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URBANISATION AND GREEN GROWTH IN CHINA

This working paper assesses national policy and governance mechanisms that can influence green growth in Chinese cities. It applies the OECD conceptual framework for urban green growth to examine the potential challenges and opportunities for increasing economic growth through reducing the environmental impact of urban land use, transport and buildings; through improving water and air quality; and through fostering supply and demand of green products and services. The paper first situates the issue of green growth within the nexus of urbanisation and environmental challenges now facing China. This is followed by a review of environmental and quality of life challenges posed by rapid urbanisation. Opportunities for national policies to influence green growth in four key urban policy sectors are then examined. The paper concludes with an assessment of governance challenges and considers potential changes to facilitate economic growth while reducing the environmental impact of cities.

JEL Classification:

O18 - Urban, Rural, Regional, and Transportation Analysis; Housing; Infrastructure
O44 - Environment and Growth
Q01 - Sustainable Development
Q55 - Technological Innovation
Q58 – Environment, Government Policy
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FOREWORD

Green growth has been a strategic topic of the OECD's work since 2009, when OECD member countries mandated the organisation to develop a *Green Growth Strategy*. Green growth has entered a number of areas of work in the OECD, including the Directorate for Public Governance and Territorial Development. The Directorate's mission is to help governments at all levels design and implement strategic, evidence-based and innovative policies to strengthen public governance, respond effectively to diverse and disruptive economic, social and environmental challenges, and deliver on government's commitments to citizens.

This working paper is one of two country-level case studies undertaken by the OECD Green Cities Programme, which was initiated by the 2010 OECD Roundtable of Mayors and Ministers in Paris. The aim of the programme is to increase understanding of the concept of green growth in cities, to enhance the potential of urban policies to contribute to urban and national green growth, and to inform national, sub-national and municipal governments as they seek to address economic and environmental challenges by pursuing green growth.

This working paper contributes to the synthesis report of the OECD Green Cities Programme, *Green Growth in Cities*, and is relevant to the *OECD Green Growth Papers* series.

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EXECUTIVE SUMMARY

The unprecedented pace of urbanisation in China has created a sense of urgency to address the negative externalities of agglomeration, particularly those involving environmental impact. This paper examines trends in economic and environmental performance in Chinese cities, and considers potential policy and governance responses to them through the lens of green growth. Green growth aims to steer economic growth in a different direction, addressing externalities and other factors poorly served by current measures of economic activity. It also recognises that environmental policies that do not support economic growth and wealth creation are not sustainable in the long term. For the purposes of this case study, green growth in cities is defined as:

Fostering economic growth and development through urban activities that reduce negative environmental externalities and the impact on natural resources and environmental services. (OECD, 2013a).

The purpose of this working paper is to assess national policy and governance mechanisms that can influence green growth in Chinese cities. While China is unique in the speed and scale of its urbanisation and related environmental challenges, experiences across the OECD can provide useful lessons for the central government's policy and governance responses to urban growth and environmental impacts. Similarly, policy makers in OECD countries can learn from the challenges and opportunities inherent in applying their experiences to the Chinese context. This working paper applies the OECD conceptual framework for urban green growth to examine the potential challenges and opportunities for increasing economic growth through reducing the environmental impact of urban land use, transport and buildings; through improving water and air quality; and through fostering supply and demand of green products and services. Section 1 situates this paper within the nexus of urbanisation and environmental challenges. Section 2 reviews the environmental and quality of life challenges posed by rapid urbanisation. Section 3 considers four key urban policy sectors and examines opportunities in each for national policies to influence green growth. Section 4 assesses governance challenges and considers potential changes to facilitate economic growth while reducing the environmental impact of cities.

Urbanisation on a massive scale is both cause and consequence of China's economic dynamism

China is in the midst of a period of rapid urbanisation, and the trend is likely to continue through 2030 and beyond. Since the mid-1970s, the urban population has more than tripled, from around 200 million in 1980 to almost 690 million in 2010. Today, just over half of China's population lives in urban areas. As China continues to converge towards the income levels typical of the OECD, it is expected that the urbanisation rate will continue to rise. The urbanisation rate is projected to reach 65% by 2030, which would imply an urban population of 950 million. China's cities have therefore become the focus of economic activity. Holding just under 30% of China's population, the country's 53 metropolitan regions produced 67% of the country's GDP in 2007. Looking ahead, urbanisation will continue to create new economic opportunities, with further productivity gains as workers migrate to urban areas. Moreover, new, more technologically advanced and dynamic industries, including high-end manufacturing and services, are likely to continue to evolve in and around large urban areas.

Rising incomes and urbanisation will also intensify some environmental challenges

While providing significant opportunities, urbanisation presents a number of resource challenges, particularly the pressure on land consumption generated by cities' expansion. Chinese cities will need to accommodate an additional population of around 250 million over the next decades – more than the entire population of Indonesia. Urban spatial expansion currently appears to be outpacing urban population growth. While density in urban cores has generally increased, suburban areas are characterised by rapid expansion. This has resulted in a loss of cultivated land in a country where the per capita stock of arable land is a mere 0.093 hectares, only 40% of the world average. It is beyond the scope of this study to determine the extent to which this expansion can be considered urban sprawl. Further research is needed on the impact of this rapid urban expansion and its relationship with an increase in liveable space for city dwellers, and how urban expansion might be better managed through a balance between market incentives and urban planning.

Additional resource challenges come from sustaining energy supply for cities. Chinese cities are estimated to account for around 75% of total national energy consumption, and the IEA expects this share to increase to 79% in 2015 and 83% in 2030. Since 2000, total final energy consumption in China has almost doubled, together with per capita total primary energy supply, which grew from 0.87 tonnes of oil equivalent (toe) in 2000 to 1.70 toe in 2009. Nevertheless, this is still much lower than the 2010 figures of 3.3 toe for OECD Europe and 7.20 toe for the United States. Most of this growth has been driven by industry, transport and construction. Despite rising household incomes and living standards, residential building energy consumption, though rising, accounts for a decreasing share of total energy consumption. The residential sector accounted for around for 25.1% of total final consumption over 2007-09, down from 36.2% in 2000-02. The World Bank has projected that from 2006-20, Chinese cities can expect an average increase in energy consumption for urban areas of between 36% and 46%, depending on the respective pathways they take.

Urbanisation also often entails a range of pressures associated with the geographic concentration of people and economic activity in cities. These include congestion, air and water pollution, as well as the accumulation and inappropriate disposal of household and industrial waste. Lagging public transport and rising income levels have led to a massive increase in the use of private vehicles and decline in the rates of bicycle use, resulting in serious traffic congestion in the urban cores. By 2010, car ownership in many large and rich cities had already reached over 100 cars per 1 000 inhabitants, and the trend is likely to continue for the foreseeable future. Total emissions of nitrous oxide (NO_x) increased from 19 million tonnes in 2007 to 22 million in 2010. The emission intensity (emissions per unit of GDP) of both sulphur dioxide (SO₂) and NO_x were recently estimated at, respectively, 4.5 and 3 times the OECD average, a sharp increase as compared with the ratio in the early 2000s. Measured in terms of the concentrations of particulate matters, Chinese cities rank among the most polluted in the world. Various studies (using human resource and contingent evaluation methods) estimate that the cost of air pollution falls in the range of 3%-7% of GDP. Despite constant improvements, China also faces serious water pollution problems, which have further reduced the availability of clean water in water-scarce cities. While wastewater discharges from industry declined over 2005-10, water pollution from urban residents grew. By and large, increases in per capita GDP correlate with increases in domestic wastewater discharges, *e.g.* Shanghai's domestic per capita wastewater discharges (92 t) were more than three times larger than Chongqing's (29 t) in 2010.

