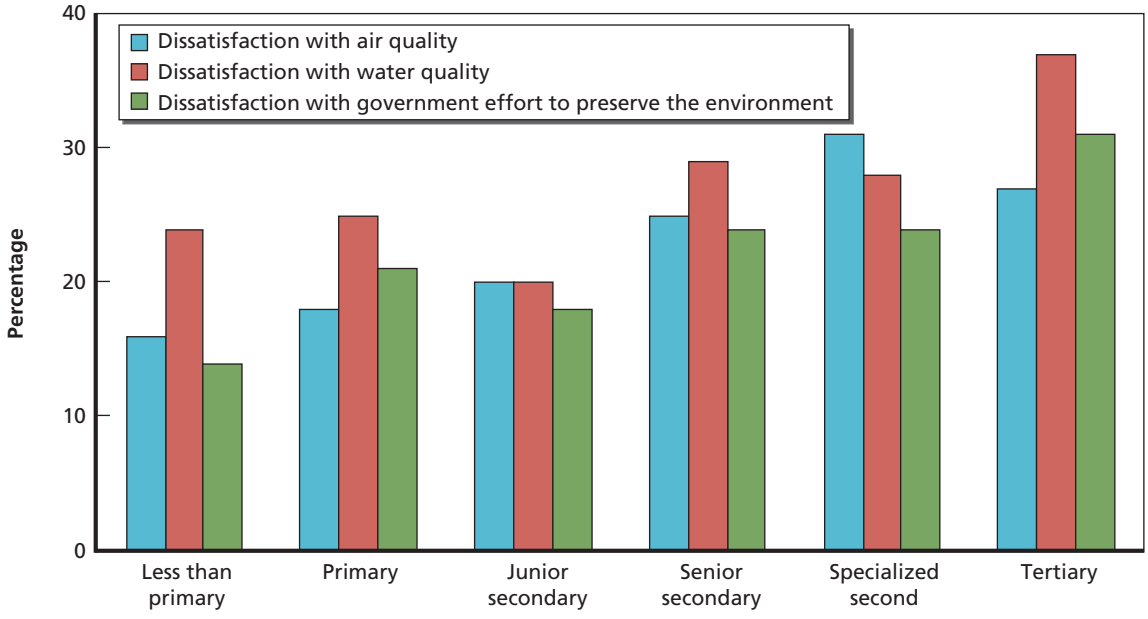
Just over half of the respondents (54 percent) were satisfied with government efforts to preserve the environment; 22 percent were dissatisfied. Respondents who live in Heping, Tiantou, Shabo, and Shijing were more dissatisfied with government efforts to preserve the environment than residents of other communities, consistent with their dissatisfaction with air and drink-

Figure C.9
Satisfaction with Air Quality and Water Quality



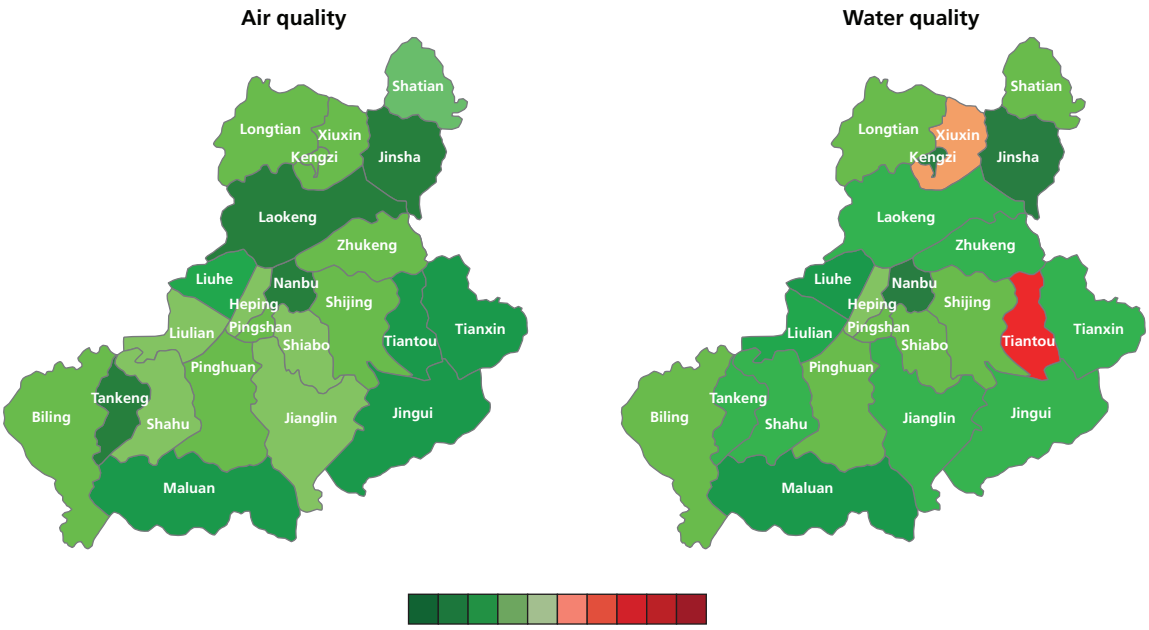
RAND *RR871-C.9*

Figure C.10
Dissatisfaction with Air and Drinking Water Quality by Education Level



RAND *RR871-C.10*

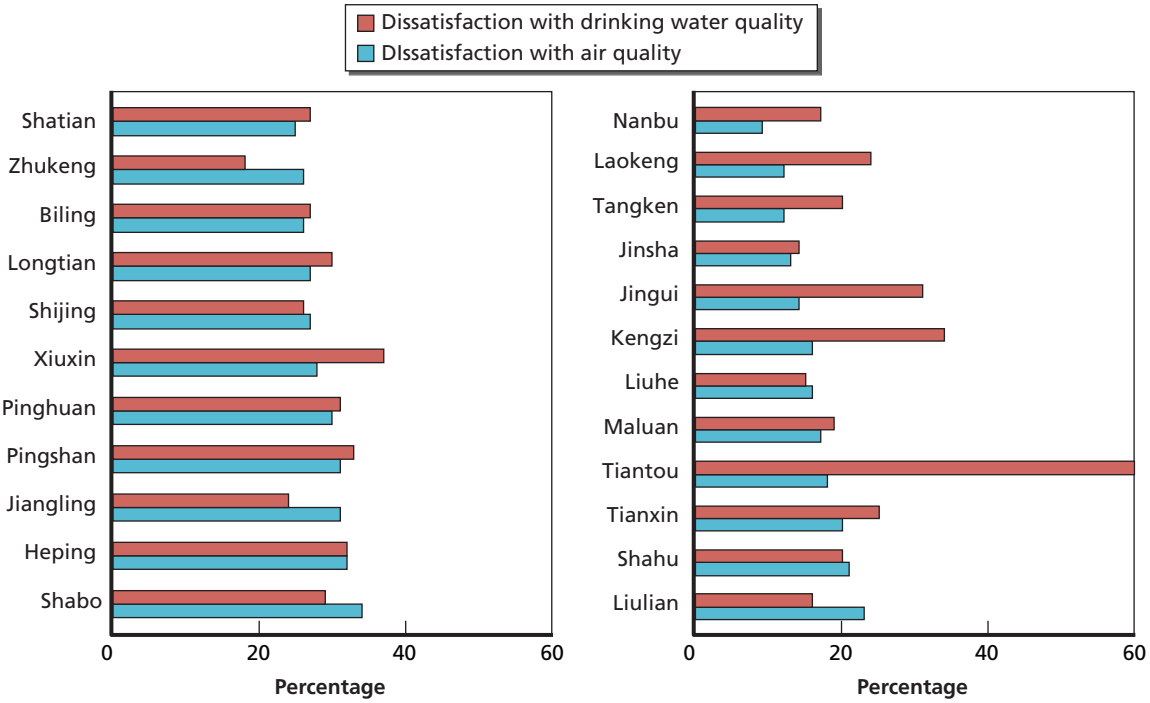
Figure C.11
Dissatisfaction with Air and Drinking Water Quality by Community



NOTE: Dark green means the most satisfaction with water or air quality. Red indicates greatest dissatisfaction with water or air quality.