Given China's urbanisation, sustainable development calls for appropriate urban policies

The reform priorities and targets in the 12th Five-Year Plan (FYP), covering 2011-15, underscore the importance that Chinese authorities attach to facilitating continued steady urbanisation, as well as improved environmental performance. The Plan includes a target to lift the urbanisation rate by around 4

percentage points, while enhancing the provision of social services for all urban residents, including migrant workers, as well as continued strong investment in essential urban infrastructure. Compared to earlier plans, an increased number of environmental targets have been set in the 12th FYP in four policy areas: energy/carbon efficiency, pollution abatement for air and water, land management and green products and services.

Urban policy has a critical role to play in achieving these targets. Policies that respond to the negative effects of urban agglomeration must address both environmental and economic growth priorities. These policies could for example address road congestion charges, brownfield redevelopment or sustainable cost recovery for water and waste services. Moreover, attractiveness can be a key driver of a city's economic growth and can be hampered by environmental degradation. Congestion, pollution and public service constraints affect not only environmental quality but also the efficiency of local economic activities and cities' ability to attract firms and skilled workers. These kinds of complementary policies can yield double benefits in the form of environmental improvements, as is the case of a mass transportation system replacing old and energy-inefficient taxis and small buses. If public transportation policies are combined with land use policies designed to increase the efficiency of urban spatial form, further reductions in local and global air pollution can be achieved. In addition, the implementation of green growth policies at the local level can address social issues in a more direct way than at the national level. Further, many Chinese cities are vulnerable to climate change, such as rising temperatures, more-severe storms, and rising sea levels, particularly the densely populated coastal cities that are also the country's economic powerhouse. Infrastructure investments to reduce vulnerability to these anticipated climate change impacts can also contribute to economic growth and prevent higher remediation costs in the future.

Obtaining efficient urban form and transport is crucial

Efficient urban form and public transport infrastructure are crucial to support sustainable growth and the long-term environmental efficiency of cities. As urban areas rely more on public transport, walking and cycling, carbon dioxide (CO₂) emissions from transport are likely to be greater in less densely populated areas. Compact urban form can reduce the cost of public service delivery and increase the efficiency of labour markets and urban service delivery. The 12th FYP includes a strategy to promote city clusters, strictly regulate land use and advance public transport infrastructure construction. While the city cluster strategy does not directly address compact urban form, it does promote the benefits of economic agglomeration and efficient land use against a backdrop of rapid growth in the urban population.

One of the primary drivers of urban expansion is land-related income: land leases, auctions and development rights are crucial to Chinese cities' revenue streams. Revenues from leasing of land-use rights may have accounted in recent years for as much as for 30%-50% of annual fiscal revenues for many cities, and up to 80% in smaller cities. This gives cities strong incentives to grow on the periphery. One alternative to generating revenue through land sales would be to tax the increases in real-estate value that result from increased access to urban amenities such as public transportation. Other essential measures include prioritising transport-oriented development and promoting mixed-use and infill development. Infill development and increased density of loosely grown urban areas can be incentivised through a number of different tax rates. Integrated transport systems play a central role for improving the functionality and efficiency of metropolitan regions and fit with the national policy framework of city clusters. Of particular importance for an integrated transport system are linkages between residential zones and employment centres, as well as between different modes of transportation. This becomes a particular challenge in peripheral areas. While train and metro systems offer lasting but expensive solutions, less costly options for connecting suburbs with downtown employment centres are bus rapid transit (BRT) systems, which have successfully been employed in various cities, such as in Curitiba (Brazil), Bogotá (Colombia) or Mexico City. While buses still provide the majority of public transport service in China, finance for maintenance and service provision is insufficient.

Given the need to preserve accessibility in fast-growing cities, there is an urgent need to invest more in public transport. This calls for diversifying funding sources while reducing the role of land sales as main revenue sources for local governments. Congestion charges can also significantly contribute to financing public transport expansion and maintenance, while at the same time reducing road congestion. Unlike fixed fees or tolls, congestion charges are usually applied dynamically, as variable fees, being most expensive at peak hours and during congestion. Such charges have been successfully implemented in a number of metro-regions, such as Singapore, London and Stockholm, and have been shown to influence travel behaviour significantly. In some cases, such as Milan, they also apply to the environmental performance of vehicles. The success of congestion charges depends in part on their joint implementation with other policies, such as policies to improve alternatives to car use. For example, congestion fees worked well in London in part because they were combined with improvements in management of the road network and substantial enhancements in bus service.

Green building construction and energy-efficiency retrofitting can help

Energy-efficiency policies for the buildings sector can help reduce energy consumption and, if applied along with a high price on carbon, can reduce greenhouse emissions. While the national framework has laid out policy directions for both new building codes and building retrofits, the scope for future work is considerable. The 11th and 12th FYPs have placed increasing importance on making buildings more energy efficient, through stricter building design standards, as well as retrofitting programmes. Energy-efficiency building retrofits are considered an important means of meeting the 12th FYP targets for additional energy-efficiency gains, given the large existing building stock. For instance, total residential floor space to be retrofitted in northern heating areas was expected to reach 0.4 billion m² over the 12th FYP period, a substantial increase from the target of 0.15 billion m² set in the 11th FYP. This is due to the fact that a total floor area of 2 billion m² is estimated to need energy-efficiency retrofitting in northern areas. Energy efficiency alone is not sufficient to reduce cities' environmental footprint. Energy efficiency measures should be implemented together with other policies that can more generally internalise environmental externalities of economic activities, such as removing or reducing fossil fuel subsidies, introducing an effective price on carbon, carbon trading scheme, and the like. While such measures may also drive up energy prices, this would in turn create a key incentive for improving energy efficiency, both in industrial production and for public and private consumption in buildings.

As financing is the primary challenge that retrofitting efforts face, mobilising private sector involvement and further public sector support will be crucial. Policy incentives for retrofitting were provided at around CNY 50/m², usually one-third to one-seventh of the actual retrofitting cost. The total retrofitting funding amounted to CNY 24.4 billion for 0.18 billion m² during the 11th FYP, and retrofitting a total of 2 billion m² will cost an estimated CNY 300 billion. Thus far, the vast majority of government subsidies for retrofits have been for public buildings, which can be logistically easier to handle, as there is one owner. In contrast, retrofits in residential buildings require convincing a majority of the residents to support the project. However, the barriers to residential energy-efficiency retrofits need to be lowered. Energy Service Companies (ESCOs) present a possible solution to financing and meeting energy targets; they are active in a number of countries such as Germany, Korea, US, France, Brazil. Increased demand for ESCOs and other energy efficiency and green building design firms can contribute to the growth of the service sector in Chinese cities. The central government could consider setting explicit goals for the growth of this sector within the framework of industrial conversion targets. In this way, energy-efficiency activities would be recognised for their contribution to local economic development, and not only as a way to help reduce building energy consumption. Another potential solution for financing energy-efficiency retrofits are low-cost loans to property owners, provided or guaranteed by city governments, similar to the Property-Assessed Clean Energy (PACE) initiatives found in the United States.

The right standards and incentives are needed to deliver high-quality water and air in Chinese cities

Hitherto, national policy targets on water and air quality have been achieved mainly through direct abatement measures. The range of policy approaches adopted includes regulatory approaches, economic instruments and information-based voluntary policy tools. During the 11th FYP period, direct abatement measures, such as upgrading industrial facilities and implementing well-established technical solutions, were the dominant contributors to some of the most significant reductions in air and water pollution. As direct abatement solutions are becoming exhausted, and pollutants with less obvious technical solutions are more difficult to tackle, a broader approach to air and water pollution will be required in the future, relying more on improved economic instruments, such as water and wastewater pricing, more stringent standards, particularly for air quality, and more coherent co-ordination between national, provincial and local governments.

Water tariffs are still too low to promote water conservation, and in most cases do not reflect the entire cost of water supply, treatment and distribution. Underfunded wastewater treatment systems hamper adequate responses to urban water quality concerns. Improved governance of water at the municipal level and water demand management needs to be the focus. A substantial body of evidence suggests that using prices to manage water demand is more cost-effective than implementing non-price conservation programmes. Such pricing mechanisms need to be designed while taking into account the needs of low income groups.