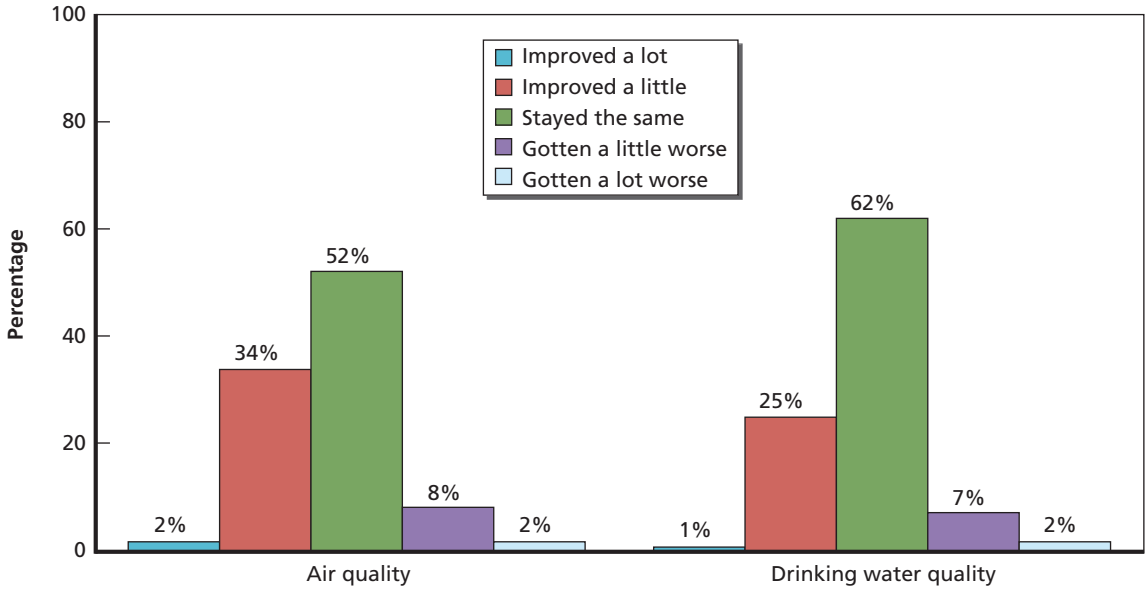
RAND *RR871-C.11*

Figure C.12
Relative Dissatisfaction with Air and Drinking Water Quality by Community



RAND *RR871-C.12*

Figure C.13
Residents' Perceptions of Changes in Air and Water Quality



RAND *RR871-C.13*

ing water quality. As with air and drinking water quality, better-educated respondents also tend to show greater dissatisfaction with government's environmental preservation efforts. The majority of residents were satisfied with the frequency of home garbage collection (72 percent) and the frequency of collection of garbage generated from commercial places near their homes (60 percent). About one in five were dissatisfied with handling of solid waste.

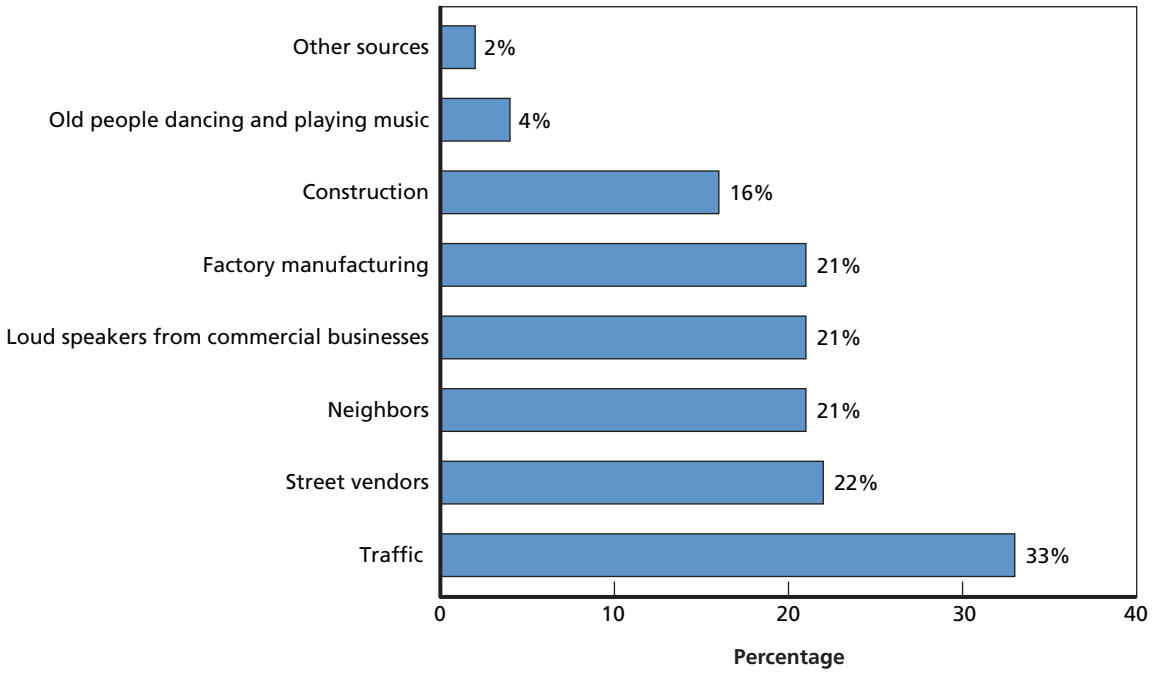
At the neighborhood level, the effective management of community noise is an important environmental issue. Most respondents (60 percent) said that noise was a minor problem or not a problem at all. But 18 percent of residents surveyed in Pingshan New District felt that noise was a serious problem in their lives, and another 21 percent said it was a moderate problem. For these respondents, the most prevalent source of the noise problem was traffic (Figure C.14). Noise seems to be a serious problem for those who live in Jiangling, Shabo, Xiuxin, and Laokeng, as more than 45 percent of their residents consider noise either a moderate or serious problem.

Given the potential natural disasters like flooding in southern China, most residents (84 percent) felt safe. The percentage that felt unsafe (14 percent) tended to live in the communities of Shijing (37 percent) and Tianxin (37 percent).

Housing

Most of the residents surveyed (84 percent) rent their housing units, and among those units, most were built by the village (79 percent). About 7 percent of respondents own their housing. These persons tended to live in Pingshan, Tianxin, and Liulian communities. Regardless of type of residence, most respondents (89 percent) said that where they live is affordable on their salary. Most respondents are satisfied with where they live in terms of amount of living space

Figure C.14
Perceptions of Sources of Noise in Pingshan New District



RAND *RR871-4.3*

(67 percent), the quality of construction (67 percent), and the bathroom facilities (66 percent) (Figure C.15). Higher percentages of residents from the Heping, Kengzi, Liulian, Maluan, and Tangken communities are satisfied with where they live in terms of the above-mentioned living conditions.