Cities should be encouraged to go beyond national standards and targets, particularly on air quality. Given the anticipated tightening of national standards, cities that are pro-active on reducing emissions should have the opportunity to turn their efforts into assets and to create local incentive structures to accelerate progress. Better measurement and monitoring of progress on CO₂ are required to unlock further potential in the energy and pollution abatement sectors. The NDRC's 2010 designation of eight cities and five provinces as low-carbon development pilots is allowing for experiments on different low-carbon standards. While the use of pilot programmes has proven an effective means to develop policy reforms in China, the low-carbon development pilots do not yet provide clarity as to the types of indicators and systems that present the best opportunities for monitoring and guiding low-carbon development. New approaches to low-carbon indicators are being studied, and experiences from other countries might offer viable options, such as the United States Lawrence Berkeley National Labs' low-carbon indicator system and the OECD metropolitan regional environmental indicators.

Green sectors and green clusters can represent a promising source of growth in cities

Green industrial sectors can play an important role in enhancing urban environmental conditions and present a promising source of growth. China enjoys crucial conditions to harness that growth, including abundant physical and human capital, a large domestic market, attractive conditions for foreign investment and a large potential for commercialisation and R&D. Beyond green sectors, green clusters have emerged in Chinese cities and could be an ideal target for promoting further development. These green clusters have been mainly developed from current industrial parks and development zones, which are the main levers that cities use to promote cluster development. Besides cluster development, green clusters could become important elements of larger urban development plans. The national policy frameworks play a crucial role for exploiting the potential of green sectors. The 12th FYP has defined seven targeted strategic industrial sectors, including green industries, among which are energy saving and environment protection and alternative energy. Within these sectors the focus is on energy-efficient technologies and products, energy service companies (ESCOs), environmental protection industries, recycling and reuse, renewable energy and production, and clean energy vehicles.

But there remain challenges and opportunities in these green sectors and clusters. First, renewable energy exploitation needs targeted demand-side policies. Renewable energy technologies have experienced exponential growth during the past few years, and prospects for future growth are driving further cluster development. Nevertheless, overlaps and duplications have resulted from the intense competition between industrial park developments in solar PV and wind manufacturing. In addition to national programmes and incentive frameworks, local governments could consider introducing additional regional standards and targeted measures and incentives to exploit regional renewable energy potential and to harness the benefits of green technologies to spur dynamic local markets. Possible measures could include green procurement policies that incorporate environmental conditions, government standards and labelling that guide private-sector consumers, as well as information and incentives that lower barriers to green consumption. Better regional co-ordination could help avoid such duplications and contribute to healthier and more effective intra-regional competition.

Second, eco-industry clusters have been growing alongside other industrial parks but have the potential to grow more *within* existing traditional clusters. The application of Eco-Industrial Park (EIP) best practices in current industrial clusters needs to be accelerated. The EIP programme started in the late 1990s, and at the end of 2011, the programme awarded the title to 59 industrial parks. While these trial practices have made good progress, efforts are needed to expand them. Several measures could be considered to scale up EIP approaches to all industrial parks, including introduction of pollution abatement technology, stricter environmental standards, ambitious energy-efficiency targets and promotion of circular economy approaches. Also, a strategy for relocating small, scattered firms into EIPs could result in lower costs for enforcement and monitoring of standards, while allowing for environmental efficiency and synergy effects. An appropriate tool for implementing coherent standards may be a roadmap, outlining different increasingly ambitious standards and phases of implementation.

Third, while the aspiration to develop green clusters is obvious, the difficulties lie in how to turn these green clusters into genuinely competitive, innovation-driven clusters. Further efforts are needed to build up the innovation potential of green clusters and move towards a regional innovation cluster approach. The current model of industrial parks should be enhanced to move beyond pure production capacity and allow greater innovation potential. Relevant measures would be to diversify the actors involved in economic activities, including SMEs, research centres and universities. In addition to already existing innovation centres, linkages between different actors could be strengthened to create a regional network, which would allow for direct exchanges between businesses, research and domestic markets. Concrete incentives, such as innovation vouchers, might help build these linkages and create innovation networks. In addition to enhancing the innovation potential of industrial parks and development zones, a more comprehensive approach to innovation on a regional scale is needed in the long run. The incorporation of a larger number of diverse actors would allow for more interdisciplinary linkages and spillovers, foster cross-fertilisation and nurture network effects.

Institutional changes could facilitate the achievement and enforcement of urban environmental targets

Attaining the ambitious environmental targets in the 12th FYP will require co-ordination and policy coherence between the central government and local governments. It is important to identify and remove perverse incentives that interactions among national policies can create for cities, so as to encourage urban policies that are truly in line with national goals. Concretely, governance mechanisms need to achieve the following objectives: national targets need to be well translated to sub-national stakeholders, funding needs to be able to support implementation (whether generated from transfers or from economic and incentive-based instruments), inter-departmental co-ordination needs to be streamlined to facilitate policy integration, systematic information collection needs to take place to track progress, local officials' capacity needs to be sufficient to carry out implementation, and inter-jurisdictional collaboration needs to be encouraged.

However, effective implementation and enforcement may be constrained by governance gaps. China has in effect a shared governance structure that requires continuous negotiations of additional functional responsibilities among different levels of governments. The significant progress in energy saving and pollution abatement during the 11th FYP period was achieved through target responsibility mechanisms and fiscal resource allocation, coupled with heavy administrative measures. Moving forward, the marginal returns to such approaches will gradually decrease as the “low-hanging fruit” runs out. The ability to deliver a coherent response to current economic and environmental pressures may face challenges from the mismatch between central and local objectives, the lack of resources, horizontal policy fragmentation, and the lack of systematic information and insufficient capacities. The central government will have an important role in bridging the gaps and improving the governance mechanism. Addressing these challenges calls for the establishment of a sound policy and regulatory framework, and well-designed incentive mechanisms, coupled with strengthened monitoring and enforcement capacity to make green growth more attractive to the private sector.

The central government will need to make firm commitments to advance green growth and development policies at the local level. With many of the major strategic decisions and steps having been taken to encourage green development priorities, the emphasis is now on assuring local compliance. However, promoting economic growth had long been the primary goal of local governments and the lax enforcement of environmental regulations had been frequent. The negotiations over additional green responsibilities reflect the mismatch between the socio-economic development objectives of the central government and the sub-national stakeholders. Despite recent changes in the national framework to include more environmental priorities, economic performance still holds an important role in performance evaluation of local officials. Strengthening compliance with environmental requirements is now becoming crucial to ensuring that the major regulatory reforms are successfully sustained over time.

Further efforts are needed to motivate cities racing to the top to improve attractiveness for high value added investment and high-skilled labour. The central government’s shifting priorities have encouraged an increasing number of local initiatives in renewable development, including preferential electricity pricing for renewable power in Jiangsu, fiscal incentives for solar PV and wind turbine manufacturing in Liaoning, Jilin and Heilongjiang, and subsidies for energy-saving and new energy vehicles in six cities. While encouraging such developments, the central government may consider enabling a “race to the top” competition among cities. This will require well-designed incentive mechanisms for cities and the private sector. Establishing clear rules and objectives can create the conditions within which cities can unleash their green growth potential, and therefore improve their attractiveness. The central government needs to encourage local authorities to pursue green initiatives and adopt the concept that environmental attractiveness can contribute to high value added urban economic growth. The private sector also needs clear regulatory and price signals, which require co-ordination by both national and sub-national authorities on assuring compliance. The effectiveness of efforts to incentivise pollution abatement and more efficient energy use has been hindered by the relatively low level of environmental charges and resource prices, as well as by the immature emissions trading market.

Getting the environmental incentives right can also help diversify funding sources for urban green priorities. Despite the central government’s direct investments and funds allocated for specific purposes, the fiscal capacity of sub-national governments is still under considerable stress. This is particularly relevant for some economically lagging regions categorised as “restricted development zones” and “prohibited development zones”, which need to focus on ecological preservation rather than economic development. On the other hand, the current environmental charges and taxes are still low compared to those of OECD countries and are also far below levels that would induce significant changes in environmental behaviour.