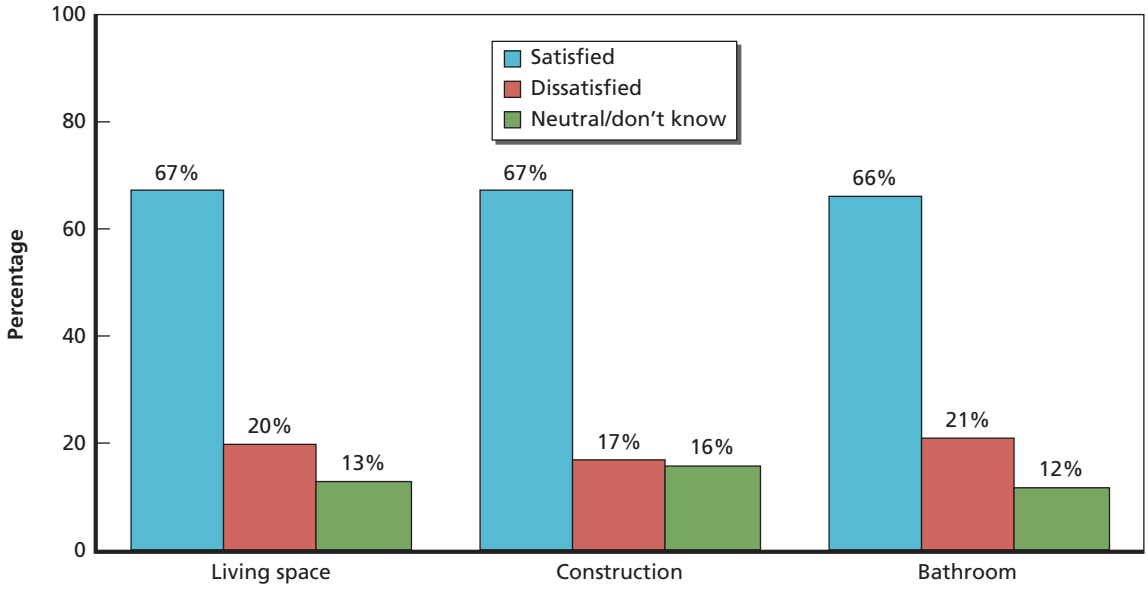
Diversity of housing options available and the availability of affordable good housing did not register among survey respondents as big concerns. In response to these questions, 54 percent of respondents were neutral on the topic, and 23 percent satisfied. Only 13 percent were dissatisfied with the diversity of housing options available to them although this varied by community: more than 25 percent of the residents in Jingui and Jiangling community felt dissatisfied with the diversity of housing options. Nearly one-quarter (23 percent) of all respondents were dissatisfied with the availability of good housing that is affordable.

People's satisfaction with where they live can be influenced by its proximity to public services and facilities. Regardless of where they live, Pingshan residents surveyed reported that they have good access to transportation (91 percent) and groceries (86 percent) (Figure C.16).

Health care is also nearby for most persons (64 percent). However, more than 40 percent of the residents in Xiuxin, Longtian, Laokeng, Jingui, Pinghuan, and Jinsha community say that they cannot reach doctors or health clinics within 10 minutes by walking. Fewer people have walking access to children's schools (56 percent), but nearly all who can are satisfied with the quality of these nearby schools (88 percent).

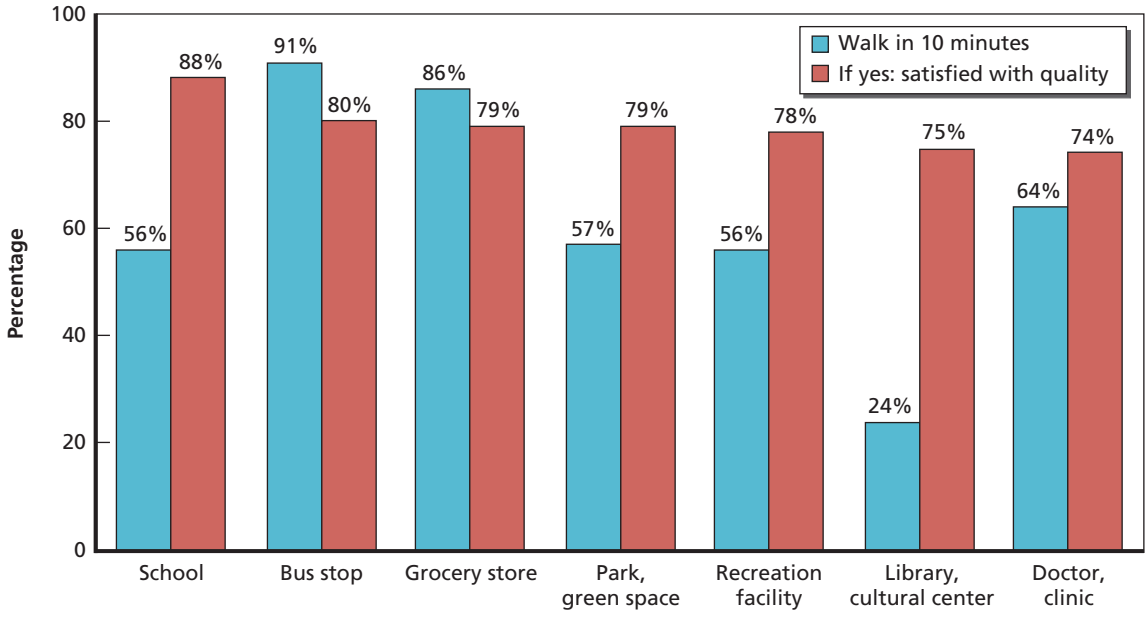
The government of Pingshan New District reported that it is placing a high priority on the development of two categories of public space: (1) parks, open, or green space and (2) leisure, recreation, or sports facilities. The government views both of these types of land use as important for livability. Slightly more than half of respondents reported that they can now

Figure C.15
Satisfaction with Amount of Living Space, Quality of Construction, and Bathroom Facilities



RAND *RR871-C.15*

Figure C.16
Perceptions of Walkability and Quality of Public Services



RAND *RR871-C.16*

walk to nearby recreation facilities or green areas. Four of five who can walk to these places within 10 minutes of their current residence are satisfied with their quality. In terms of differences by age, 40 percent of the 18–24 year olds felt satisfied with the quality of park compared to 60 percent of the residents older than 65 years.

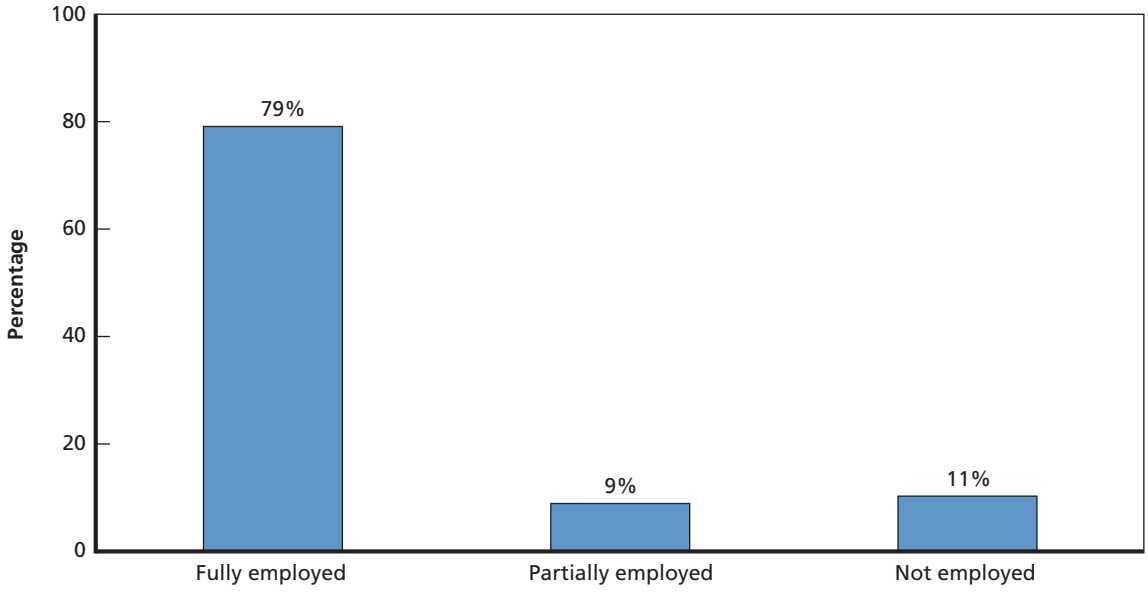
What seems to be lacking is easy access to public libraries or cultural buildings. Only 24 percent of residents said that they could walk to such buildings in 10 minutes, but those who can generally seem to be satisfied with their quality. However, only 15 percent of those residents between 18–24 years are satisfied with the quality of public libraries or cultural buildings, while half of those who are 65 years or above felt satisfied.