As urban form matters, national urban policies could be better co-ordinated to better manage urban spatial expansion. Urban policy mandates are fragmented and overlap across many ministries, with the main responsible administrations including the National Development and Reform Commission (NDRC), the Ministry of Housing and Urban-Rural Development (MHURD), and the Ministry of Land and Resources (MLR). The policy gap needs to be addressed in order to promote integrated approaches to urban expansion and to promote efficient land management practices. A further necessary step is to incorporate urban form into the national urban policy framework, which is not yet included in the current 12th FYP. There is a need to review national-level urbanisation policies to increase coherence with other environmental policy priorities, such as the eco-city standards from MHURD and MEP.

In addition, horizontal policy co-ordination needs to be improved to better integrate policies at the urban level and encourage cross-municipal collaboration. Moreover, there is considerable room to integrate economic, environmental and construction policies in the urban administrative structure, which may need incentives and technical assistance from the central level. Finally, inter-municipal collaboration needs to be encouraged by central and provincial governments. Enhanced horizontal co-ordination among local governments can enable local authorities to maximise financial and human resources, facilitate knowledge spillovers and help tackle congestion, air pollution, health problems and greenhouse gas emissions. The central government could also consider encouraging voluntary inter-municipal co-operation agreements, which have been employed in many OECD countries, often encouraged from above via the use of fiscal and legal instruments.

Finally, monitoring, compliance assurance and implementation capacity needs to be enhanced. Developing harmonised city-scale emissions inventories could be useful so that mitigation performance and efforts can be monitored, supported and compared across urban jurisdictions. While a common framework remains to be established in China, the central government might consider borrowing international experiences in measuring progress, so as to better inform policy makers and other stakeholders. Moreover, Chinese cities could encourage a greater role for the general public in monitoring pollution through better information advocacy and public participation. While the indicators provide a necessary tool to track progress, the central government could address concerns about the capacity gaps at the local level. Bridging the capacity gap calls for enhanced training and capacity building among local level officials, in particular to improve local compliance with green development targets. The international community could be helpful in providing knowledge inputs to the government's training programme for achieving urban green growth.

1. INTRODUCTION: URBANISATION AND THE ENVIRONMENT IN CHINA

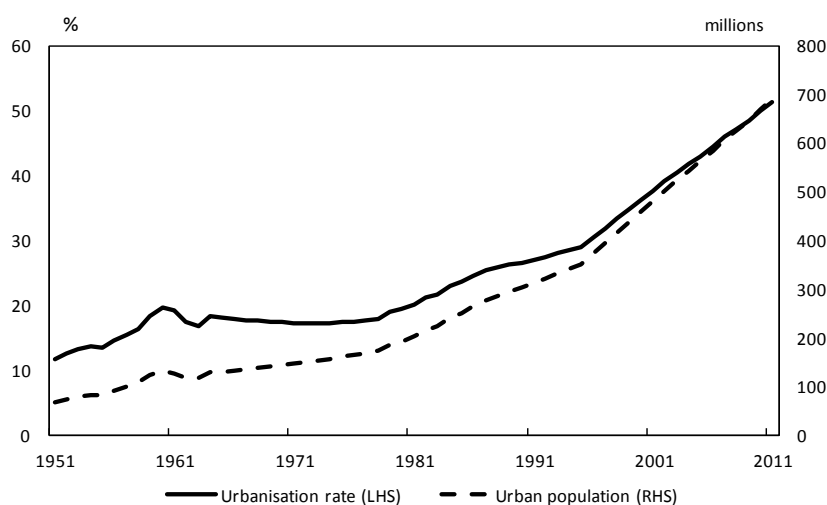
Cities in China are growing at an unprecedented pace. Now that over half of all Chinese live in a city, there are concerns on how to accommodate the rapidly rising urban population while also addressing pressures on the environment that accompany economic growth. This paper looks at the opportunities for pursuing green growth in Chinese cities from the perspective of central government policies. The first section provides an overview of the urbanisation challenge and the argument for green growth. The second section provides data on economic and environmental trends in Chinese cities. The third section discusses opportunities for green growth in Chinese cities, through the lens of land-use and transportation policies, building policies, policies to reduce water and air pollution, and strategies to increase regional clusters of green technologies. The fourth section considers the institutional reforms that could be implemented to take better advantage of the potential for green growth in Chinese cities.

1.1. Urbanisation is occurring on a massive scale as environmental challenges loom

China is in the midst of a period of rapid urbanisation, involving the relocation of hundreds of millions of people from rural to urban areas. This process represents the largest migration in human history and a key dimension of China's extraordinary transformation towards a modern and prosperous society. Although urbanisation began relatively late in China, it has accelerated markedly over the past three decades (Figure 1.1). During the 1960s, the government favoured the development of rural and regional areas, and the migration of people to urban areas was severely restricted, so much so that by the mid 1970s, less than 20% of the population lived in cities. However, a marked shift in policy in the late 1970s, at the onset of "the period of opening-up", reduced restrictions on population mobility, which sharply accelerated rural-to-urban migration. The number of administrative areas defined as cities ballooned, and over time restrictions on the movement of people were further eased. These changes, together with economic reforms that lead to a dynamic industrial sector – offering workers an attractive alternative to farm labour – resulted in a steady rise in urbanisation. Today, just over half of China's population lives in urban areas, a similar rate to other middle-income countries, and China is home to the largest number of urban residents. However, China's urbanisation level is lower than that typical for a country with similar real income per capita, and its annual rate of urban population growth (3.5 %/year) is lower than the 5% -6% rates that have been seen in other developing countries during their periods of rapid economic growth (Henderson, 2009).

As China continues its economic transition towards a high-income country it is expected that the urbanisation rate will continue to rise and the population of its cities to swell, as witnessed in other countries that have experienced rapid industrialisation. Some estimates suggest that the urbanisation rate may reach 65% by 2030, which would see the ranks of the urban population grow to 950 million (CDRF, 2010). At this rate, Chinese cities would need to expand sufficiently to accommodate an additional population of around 250 million – more than the entire population of Indonesia. With the Chinese government targeting the growth of a number of large cities, as well as the development of a smaller number of key urban agglomerations that will each be home to tens of millions of residents, this process is likely to see the rise of some of the largest urban concentrations in the world (Hu, 2011). Urbanisation in China will therefore continue to redefine not only the economic, physical and social landscape of China but also the nature of megacities.

Figure 1.1. Urbanisation and the urban population in China



Source: CEIC (2012), "Macroeconomic Databases for Emerging and Developed Markets", www.ceicdata.com; and NBS (N.D.), China Database, www.stats.gov.cn/english/statisticaldata/yearlydata.

As in other industrialising countries, urbanisation in China represents an important dimension of economic development that has both contributed to, and been shaped by, sustained rapid economic growth. As the share of agriculture in GDP has dwindled, cities have become the focus of economic activity. The reallocation of workers from low value added agriculture in rural areas to higher value added sectors – many of which are concentrated in urban areas – has made a significant direct contribution to growth over the past couple of decades (OECD, 2010a). Urbanisation has been especially rapid along many parts of the coastal fringe and synonymous with the rise of dynamic export-oriented manufacturing industries. This includes a number of locations around the Pearl River Delta where large cities have emerged from areas that were largely rural less than a generation ago. Looking ahead, urbanisation will continue to create new economic opportunities. With a large share of the workforce still engaged in agriculture, there is significant scope for further productivity gains from workers migrating to urban areas. This is even more so given that new, more technologically advanced and dynamic industries, including high-end manufacturing and services, are likely to continue to evolve in and around large urban areas.