Economic Development

Most respondents were either fully employed (79 percent) or partially employed (9 percent), as shown in Figure C.17. As might be expected, the most common type of job was in manufacturing (58 percent); 28 percent of jobs were in the service sector, and 4 percent of jobs in high-tech or research (Figure C.18). More than 80 percent of respondents who are employed work in the community in which they live, 15 percent work elsewhere in Pingshan, 3 percent work elsewhere in Shenzhen, and 1 percent elsewhere.

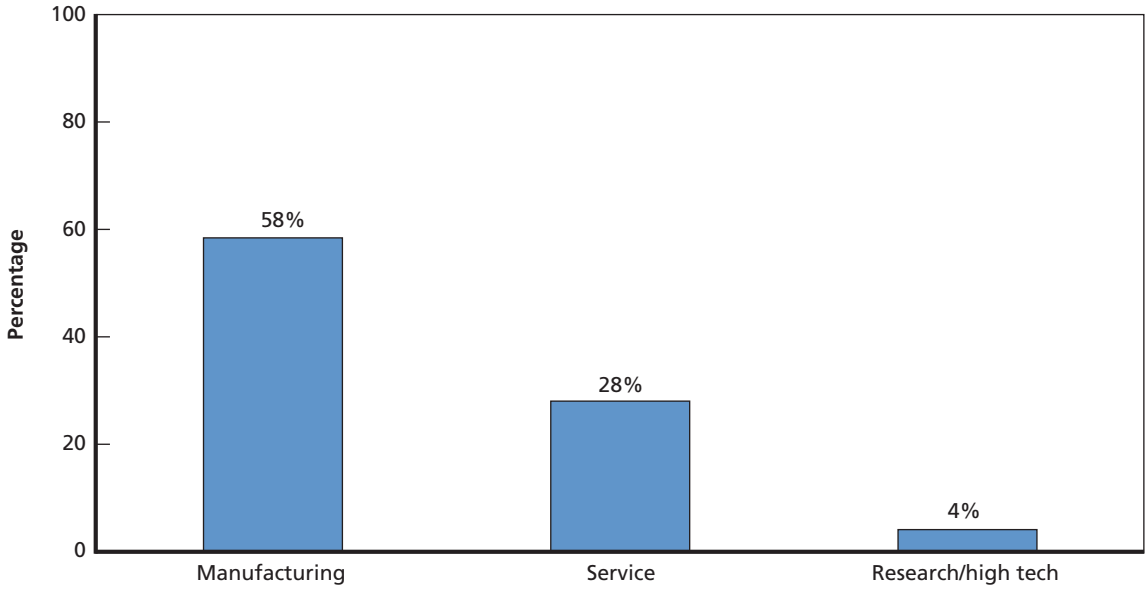
Most respondents seem somewhat satisfied with how well their total income meets their everyday, essential needs (food, housing, clothing, etc.). A majority of people (51 percent) said they had more than enough or enough money to meet their everyday essential needs. Few people (8 percent) said that they did not have enough money, and about one-third (36 percent) said they had just enough money. Difficulty in meeting everyday needs crossed educational levels: 15 percent of those with specialized secondary education and 12 percent of those with tertiary education said that they did not have enough income to cover everyday needs, com-

Figure C.17
Employment Status of Respondents



RAND *RR871-C.17*

Figure C.18
Employment of Respondents by Sector

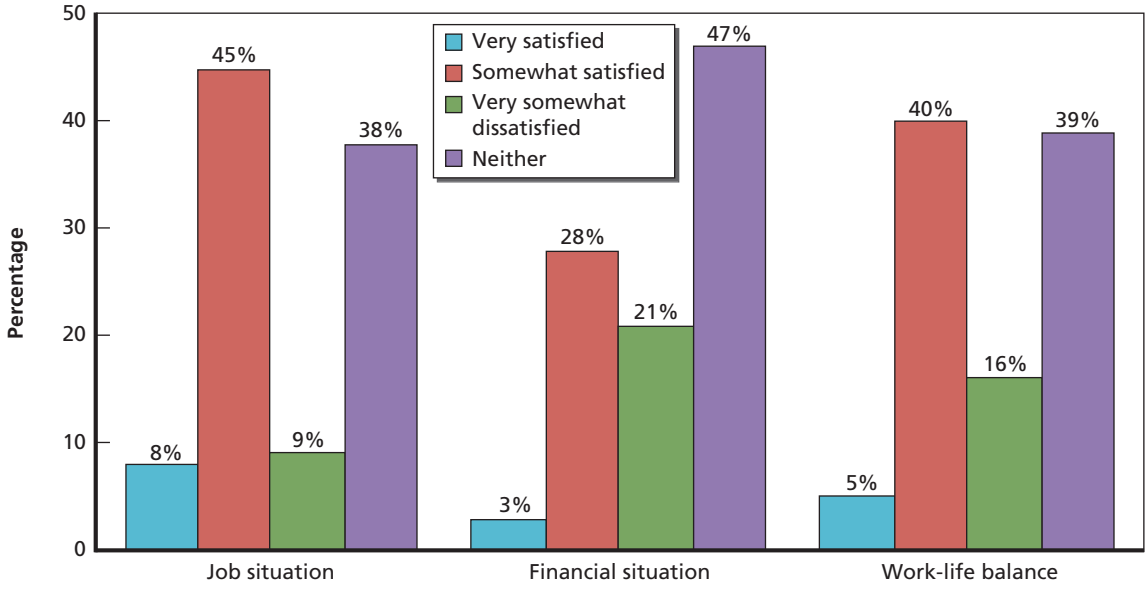


RAND *RR871-C.18*

pared with less than 10 percent of residents with lower education levels. Few people reported having extra money for spending on discretionary items.

As shown in Figure C.19, less than a third of all respondents (31 percent) were satisfied with their personal *financial* situation, and only 3 percent were very satisfied, compared with 57 percent of people who are satisfied with their *job* situation. Less than half (45 percent) are satisfied with the balance between their work and other aspects of their lives, such as time with family or friends.

Figure C.19
Satisfaction with Job, Financial Situation, and Work-Life Balance



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APPENDIX D

Summary of Indicators and Data Availability

Table D.1
Land Use Indicators and Data Availability

Challenges, Goals, and Strategies		Proposed Indicators		Availability of Data for Preferred Indicator or Proposed Interim Indicator
CL1	**Unplanned outward expansion of urban boundaries has led to fragmentation of both urban and rural land.**			
GL1	Increase the contiguity of urban and rural land.			
SL1	Map ecological protection zones and agricultural land based on productivity.	L1	Land area within the ecological control line as percentage of total area of land in the region	Available after cities identify boundaries of ecological protection zones
		L2	Area of cultivated land as percentage of total areas of land in region	Available
SL2	Enforce limits on development of more valuable ecological and agricultural lands.	L3	Land area within the ecological control line that was developed in the prior year as percentage of total land area within ecological control line (2013 as baseline year)	Available after cities identify boundaries of ecological protection zones
		L4	Portion of land area designated as cultivated that was converted to development in the prior year as percentage of total cultivated land (2013 as baseline year)	Available
CL2	**Urban land is not utilized in a way that allows for efficient provision of public services and facilities.**			
GL2	Increase density of residential space and employment opportunities through provision of high-quality compact development.			
SL3	Promote transit-oriented development near rail stations (both intercity and urban rail).	L5	Number of housing units within 0.5 kilometers of a rail station as a percentage of all housing units (in region, city, district, or county) (Q26f)	Will be available in GIS after the strategy is implemented
SL4	Adopt and enforce a zoning system that uses control on space such as density and design ("form-based codes") rather than a system based on land use function.	L6	Percentage of residents who agree there is a good mix of building types (e.g., residential housing, shops, office buildings) (Q10a)	Available in survey (Q10a)

Table D.1—Continued

Challenges, Goals, and Strategies		Proposed Indicators		Availability of Data for Preferred Indicator or Proposed Interim Indicator
SL5	Create a well-connected street network.	L7	Average block length of new rebuilt roads	Available from GIS
		L8	Percentage of residents who feel safe crossing at crosswalks (Q27h)	Available in survey (Q27h)
SL6	Provide high-quality green space and attractive public spaces within residential and commercial areas.	L9	Percentage of residents who think the city, district, or county provides access to nature in parks, open spaces, or gardens (Q10c)	Available in survey (Q10c)
		L10	Percentage of districts with under 30 percent open space	Available from GIS
		L11	Percentage of residents who think the city, district, or county provides attractive public spaces (Q10d)	Available in survey (Q10d)
GL3	Increase efficiency and cost-effectiveness in the provision of public services and facilities.			
SL7	Create incentives to concentrate development by providing key infrastructure only in designated areas, consistent with compact development.	L12	Average distance to primary school (defined as elementary, middle, and other schools within the nine-year compulsory education system)	Available from GIS or by survey
		L13	Average distance to community health service center	Available from GIS or by survey
		L14	Average distance to hospital (general or specialized)	Available from GIS or by survey
		L15	Average distance to (a) fire stations and (b) police stations	Available from GIS or by survey
GL4	Reduce the presence of industrial properties in prime residential and commercial areas.			
SL8	Develop a brownfieldss program that includes remediation standards and clear roles for various agencies.	L16	Number of brownfields sites that are available for redevelopment, according to redevelopment plans, as a share of all brownfieldss sites in the annual inventory	Will be available after the strategy is implemented
CL3	**Historic and cultural preservation has been neglected.**			
GL5	Strengthen measures to protect properties and assets with historical importance and distinctive local characteristics.			
SL9	Identify and prioritize buildings and neighborhoods with historical and cultural value.	L17	Number of buildings listed on a historic registry	Available
SL10	Enact and enforce historic preservation regulations.	L18	Percentage of residents who think their city, district, or county provides historic preservation of structures or buildings (Q10b)	Available in survey (Q10b)

Table D.1—Continued

Challenges, Goals, and Strategies		Proposed Indicators		Availability of Data for Preferred Indicator or Proposed Interim Indicator
CL4	**Current development patterns and processes do not adequately address the need for resilience from natural disasters.**			
GL6	Reduce vulnerability to damage from natural disasters.			
SL11	Identify and evaluate assets at risk of flooding through mapping.	L19	Number of structures in flood-prone areas	Will be available after the strategy is implemented
		L20	Value of assets in flood-prone areas	Will be available after the strategy is implemented
SL12	Identify and evaluate assets at risk of typhoon damage through mapping.	L21	Number of structures in typhoon-vulnerable areas	Will be available after the strategy is implemented
		L22	Value of assets in typhoon-vulnerable areas	Will be available after the strategy is implemented
SL13	Identify and evaluate assets at risk of earthquake damage through mapping.	L23	Number of structures in seismically unsound areas	Will be available after the strategy is implemented
		L24	Value of assets in earthquake-prone areas	Will be available after the strategy is implemented

Table D.2
Transportation Indicators and Data Availability

Challenges, Goals, and Strategies		Proposed Indicators		Availability of Data for Preferred Indicator or Proposed Interim Indicator
CT1	**Without high-quality public transit alternatives, VKT in privately owned cars per capita will increase and congestion and air pollution will worsen.**			
GT1	Mitigate the need for people to travel by privately owned cars.			
ST1	Enhance the competitiveness of bus and rail through improvements in service coverage and frequency.	T1	Annual VKT per capita in privately owned cars	May be available in some cities
		T2	Percentage commute mode (for driving a car, riding in a car, taxi/ridesharing, bus, rail, high-speed rail, bicycle, and walk)	Available in survey (Q39)
		T3	Satisfaction with public transportation service frequency	Available in survey (Q36b)
		T4	Satisfaction with public transportation service coverage	Available in survey (Q36c)
ST2	Promote bicycle-sharing, car-sharing, taxi, and dynamic ride-sharing services.	T2	Same as above	
GT2	Improve connectivity among transportation modes and among PRD cities.			
ST3	Develop multimodal transit hubs to enhance transportation connections, choices, and coordination among modes.[a]	T5	Number of multimodal transit hubs	Available from city departments of transportation
		T6	Average bus speeds on selected high-use corridors during morning and afternoon peak periods	Available from city departments of transportation
ST4	Implement smart, interoperable ticketing within the region to make it easier to use alternative forms of public transit.	T7	Number of cards sold as a share of number of permanent residents	Will be available after the strategy is implemented
ST5	Develop a travel survey that captures inter- and intracity travel flows and mode use.	T8	Number of data entries as a consequence of implementation of travel surveys.	Will be available after the strategy is implemented
GT3	Create an environment that emphasizes nonmotorized transportation modes.			
ST6	Connect pedestrian and bicycle greenways and paths to major employment destinations.	T2	Same as above	
GT4	Manage parking demand and supply.			
ST7	Institute a parking pricing system for on-street parking and encourage entrepreneurs to develop a mobile app that facilitates making payments.	T9	Proportion of paid parking spaces relative to all public parking spaces	Not available to public, but may be available from app developers
ST8	Encourage entrepreneurs to develop apps that provide real-time information on available parking spaces to make finding parking easier and to avoid illegal parking.	T10	Satisfaction with parking availability	Available in survey (Q34)

Table D.2—Continued

Challenges, Goals, and Strategies		Proposed Indicators		Availability of Data for Preferred Indicator or Proposed Interim Indicator
ST9	Enforce parking regulations and impose high penalties for illegal parking in central business district and other high-demand areas.	T11	Number of parking citations issued	Available from the Department of Public Safety
		T12	Percentage of parking citations paid	Available from the Department of Public Safety
CT2	**Road-based freight transport is a major source of congestion and safety problems.**			
GT5	Reduce interactions between passenger cars and trucks.			
ST10	Implement peak-period delivery restrictions in the central business district and other highly congested areas.	T13	Truck volume counts on high capacity urban roads during peak periods	Probably available from the Department of Transportation
ST11	Create freight consolidation centers in urban fringe areas to reduce the number of deliveries in the city center.	T14	Percentage of residents who think congestion from trucks is a problem	Available in survey (Q27b)
CT3	**An extremely high number of deaths and serious injuries are caused by everyday use of the roads.**			
GT6	Reduce deaths and injuries on the roads.			
		T15	Number of traffic deaths per year	Available
		T16	Number of traffic injuries per year	Available
ST12	Integrate road safety audits (RSA) into the project development process for new roads and intersections.	T17	Number of RSAs conducted per year	Will be available after the strategy is implemented

[a] A multimodal transit hub is defined in Chapter Six as "Physical passenger facility where one or more transit services or other modes can be easily accessed, thus facilitating transfers between modes. A hub can be a building or a shelter" (Lyndon Henry and David L. Marsh, *Intermodal Surface Public Transport Hubs: Harnessing Synergy for Success in America's Urban and Intercity Travel*, Austin, Tex.: Capital Metropolitan Transportation Authority and Capital Area Rural Transportation System, 2009).