Urbanisation in China has offered a pathway to higher living standards, with urban residents enjoying average per capita incomes around three times higher than their rural counterparts (NBS, 2011b). Notwithstanding higher prices for many goods and services in cities, higher incomes have translated into greater levels of consumption, including higher ownership rates for many consumer durables and other goods (OECD, 2010b). The Chinese government has invested heavily in improving essential social services across the country, including rural areas. Nevertheless, city dwellers often enjoy better access. In the health sector, the number of beds in hospitals and health care centres per capita, as well as the overall number of health professionals, is significantly higher in cities. Urban residents are also better educated, with around 20% of the urban population educated to at least senior secondary level, compared to less than 10% in rural areas (NBS, 2010a). The continued trend of working age Chinese flocking to cities in large numbers, even when faced with the prospect of challenging working and living conditions, reveals a strong belief that cities offer greater opportunities and better lifestyles. Many rural households have also directly benefitted from urbanisation through remittances from rural workers who have migrated to cities. The migration of workers to the cities has also helped improve agricultural labour productivity by reducing the average number of workers on small agricultural plots, as well as the number of people supported by the income of each farm.

While providing significant opportunities, urbanisation can also present a number of challenges. The expansion of cities without adequate investment in housing and other essential infrastructure, or poor planning more generally, can give rise to substandard living conditions. Poor housing, lack of economic opportunity and disparities in incomes may also lead to increases in crime and broader social tensions. Urbanisation also often entails a range of environmental pressures associated with the geographic concentration of people and economic activity, including severe air and water pollution, as well as the accumulation and inappropriate disposal of household and industrial waste. In some cases, per capita pressures on the environment are lower in urban areas than non-urban areas, such as per capita CO₂ emissions. While rising incomes, rather than urbanisation itself, are largely responsible for increases in environmental pressures, the concentration of these pressures in cities makes addressing them at the city level a priority.

Rapid economic development has given rise to a number of environmental challenges in China, many of which are strongly intertwined with ongoing urbanisation. Measured in terms of ambient concentrations of particulate matter, one of the most damaging pollutants for human health, the air in Chinese cities ranks amongst the most polluted in the world (WHO, 2011). Levels of other air pollutants that have been closely monitored in China over an extended period, including sulphur dioxide (SO₂) and nitrogen oxides (NO_x) are also high. China is now the largest emitter of carbon dioxide (CO₂) emissions, and is expected to be the single largest contributor to global emissions in the coming decades (IEA, 2011a). High concentrations of primary pollutants have also led to a high incidence of other types of pollution, including smog and acid rain. Water pollution is also a severe problem, with over 40% of inland rivers that make up China's seven main river systems deemed to be unsuitable for human contact (MEP, 2011a). The management of growing volumes of household, construction and industrial waste poses a major challenge.

High levels of pollution and other environmental problems present a challenge to China's vision of healthy and harmonious cities. There is mounting evidence of significant adverse health effects in China from exposure to ambient pollution and environmental accidents, which international evidence suggests tends to fall most heavily on the more vulnerable segments of the population, including children, the elderly, the ill and those with a lower socio-economic status (Zhang, J. *et al.*, 2010; Jianrong, 2011; Peled, 2011). Notwithstanding some notable improvements in pollution levels in recent years, urbanisation and rising incomes are continuing to push up the economic cost of environmentally related health problems (Matus *et al.*, 2011). In some instances, environmental factors are already imposing constraints on the growth of Chinese cities, notably in ensuring adequate supplies of fresh water. China is a relatively water-scarce country and faces the additional problem of an uneven distribution of water: while many regions in southeastern China enjoy high rainfall, many northern and inland provinces suffer from low rainfall. A number of cities already rely heavily on groundwater supplies that are being rapidly depleted. Securing alternative sources of water poses a considerable challenge exacerbated by the presence of high levels of pollution in major river systems.

Given the importance of urbanisation as a driver of economic growth there are strong complementarities between efforts to promote greener, more environmentally friendly cities and China's continued rapid economic development. A policy approach that aims to address the negative environmental externalities of agglomeration can also help to make cities more economically dynamic, thereby supporting broader national economic goals. Access to well-designed and reliable transport systems lowers congestion and reduces operating costs for firms and commuting times, drawing workers to cleaner and more attractive cities. This is likely to be especially true for highly skilled workers that are needed to ensure the development of more technologically advanced and higher value added industries. Such workers will tend to be more mobile, and hence have more choice over where they live and place greater value on environmentally related considerations. This notion is supported by evidence that higher levels of pollution in Chinese cities tend to depress property prices (Zhang, S. *et al.*, 2011).

1.2. Promoting a better environment and continued urbanisation are key sustainable development priorities

China, like other fast growing emerging economies, faces a major challenge in decoupling environmental degradation from economic development. A common hypothesis concerning economic development and the environment is that the environment tends to suffer as countries begin the process of industrialisation and economic activity shifts towards more energy-intensive and polluting activities (Carson, 2009). As prosperity rises, greater importance is attached to protecting and improving the environment and further economic advances become associated with continued environmental progress. This relationship between economic development and the environment is not, however, predetermined. Steps to improve the environment require proactive and wide-ranging reforms, including strengthening environmental regulations and property rights, improving price signals, educating firms and households, implementing foresighted planning and investing heavily in a range of environmental-related infrastructure.

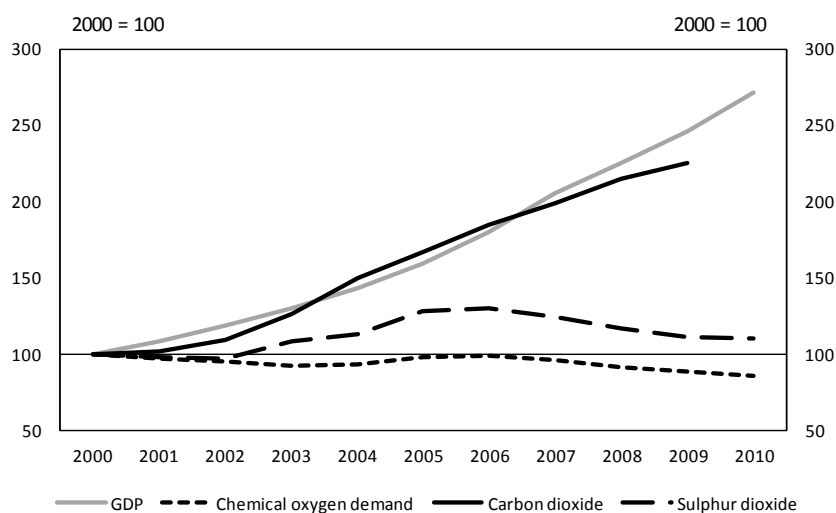
In response to broad environmental challenges, notably a rising incidence of visible pollution, China has taken a number of important steps to address pollution and promote a more environmentally sustainable development path. Over the past decade, new laws were introduced to encourage cleaner production in the industrial sector, strengthen the role of environmental impact assessments and promote the circular economy, including recycling (McElwee, 2011). In addition, existing key legislation has been modernised and amended, and new regulations implemented to reflect evolving environmental needs. The government has elevated environmental issues to the ministry level by replacing the State Environmental Protection Agency, the previous national agency with primary responsibility for environmental protection, with the Ministry of Environmental Protection. Governments at all levels have also invested vast sums in key environmental infrastructure to reduce immediate sources of pollution, notably the expansion of water and waste treatment facilities.

A concerted effort is being made to conserve energy and promote cleaner energy sources. China relies heavily on fossil fuels for its energy needs, especially coal which accounts for around three-quarters of total energy production and 80% of electricity generation (NBS, 2011b). Hydropower represents roughly 16% of electricity production (IEA, 2011b). The authorities are investing heavily in nuclear power and have taken a number of steps to promote renewable energy, including through the introduction of feed-in tariffs, which provide a subsidy for solar PV and wind-power generators. Such measures have seen a sharp rise in solar PV and wind-power capacity, though from a small base. Gasoline and diesel prices have also been deregulated so that they now reflect prevailing international oil prices, and hence provide better signals to end users. Nevertheless, they remain relatively low by international standards, as do electricity prices, which are tightly regulated and have barely moved in the past few years despite rising generation costs. A number of command-and-control initiatives were also launched in the second half of the 2000s to curb energy consumption growth. These initiatives focused on promoting improved energy conservation amongst the leading industrial energy consuming firms, closing down outdated and inefficient industrial production capacity and lifting energy standards for buildings and consumer durables (Yuan *et al.*, 2011).