Table D.3
Environmental Indicators and Data Availability

Goals and Strategies		Proposed Indicators		Availability of Data for Preferred Indicator or Proposed Interim Indicator
CE1	**Water and air pollution and soil contamination are causing significant harm to human health and ecological resources, and diminishing economic growth.**			
CE2	**Regulators have insufficient resources and incentives to enforce laws and standards.**			
GE1	Increase enforcement capacity and accountability for air and water pollution and soil contamination.			
SE1	Increase the number of inspections by trained inspectors.	E1	Number of facilities inspected annually by trained inspectors as a percentage of the total number of facilities that have one or more permits for air emissions, water discharge, and hazardous chemical storage.	Available from Department or Bureau of Environmental Protection at provincial and city level
		E2	Number of facilities identified but lacking permits as a share of total number of facilities (permitted and unpermitted).	Available from Department or Bureau of Environmental Protection at provincial and city level
SE2	Increase incentives for enforcement.	E3	Number of facilities (above a specified size) with up-to-date air, water, and chemical storage permits as a percentage of all facilities (above a specified size) eligible for permitting	Available from Department or Bureau of Environmental Protection at provincial and city level
		E4	Percentage of total permitted facilities in full compliance with their permits	Available from Department or Bureau of Environmental Protection at provincial and city level
SE3	Increase incentives for compliance.	E5	Amount (in RMB) of fines collected per year	Available from Department or Bureau of Environmental Protection at provincial and city level
GE2	Reduce unlawful industrial and municipal wastewater discharges into rivers and groundwater.			
		E6	Percentage of residents who feel that drinking water quality has improved	Available in survey (Q13b)
		E7	Percentage of residents who are dissatisfied with drinking water quality	Available in survey (Q13b)
		E8	Number of surface water monitoring stations where Class II water quality standards[a] have been met for 12 consecutive months	Available from Department or Bureau of Environmental Protection at provincial and city level
		E9	Number of groundwater well monitoring locations where Class II water quality standards have been met for 12 consecutive months	Available from Department or Bureau of Environmental Protection at provincial and city level

Table D.3—Continued

Goals and Strategies		Proposed Indicators		Availability of Data for Preferred Indicator or Proposed Interim Indicator
SE4	Allow cities, districts, and counties downstream of unlawful discharge of sewage and industrial waste to receive some percentage of the revenue from fines imposed on polluters.	E10	Amount (in RMB) of fines directed to cities, districts, and counties per year	After implementation, will be available from Department or Bureau of Environmental Protection at provincial and city level
SE5	Expand water quality monitoring networks for both surface and groundwater.	E11	Number of surface water monitoring stations fully operational for 12 consecutive months	Available from Department or Bureau of Environmental Protection at provincial and city level
		E12	Number of groundwater well monitoring locations fully operational for 12 consecutive months	Available from Department or Bureau of Environmental Protection at provincial and city level
GE3	Reduce contamination of current and former industrial lands.			
		E13	Number of hectares requiring major cleanup based on site inventory	Will be available after the strategy is implemented
SE6	Produce an annual inventory of contaminated waste sites in the PRD region. Assign responsibility to the director-general of the Environmental Protection Bureau for oversight of clean up at sites within the appropriate jurisdiction, and publish a list of sites with the name of the facility owner and a description of the nature of the contamination.	E14	Number of sites identified	Will be available after the strategy is implemented
		E15	Number of hectares contaminated on the sites identified	Will be available after the strategy is implemented
SE7	Establish waste site cleanup funds at the municipal and provincial levels to use to remediate contaminated sites where the owner cannot be found.	E16	Expenditures (in RMB) for site cleanup from the provincial and municipal cleanup funds	Will be available from Department of Environmental Protection after strategy is implemented
GE4	Reduce unlawful emissions from air pollution from stationary and mobile sources.			
		E17	Percentage of residents who feel that air quality has improved	Available in survey (Q14)
		E18	Percentage of residents dissatisfied with air quality	Available in survey (Q13a)
		E19	Average daily and annual peak levels of $PM_{2.5}$ (E19a), ozone (E19b), sulfur dioxide (E19c), nitrogen oxides (E19d), and mercury (E19e)	Available from Department or Bureau of Environmental Protection
SE8	Accelerate Guangdong's phase-out of coal use, especially for household heating and industrial use, and coal-fired power plants serving all PRD cities.	E19	Same as above.	
		E20	Annual greenhouse gas emissions reported by type of source (e.g., power plants, industry facilities, residential and commercial buildings, and mobile sources)	Available from Department or Bureau of Environmental Protection

Table D.3—Continued

Goals and Strategies		Proposed Indicators		Availability of Data for Preferred Indicator or Proposed Interim Indicator
SE9	Accelerate the implementation of green building codes and appliance efficiency programs.	E21	Annual energy consumption per square meter in public, commercial and residential buildings	Need to calculate based on data that will be available after the strategy is implemented
		E22	Floor area of certified newly constructed green buildings as a share of total floor area of all newly constructed buildings (annual)	Available following implementation of Guangdong Green Building Action Plan
SE10	Accelerate removal of highly polluting vehicles through incentive payments.	E23	Number of yellow-tag vehicles remaining in use	Available from the Department of Transportation
SE11	Increase the number of cleaner cars registered.	E24	Percentage of vehicles registered that meet China VI pollution control standards	Available from the Department of Transportation
SE12	Accelerate adoption of cleaner vehicle fuels.	E25	Percentage of fuels sold in Guangdong that meets the new China VI standard	Available from the Department of Transportation

[a] Suggested chemical pollutants include: dissolved oxygen, nitrogen, phosphorus, and cadmium. A particular biological species present in a river could also be used (e.g., population of a type of fish).

Table D.4
Housing Indicators and Data Availability

Goals and Strategies		Proposed Indicators		
CH1	**There is a lack of good-quality public rental housing and housing for purchase for middle-income residents.**			
GH1	Ensure that housing (for rental and purchase) remains affordable to households at medium-income levels.			
SH1	Create incentives for developers to build more affordable rental housing and housing for purchase through competitive RFPs for below-market priced land.	H1	Among middle-income households, share of household income spent on rent or mortgage	Will be available after the strategy is implemented
		H2	Sum of public rental housing units and affordable rental housing units built by private developers as a share of all available housing units	Available
SH2	Increase funding capacity and reduce government reliance on development fees by levying property taxes on homes.	H3	Units built as a result of awards made to private developers through RFPs	Will be available after the strategy is implemented
SH3	Require a certain percentage of public rental housing units and affordable housing for purchase in TODs.	H4	Property tax income received by government	Will be available after the strategy is implemented
		H5	Share of public rental housing units and affordable housing for purchase built in TODs	Will be available after the strategy is implemented
CH2	**There is a lack of good-quality public rental housing for lower-income residents.**			
GH2	Enhance construction of better-quality rental housing that is affordable to lower-income groups.			
		H6	Among lowest to lower-middle-income households, share of household income spent on housing	Will be available after the strategy is implemented
SH4	Redevelop "villages in cities" using land readjustment techniques.	H7	Number of rental homes located in villages in cities in which lower-income households pay more than 30 percent of household income in rent	Will be available after the strategy is implemented
SH5	Adjust housing construction programs like CRH to allow developers to build low-cost rental units.	H8	Number of newly constructed low-cost units, defined as affordable to lowest and lower-middle-income households, based on paying no more than 30 percent of income on rent	Uncertain
SH6	Provide housing vouchers to low-income residents, where voucher payments are directly provided to landlords after unit inspected and lease signed.	H9	Percentage of households that receive vouchers who pay more than 30 percent of their income for housing	Will be available after the strategy is implemented
SH7	Implement and enforce building and amenity standards for all public rental housing units and rental units built by private developers.	H10	Percentage of rental units that meet standards	Will be available after the strategy is implemented

Table D.5
Economic Development Indicators and Data Availability

Goals and Strategies		Proposed Indicators		Availability of Data for Preferred Indicator or Proposed Interim Indicator
CD1	**Accelerate the economic transition by encouraging more sales to other Chinese provinces, while seeking new, low-carbon opportunities to expand the regional economy.**			
GD1	Raise output and employment by encouraging businesses in the PRD to sell more to other regions in Guangdong and elsewhere in China.			
SD1	Reduce internal barriers to trade.	D1	Annual number of shipping containers (in TEUs) to other regions	Uncertain
SD2	Improve provision of market information on prices, quality, grade, and other product attributes in provinces where PRD businesses are targeting their sales efforts.	D2	Annual growth rate in sales value, by province from base year	Available
SD3	Pilot a preclearance program at a border crossing with Hong Kong–Macao.	D3	Wait times of goods traffic (trucks) when crossing Shenzhen (border with Hong Kong) and Zhuhai (border with Macao)	Uncertain
GD2	Reduce income inequality by improving access to higher levels of education and developing a labor force with more sophisticated skills needed for higher-wage work.			
SD4	Improve the tracking of changes in the PRD labor market.	D4	Number of new jobs created	Available
		D5	Number of jobs lost	Will be available after implementation
SD5	Attract workers with higher skills to the PRD.	D6	Number of workers in key areas: assembly (D6a), high tech (D6b), and services (D6c)[a]	Available, but will need to calculate
		D7	Percentage of residents satisfied with their job situation	Available in survey (Q44a)
SD6	Train graduates for work in emerging industries.	D8	Number of graduates from local vocational-technical schools in relevant fields	Available, but will need to calculate after defining the field
GD3	Implement low-carbon economic development strategies.			
SD7	Improve monitoring and verification of emissions reductions resulting from low carbon development strategies [SL3, SL7, ST1–ST6, SE8–SE12].	D9	Energy intensity of relevant sectors/areas: transportation (D9a), industry (D9b), and waste water treatment (D9c)	Probably available through statistics bureau, but will need to calculate

[a] According to the *Chinese Urban Statistics Yearbook* industries list, we consider the assembly sector to include the manufacturing industry; the high-tech sector to include the following industries: information, computer services, software, and scientific research; and the services sector to include the following industries: finance and real estate services; health care and social welfare; transport, storage, and postal services; hotels and restaurants; and environment and public facilities management.

Table D.6
Classification of Indicators Based on Type and Availability

Policy Area	Objective Indicators (not GIS) Available Now	Objective Indicators Available in GIS	Objective Indicators Available After Implementation of Strategy	Subjective Indicators Available After Survey	Total by Policy Area
Land Use	L2, L17	L5, L7, L10, L11–L15	L1, L3, L4, L16, L19–L24	L6, L8, L9, L11, L18	24***
Transportation	T5, T6, T11, T12, T13**, T15, T16		T1, T7, T8, T9**, T17	T2-T4, T10, T14	17
Environment	E1–E5, E8–E12, E19, E20, E23–E25		E13–E16, E21, E22	E6, E7, E17, E18	25
Housing	H7, H8**		H1*, H2, H3–H5, H6*, H9, H10		10
Economic Development	D1**, D2, D3**, D4, D6*, D8*, D9*		D5*	D7	9
Total by category	33	8	30	15	85***

* Indicator will require some calculation using available data (total = 6).

** Uncertain about availability (total = 5).

*** L11, noted in italics above, could be available either through GIS or by survey. It is only counted twice in the far right column of totals.

APPENDIX E

Priorities for Implementation of Strategies

Table E.1
Land Use Strategies: Priorities for Implementation

Challenges, Goals, and Strategies		Impact	Time to Completion	Ease
CL1	**Unplanned outward expansion of urban boundaries has led to fragmentation of both urban and rural land.**			
GL1	Increase the contiguity of urban and rural land.			
SL1	Map ecological protection zones and agricultural land based on productivity.	High	1–3 years	Hard
SL2	Enforce limits on development of more valuable ecological and agricultural lands.	High	Under one year	Hard
CL2	**Urban land is not utilized in a way that allows for efficient provision of public services and facilities.**			
GL2	Increase density of residential space and employment opportunities through provision of high-quality compact development.			
SL3	Promote transit-oriented development near rail stations (both intercity and urban rail).	High	1–3 years	Moderate
SL4	Adopt and enforce a zoning system that uses control on space such as density and design ("form-based codes") rather than a system based on land use function.	Lower	More than 3 years	Hard
SL5	Create a well-connected street network.	High	More than 3 years	Hard
SL6	Provide high-quality green space and attractive public spaces within residential and commercial areas.	Medium	1–3 years	Moderate
GL3	Increase efficiency and cost-effectiveness in the provision of public services and facilities.			
SL7	Create incentives to concentrate development by providing key infrastructure only in designated areas, consistent with compact development.	High	1–3 years	Moderate
GL4	Reduce the presence of industrial properties in prime residential and commercial areas.			
SL8	Develop a brownfields program that includes remediation standards and clear roles for various agencies.	High	1–3 years	Moderate

Table E.1—Continued

Challenges, Goals, and Strategies		Impact	Time to Completion	Ease
CL3	**Historic and cultural preservation has been neglected.**			
GL5	Strengthen measures to protect properties and assets with historical importance and distinctive local characteristics.			
SL9	Identify and prioritize buildings and neighborhoods with historical and cultural value.	High	Under one year	Moderate
SL10	Enact and enforce historic preservation regulations.	Medium	1–3 years	Moderate
CL4	**Current development patterns and processes do not adequately address the need for resilience from natural disasters.**			
GL6	Reduce vulnerability to damage from natural disasters.			
SL11	Identify and evaluate assets at risk of flooding through mapping.	High	1–3 years	Moderate
SL12	Identify and evaluate assets at risk of typhoon damage through mapping.	High	1–3 years	Moderate
SL13	Identify and evaluate assets at risk of earthquake damage through mapping.	High	1–3 years	Moderate
Supporting Strategies				
SL14	GIS mapping	High	Under one year	Easy
SL15	Master planning review	High	Under one year	Moderate