Against the backdrop of continued high economic growth and rising consumption, China has made notable advances in curbing different types of pollution, suggesting that prosperity may be leading to environmental improvements (CCICED, 2011a; Jiang *et al.*, 2010); however, progress has varied across the country. Over the past decade, the authorities have been successful in decoupling the rise in SO₂ emissions from economic growth (Figure 1.2), and since the mid-2000s absolute SO₂ emissions have gradually declined. Carbon dioxide emissions continue to rise, reflecting strong energy consumption growth and reliance on fossil fuels, although progress has been made in slowing the rate of emissions growth, thereby enabling a degree of decoupling with rising economic output. Improvements in overall levels of water pollution have also been made with aggregate concentrations of chemical oxygen demand

(COD), which reflect the presence of organic and inorganic pollutants, having declined by around 15% in 2010 compared with the turn of the millennium.

Figure 1.2. GDP and key air and water pollutants in China, 2000s



Source: CEIC (2012), "Macroeconomic Databases for Emerging and Developed Markets", www.ceicdata.com; and IEA (2011), *World Energy Outlook 2011*, OECD Publishing, doi: 10.1787/weo-2011-en.

Looking ahead, reform priorities and targets in the 12th Five-Year Plan (FYP) for 2011-15, underscore the importance the Chinese authorities commitment to facilitating continued steady urbanisation and lifting environmental performance. The Plan includes a target to lift the urbanisation rate by around four percentage points, from 47.5% -51.5%, even though the latest census figures show that the rate had already reached around 50% by 2010. Emphasis is also placed on enhancing the provision of social services for all urban residents, including migrant workers, as well as on continued strong investment in essential urban infrastructure. The need to promote employment growth is also underscored, with the government expecting 45 million jobs to be created in cities.

The 12th FYP contains both binding and aspirational environmental targets, building on the achievements and objectives previous plans (Table 1.1). The binding targets can be enforced since they demand concrete policy measures and are placed in officials' performance evaluation. Aspirational targets, if complemented with quantitative goals, make general guidelines more explicit and thus put pressures on voluntary compliance. Reflecting regional disparities in development and industry and energy structures, differentiated environmental targets have been set across provinces.

Compared to the earlier plans, an increased number of environmental targets have been set in the 12th FYP in four policy areas: energy/carbon efficiency, pollution abatement (for air and water), land management and green sectors (e.g. clean energy and energy-efficiency technologies). Binding targets for further reductions in key air pollutants have been set, with SO₂ and N₂O emissions to fall by 8% and 10% respectively and water pollution COD and ammonium nitrogen levels targeted to fall by 10%. For the first time in China, the 12th FYP adopted an urban air quality target, requiring that 80% of urban areas reach "National Ambient Air Quality Class II". Carbon dioxide emissions per unit of GDP are targeted to fall by 17% – a target set with a view to reaching the 2009 longer-term commitment to reduce the carbon intensity of production by between 40% and 45% in 2020 relative to 2005. To help achieve these goals the government intends to establish pilot emissions trading schemes in selected provinces. The Plan also targets improved resource efficiency, which will yield indirect environmental benefits and continued strong

growth in cleaner energy. Energy consumption per unit of GDP is set to fall by 16% and water consumption per value added unit of industrial production by 30%, while the non-fossil fuel share of energy is expected to rise to over 11%. In addition to the energy-efficiency target, the 12th FYP proposes to put forth a working plan to reduce total energy consumption by 2015, in the same way targets were set for 2010. The Plan's land use target, which is set to drop by 30% per unit of GDP, is particularly relevant to cities, and reflects the government's aim to further promote compact urban development and more-efficient land use. Further, the 12th FYP promotes the development of several green sectors, including energy conservation (*e.g.* heat electricity cogeneration, energy-efficient light bulbs), environmental protection (*e.g.* desulphurisation equipment, wastewater treatment facilities), and non-fossil fuel energy (*e.g.* wind power, solar PV energy and smart grids).

Table 1.1. The evolution of urban development and green development targets in Five-Year Plans, 2000-2015

			10 th FYP (2001-05)	11 th FYP (2006-10)	12 th FYP (2011-15)
Urbanisation pillar	Key quantitative targets	Binding		Arable land to be maintained at 120 million hectares.	Arable land to be maintained at 121.2 million hectares. 36 million affordable housing units to be built
		Aspirational	Green space coverage ratio to increase to 35% in urban constructed area Urban residents income to increase over 5% annually	Urbanisation rate to reach 47% Urban residents income to increase over 5% annually More than 45 million jobs to be created on average Urban registered unemployment to fall below 5%	Urbanisation rate to reach 51.5% Urban residents income to increase over 7% annually More than 45 million jobs to be created on average Urban registered unemployment to fall below 5%
Green Development pillar	Key Quantitative targets	Binding		Energy consumption per unit GDP reduced by 20% Water consumption per unit of value-added industrial output reduced by 30% SO ₂ and COD emissions reduced by 10%	Energy consumption per unit GDP reduced by 16% Water consumption per unit of value-added industrial output reduced by 30% SO ₂ and COD emissions reduced by 8% Carbon emission per unit GDP reduced by 17% Non-fossil energy as a proportion of primary energy consumption to reach 11.4% (from the current 8.3%) NOx and ammonia nitrogen emissions reduced by 10%
		Aspirational	Total amount of main emitted pollutants to be reduced by 10% (mainly SO ₂)	Industrial solid waste recycle and reuse rate to increase to 60% Wastewater treatment rate to reach 70% Treatment and disposal rate of domestic waste to reach 60%	Industrial solid waste recycle and reuse rate to increase to 72% Wastewater treatment rate to reach 85% Treatment and disposal rate of domestic waste to reach 80% Constructed land per unit of GDP to reduce by 30% 80% prefecture-level cities' urban areas to reach national ambient air quality Class II* Production-resource ratio to increase by 15%

Note*: China has three classes of ambient air quality standards: Class I are tourist, historic and conservation areas; Class II are residential urban and rural areas; and Class III are industrial areas and heavy traffic areas.

Source: Government of China (2011), “中华人民共和国国民经济和社会发展第十二个五年规划纲要” (12th National Five-Year Plan on Social and Economic Development), news.xinhuanet.com/politics/2011-03/16/c_121193916.htm; Government of China (2006), 11th National Five-Year Plan on Social and Economic Development, www.gov.cn/english/special/115y_index.htm; Government of China (2001), 10th National Five-Year Plan on Social and Economic Development, www.gov.cn/english/2006-04/05/content_245624.htm

Ensuring continued environmental progress over the medium and longer term requires a commitment to implementing further reforms. Some of the most significant reductions in air and water pollution in recent years have relied heavily on abatement measures, including upgrading industrial facilities and implementing well-established technical solutions (CCICED, 2011a). In the second half of the 2000s, the proportion of household wastewater treated in cities rose from around one-half to over three-quarters, while treatment rates for industrial wastewater were even higher. Much of the reduction in SO₂ emissions was achieved through the installation of desulphurisation equipment in thermal electricity generators, and the coverage has increased to over 80% of generators by 2010. As these types of solutions are gradually exhausted, and as efforts to tackle pollutants with less obvious technical solutions, notably CO₂, gain prominence, a broader approach to tackling environmental issues will be required.