Table E.2
Transportation Strategies: Priorities for Implementation

Challenges, Goals, and Strategies		Impact	Time to Completion	Ease
CT1	**Without high-quality public transit alternatives, VKT in privately owned cars per capita will increase and congestion and air pollution will worsen.**			
GT1	Mitigate the need for people to travel by privately owned cars.			
ST1	Enhance the competitiveness of bus and rail through improvements in service coverage and frequency.	High	1–3 years	Moderate
ST2	Promote bicycle-sharing, car-sharing, taxi, and dynamic ridesharing services.	Lower	Under one year	Easy
GT2	Improve connectivity among transportation modes and among PRD cities.			
ST3	Develop multimodal transit hubs to enhance transportation connections, choices, and coordination among modes.[a]	Medium	1–3 years	Hard
ST4	Implement smart, interoperable ticketing within the region to make it easier to use alternative forms of public transit.	High	1–3 years	Easy
ST5	Develop a travel survey that captures inter- and intracity travel flows and mode use.	High	1–3 years	Moderate
GT3	Create an environment that emphasizes nonmotorized transportation modes.			
ST6	Connect pedestrian and bicycle greenways and paths to major employment destinations.	High	1–3 years	Moderate
GT4	Manage parking demand and supply.			
ST7	Institute a parking pricing system for on-street parking and encourage entrepreneurs to develop a mobile app that facilitates making payments.	Medium	Under one year	Moderate
ST8	Encourage entrepreneurs to develop apps that provide real-time information on available parking spaces to make finding parking easier and to avoid illegal parking.	Lower	Under one year	Easy
ST9	Enforce parking regulations and impose high penalties for illegal parking in central business district and other high-demand areas.	High	1–3 years	Moderate
CT2	**Road-based freight transport is a major source of congestion and safety problems.**			
GT5	Reduce interactions between passenger cars and trucks.			
ST10	Implement peak-period delivery restrictions in the central business district and other highly congested areas.	Medium	1–3 years	Moderate
ST11	Create freight consolidation centers in urban fringe areas to reduce the number of deliveries in the city center.	Medium	Under one year	Moderate
CT3	**An extremely high number of deaths and serious injuries are caused by everyday use of the roads.**			
GT6	Reduce deaths and injuries on the roads.			
ST12	Integrate road safety audits (RSA) into the project development process for new roads and intersections.	Medium	More than 3 years	Easy

Table E.3
Environment Strategies: Priorities for Implementation

Goals and Strategies		Impact	Time to Completion	Ease
CE1	**Water and air pollution and soil contamination are causing significant harm to human health and ecological resources, and diminishing economic growth.**			
CE2	**Regulators have insufficient resources and incentives to enforce laws and standards.**			
GE1	Increase enforcement capacity and accountability for air and water pollution and soil contamination.			
SE1	Increase the number of inspections by trained inspectors.	High	1–3 years	Easy
SE2	Increase incentives for enforcement.	High	Under one year	Hard
SE3	Increase incentives for compliance.	High	Under one year	Hard
GE2	Reduce unlawful industrial and municipal wastewater discharges into rivers and groundwater.			
SE4	Allow cities, districts, and counties downstream of unlawful discharge of sewage and industrial waste to receive some percentage of the revenue from fines imposed on polluters.	Medium	1–3 years	Hard
SE5	Expand water quality monitoring networks for both surface and groundwater.	Lower	1–3 years	Moderate
GE3	Reduce contamination of current and former industrial lands.			
SE6	Produce an annual inventory of contaminated waste sites in the PRD region. Assign responsibility to the director-general of the Environmental Protection Bureau for oversight of clean up at sites within the appropriate jurisdiction, and publish a list of sites with the name of the facility owner and a description of the nature of the contamination.	High	Under one year	Easy
SE7	Establish waste site cleanup funds at the municipal and provincial levels to use to remediate contaminated sites where the owner cannot be found.	High	1–3 years	Hard
GE4	Reduce unlawful emissions from air pollution from stationary and mobile sources.			
SE8	Accelerate Guangdong's phase-out of coal use, especially for household heating and industrial use, and coal-fired power plants serving all PRD cities.	High	1–3 years	Hard
SE9	Accelerate the implementation of green building codes and appliance efficiency programs.	Medium	1–3 years	Moderate
SE10	Accelerate removal of highly polluting vehicles through incentive payments.	High	1–3 years	Easy
SE11	Increase the number of cleaner cars registered.	Medium	More than 3 years	Moderate
SE12	Accelerate adoption of cleaner vehicle fuels.	High	Under one year	Hard

Table E.4
Housing Strategies: Priorities for Implementation

Goals and Strategies		Impact	Time to Completion	Ease
CH1	**There is a lack of good-quality public rental housing and housing for purchase for middle-income residents.**			
GH1	Ensure that housing (for rental and purchase) remains affordable to households at medium-income levels.			
SH1	Create incentives for developers to build more affordable rental housing and housing for purchase through competitive RFPs for below-market priced land.	Medium	Under one year	Moderate
SH2	Increase funding capacity and reduce government reliance on development fees by levying property taxes on homes.	High	1–3 years	Hard
SH3	Require a certain percentage of public rental housing units and affordable housing for purchase in TODs.	Medium	1–3 years	Easy
CH2	**There is a lack of good-quality public rental housing for lower-income residents.**			
GH2	Enhance construction of better-quality rental housing that is affordable to lower-income groups.			
SH4	Redevelop "villages in cities" using land readjustment techniques.	Medium	1–3 years	Hard
SH5	Adjust housing construction programs like CRH to allow developers to build low-cost rental units.	Medium	Under one year	Moderate
SH6	Provide housing vouchers to low-income residents, where voucher payments are directly provided to landlords after unit inspected and lease signed.	High	Under one year	Easy
SH7	Implement and enforce building and amenity standards for all public rental housing units and rental units built by private developers.	Medium	1–3 years	Easy

Table E.5
Economic Development Strategies: Priorities for Implementation

Goals and Strategies		Impact	Time to Completion	Ease
CD1	**Accelerate the economic transition by encouraging more sales to other Chinese provinces, while seeking new, low-carbon opportunities to expand the regional economy.**			
GD1	Raise output and employment by encouraging businesses in the PRD to sell more to other regions in Guangdong and elsewhere in China.			
SD1	Reduce internal barriers to trade.	High	1–3 years	Moderate
SD2	Improve provision of market information on prices, quality, grade, and other product attributes in provinces where PRD businesses are targeting their sales efforts.	High	Under one year	Moderate
SD3	Pilot a preclearance program at a border crossing with Hong Kong–Macao.	Lower	1–3 years	Hard
GD2	Reduce income inequality by improving access to higher levels of education and developing a labor force with more sophisticated skills needed for higher wage work.			
SD4	Improve the tracking of changes in the PRD labor market.	High	Under one year	Moderate
SD5	Attract workers with higher skills to the PRD.	Medium	1–3 years	Hard
SD6	Train graduates for work in emerging industries.	Medium	1–3 years	Easy
GD3	Implement low-carbon economic development strategies.			
SD7	Improve monitoring and verification of emissions reductions resulting from low carbon development strategies [SL3, SL7, ST1–ST6, SE8–SE12].	High	More than 3 years	Hard

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This report proposes a set of land use and transportation goals and strategies and an accompanying system of indicators to characterize and monitor quality of life in the Pearl River Delta (PRD) of Guangdong Province in the People's Republic of China. Goals, strategies, and indicators are also developed in less detail for the environment, housing, and economic development policy areas. The purpose of the indicator system is to provide an analytical foundation for guiding policy choices that strike a balance between meeting residents' needs and at the same time attracting new employers and employees to the region. The indicator system is designed to be flexible enough to work at the provincial, municipal, and district/county levels of government. Indicators are placed within a decision framework that first defines regional challenges, policy goals to meet those challenges, and strategies to address policy goals. The report identifies 12 challenges and proposes 21 goals and 53 strategies, to address the challenges, as well as a set of 85 indicators to monitor progress. The authors prioritize strategies based on their likely impact on progress toward goals, degree of difficulty, and time required to put the strategy in place.

Implementation of the indicator system will require several years, and periodic updating after that to keep it fresh and relevant to Guangdong's needs. Although strategies will be implemented at the provincial and local levels by multiple agencies, central oversight and maintenance of the indicator system will be crucial to its success. RAND recommends a cross-agency and cross-government council approach with a single agency lead.

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