1.3. The concept of urban green growth

As the population and focus of economic activity continue to shift towards urban areas in China, environmental prospects will become even more closely tied to how Chinese cities develop. Motor vehicle ownership rates in China remain low by international standards but are rising quickly. Average income in China has reached levels that are typically associated with a sharp increase in ownership rates, and given the outlook for continued strong economic growth, the number of privately owned motor vehicles is expected to increase dramatically (Haugh *et al.*, 2010). It is likely that Chinese preferences for alternative modes of transport will be shaped in part by the urban form of cities and the efficiency and effectiveness of urban transport systems. The environmental credentials of the expanding stock of modern housing and commercial office space will have a major bearing on future energy consumption, while approaches to waste management, including recycling, will have wide-ranging environmental implications. Altering mature cities to reduce the environmental footprint can be extremely costly, but with further large-scale urbanisation still to come, China has the opportunity to ensure that its cities continue to grow in a manner that will minimise the adverse environmental effects of urbanisation.

Cities have a unique role to play in advancing green growth. Green growth fosters economic growth and development while ensuring that natural assets continue to provide the resources and ecosystem services on which our well-being relies. To do this, green growth must catalyse investment, competition and innovation, which will underpin sustained growth and give rise to new economic opportunities. In that sense, green growth is not a replacement for sustainable development, but a means to help achieve it (Hammer *et al.*, 2011). Cities have greater potential to create synergies between environmental and economic objectives because policies that respond to the negative effects of urban agglomeration address both environmental and economic growth priorities, for example road congestion charges, brownfield redevelopment or sustainable cost recovery for water and waste services. Moreover, attractiveness can be a key factor in a city's economic growth and can be hampered by a poor environment. Congestion, pollution and public service constraints affect not only environmental quality, but also the efficiency of local economic activities and cities' ability to attract firms and skilled workers. Finally, the implementation of green growth at the local level can address social issues in a more direct way than at the national level. There are clear instances where green growth initiatives can provide social co-benefits simultaneously, such as reducing social exclusion through public transit enhancements and reducing households' energy costs through energy-efficiency retrofits or solar water heaters (OECD, 2012a). Taking these examples into account, we define urban green growth as:

Fostering economic growth and development through urban activities that reduce negative environmental externalities and the impact on natural resources and environmental services.(OECD, 2013a).

National policies in China can help cities make the most out of complementary policies. Given the importance of urbanisation as a driver of economic growth, there are strong opportunities for efforts that

promote greener cities to complement those that promote rapid economic development. A policy approach that aims to address the adverse effects of urbanisation, including environmental degradation, will also contribute to making cities more economically dynamic, thereby supporting broader national economic goals. These kinds of policies often yield double benefits in the form of environmental improvements, as in the case of a mass transportation system replacing old and energy-inefficient taxis and small buses. This is also the case with policies aimed at substituting cooking fuel sources from wood and charcoal to electricity and bottled gas to reduce indoor air pollution and excessive deforestation (Hammer *et al.*, 2011).

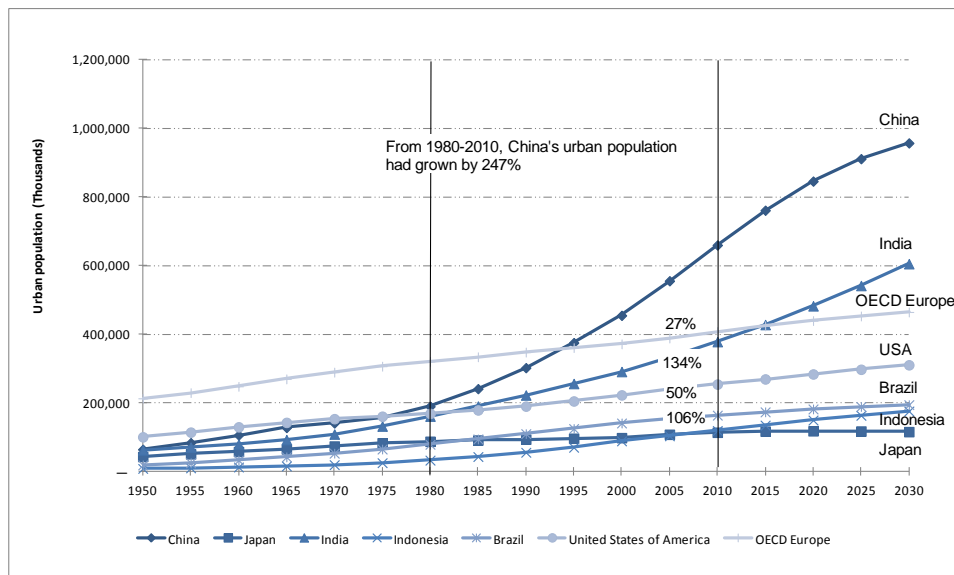
Orienting ongoing investments to make cities more environmentally resilient can contribute to green growth. Chinese cities are vulnerable to the impacts of climate change (*e.g.* rising temperatures, more-severe storms and rising sea levels), particularly those densely populated coastal cities that are also the country's economic powerhouse, *e.g.* cities in the Yangtze River Delta and Pearl River Delta (OECD 2010b; NDRC, 2007a; Nicholls, 2008). Infrastructure investments to reduce vulnerability to these anticipated climate change impacts can contribute to economic growth. For example, investments in resilient infrastructure will also become increasingly important to the extent that insurance companies factor in vulnerability to climate impacts into the cost of coverage. Resilient infrastructure investments can result in new jobs, particularly in occupations related to construction and engineering.

2. DYNAMISM AND EXTERNALITIES IN URBAN CHINA

2.1. Characterising urbanisation in China

The scale and speed of China's urbanisation are unprecedented globally. China has the world's largest urban population, with close to 700 million urban citizens according to the latest statistics. The urbanisation process in China has been ongoing for many decades, and in absolute numbers, China became the largest urban nation in human history over 30 years ago. Since then, total urban population has more than tripled (NBS, 2012a; United Nations, 2012; Figure 2.1). As introduced in Section 1, various projections indicate that China will continue to urbanise (Kamal-Chaoui *et al.*, 2009; OECD, 2012b; NBS, 2012a).

Figure 2.1. Urban population of China and major economies, 1950–2030



Source: United Nations (2012), *World Urbanisation Prospects: The 2011 Revision*, CD-ROM Edition, Department of Economic and Social Affairs, Population Division.

Estimates of urbanisation in China are derived from statistics that are largely based on administrative designation, which makes it difficult to compare with OECD countries in a meaningful way. China has official definitions for statutory cities and towns, and also for urban settlements and urban population (Table 2.1) (Kamal-Chaoui *et al.*, 2009; OECD, 2012b). By 2010, China had 657 statutory cities, broken-down into three types: 1) 4 provincial-level municipalities (Shanghai, Beijing, Tianjin, Chongqing); 2) 283 prefecture-level cities (PLCs)¹; and 3) 370 county-level cities (CLCs). In addition, there are 1633 county-level towns (towns with the seat of county government) and 16 774 statutory towns (non-county) (MHURD, 2011a; Table 2.1).

1. Prefecture level cities (PLCs) are cities with designation at the prefecture level. In other words, a PLC not only manages its city boundary, but also act as the prefecture authority that oversees the entire prefecture of several times of the city boundary.

Table 2.1. Summary of Chinese official definitions for cities/towns, urban settlements and urban population

	Types of main criteria	Official source document
Statutory cities	1) Registered population, 2) economic performance, 3) public finance, 4) infrastructure progress	State Council Criteria for Statutory Designation of Cities, 1993
Statutory towns	Population	State Council Criteria for Statutory Designation of Towns, 1984
Urban settlements	1) Building on official designated “city proper” ² of statutory cities and official designated town districts of statutory towns; 2) contiguity of “urban construction” (e.g. urban infrastructure and urban public services); 3) population densities	State Council Stipulations on Statistical Classification for Rural and Urban Areas, 2008
Urban population	Permanent residents living in urban settlements defined above (including migrants without urban <i>hukou</i>)	State Council Stipulations on Statistical Classification for Rural and Urban Areas, 2008

Source: Authors' compilation based on Kamal-Chaoui, L., E. Leeman and Z. Rufeï (2009), "Urban Trends and Policy in China", *OECD Regional Development Working Papers*, No. 2009/01, OECD, Paris, and various official documents.

While *functional* definitions of cities can facilitate valid international comparisons, the lack of commuting data in China hinders the direct application of the OECD methodology and refers to an alternative but similar approach developed by OECD/Chreod (Kamal-Chaoui *et al*, 2009). The OECD methodology defines urban areas as functional economic places, using a method that is comparable across countries. The main determinant of functional urban areas is the size of labour markets, *i.e.* the delineation of functional regions in most member countries is based on the principle of commuting conditions. Currently, data on commuting flows in metropolitan areas are not collected in China on a consistent, comparable basis, suggesting that the OECD methodology cannot yet be directly applied. Therefore, following similar principles, the OECD/Chreod approach has been adopted, using proxies to identify the majority of periodic social and economic interactions occurring in metropolitan regions within a reasonable travel-time from the centre of China's cities. Despite data limitations, the OECD/Chreod approach can facilitate relatively meaningful international comparison (Box 2.1).

Throughout this report, the OECD uses main two units of analysis when assessing the socio-economic performances of urban China:

1. *Urban areas*. These refer to statutory cities/town and urban settlements defined by the national authority. In particular, this is used when referring to the international population comparison based on UN data.
2. *Metropolitan areas (functional areas)*. These refer to the (a) OECD/Chreod approach defined metropolitan regions in China and (b) OECD methodology defined large metropolitan regions. These are typically large cities comprised by a number of administrative and adjacent areas where economic relations are intense. The approach identifies 53 metropolitan regions in China anchored on cities with over 1 million non-farming residents and encompassing adjacent counties.

2. The term “city proper” is often used in government. It generally refers only to the urban districts in which a municipal government provides public services. Recently, some cities have added selected suburban districts that benefit from some municipal services to their definition of “city proper”. Under China's Constitution, there is no differentiation between urban and suburban districts: it sets districts at the same administrative level as counties.

Box 2.1. Defining metropolitan regions: OECD methodology and OECD/Chreod approach

The OECD defines metropolitan regions based on a "functional approach" that considers criteria such as population size, density, self-contained labour market and GIS techniques. Due to lack of commuting flow data in China, the OECD methodology cannot be applied there and has been modified using the OECD/Chreod approach to define Chinese metropolitan regions, which circumvents data availability problems.

OECD methodology

The methodology uses population grid data at 1 km² to define urban cores in a way that is robust to cross-country differences in administrative borders. For European countries, the source of the population grid data is population density disaggregated with the Corine Land Cover dataset, produced by the Joint Research Centre for the European Environmental Agency (EEA). For all of the other countries, harmonised gridded population data from the Landscan project are used.

The methodology consists of three main steps:

1. identify contiguous or highly interconnected densely inhabited urban cores;
2. identify interconnected urban cores that are part of the same functional areas; and
3. define the commuting shed or hinterland of the functional urban area.

OECD/Chreod approach

The approach uses proxies to identify the majority of periodic social and economic interactions occurring in metropolitan regions within a reasonable travel time from the centre of China's cities. Therefore, the approach captures the reality of the functional economic basis of metropolitan areas using GIS technology. It is also based on several assumptions: (a) that a one-hour travel time is generally the limit that households are willing to commute to work, (b) that most suppliers to enterprises can effectively travel for daily deliveries, and (c) that in China, constraints to physical mobility mean that the 50 km radius is probably a maximum catchment area. Given these conditions, the following steps have been followed to identify and describe the spatial extent and structure of metropolitan regions in China:

1. Identify, using GIS technology, areas that are anchored on the urban districts of statutory cities with over 1 million non-farming residents;
2. Identify where these cities appear to spill over to capture non-farming populations, enterprises in towns and cities in adjacent counties, and county-level cities (CLCs) that have population densities over 500 inh/km², where non-farming GDP comprises more than 40% of total GDP and connection to by good quality roads is present (either National Trunk Highway System or national highway segments with road quality above Class 3); and
3. Capture the core city and adjacent counties, or CLCs generally within a 50 km radius of the core city centre, representing a notional one hour's travel time. Analysis of traffic volumes along the national highway network suggests that a few metropolitan regions spill over to capture selected counties beyond those immediately adjacent to the core city; *i.e.* that the reach of some is wider than 50 km.

Source: OECD (2012), *Redefining "Urban": A New Way to Measure Metropolitan Areas*, OECD Publishing, doi: 10.1787/9789264174108-en; Kamal-Chaoui, L., E. Leeman and Z. Rufeï (2009), "Urban Trends and Policy in China", *OECD Regional Development Working Papers*, No. 2009/01, OECD, Paris, and various official documents.

2.2. Benefits and limits of Chinese urban areas' economic dynamism

Urbanisation is generally associated with higher income and productivity levels. In OECD countries, higher urban population shares are associated in most cases with higher per capita GDP than their national average (Kamal-Chaoui and Sánchez-Reaza, 2012). A similar trend can be observed in China where a group of metropolitan regions have become the main engines of China's fast-growing economy³. Holding just over 30% of China's population, the 53 metropolitan regions produced 61.5% of the country's GDP in 2007, up from 50.3% in 1998 (OECD/CDRF, 2010) (Figure 2.2). While the country became a predominantly urban economy

3. The metropolitan region definition is based on OECD/Chreod (Kamal-Chaoui *et al.*, 2009).

in the late 1990s, perhaps more significantly, its 53 metropolitan areas accounted for more than two-thirds of China's overall growth in GDP from 1998 to 2007, leading to acceleration and strengthening of the economic importance of these metropolitan regions (Figure 2.2).

However, the benefits associated with economies of agglomeration are not unlimited. Cities can reach a point where external diseconomies outweigh centripetal forces and become less competitive (OECD, 2006). Among the 78 OECD metro-regions with 1.5 million inhabitants or more, one-third rank systematically lower than their national average for almost all indicators, such as income, growth, productivity, skills, employment and unemployment. Similar findings emerge from an EU report on 258 metropolitan areas of 250 000 inhabitants or more, which shows that between 2000-06 more than half experienced growth rates below their national averages (EU, 2009). It can be argued that lower growth rates are a normal result of development and convergence. However, growth rates in 41 out of 258 metro-regions were more than 5% than the national average. This suggests that a number of metropolitan areas are confronted with a more serious challenge than merely a reduction in the benefits of agglomeration economies due to higher overall levels of development. The EU report found that metropolitan areas that also function as national capitals tend to have the highest per capita GDP, whereas smaller metropolitan areas and some of the second tier metros scored lower (EU, 2009); similar findings are highlighted in OECD (2006). In general, in the less developed EU countries, the capital city holds a large share of GDP. It can be argued that as development takes place, growth will tend to emerge in other urban areas as well – as seen in many western European countries (Kamal-Chaoui and Sánchez-Reaza, 2012).

In the same vein, although metropolitan economies in China have in aggregate grown significantly, there are wide differences in productive capacities among them. Figure 2.2 shows the change in the share of China's GDP produced in each of the 53 metropolitan regions from 1998 to 2007. Not surprisingly, Beijing, Guangzhou-Foshan and Shenzhen have grown in national importance, each producing almost 1% more of China's GDP in 2007 than in 1998. Eight metropolitan regions in the Yangtze Delta Megalopolis (Shanghai, Hangzhou, Ningbo, Suzhou, Wuxi, Changzhou, Nanjing, Taizhou) produced 16% of China's GDP in 2007, up from 12.3% in 1998. This compares with the three metropolitan regions in the Pearl River Delta Megalopolis (Guangzhou-Foshan, Shenzhen, Dongguan) which grew from producing 4.9% of China's GDP in 1998 to 8.2% in 2007. Figure 2.2 illustrates divergent economic dynamics of China's metropolitan regions in recent years: 4 of 28 coastal metropolitan areas experienced declines in their share of China's production from 1998 to 2007; 3 of 6 in the northeast also had declining shares; only 1 of 7 metropolitan regions in central China experienced a drop; and, perhaps significantly, only 2 of 12 in the west declined.

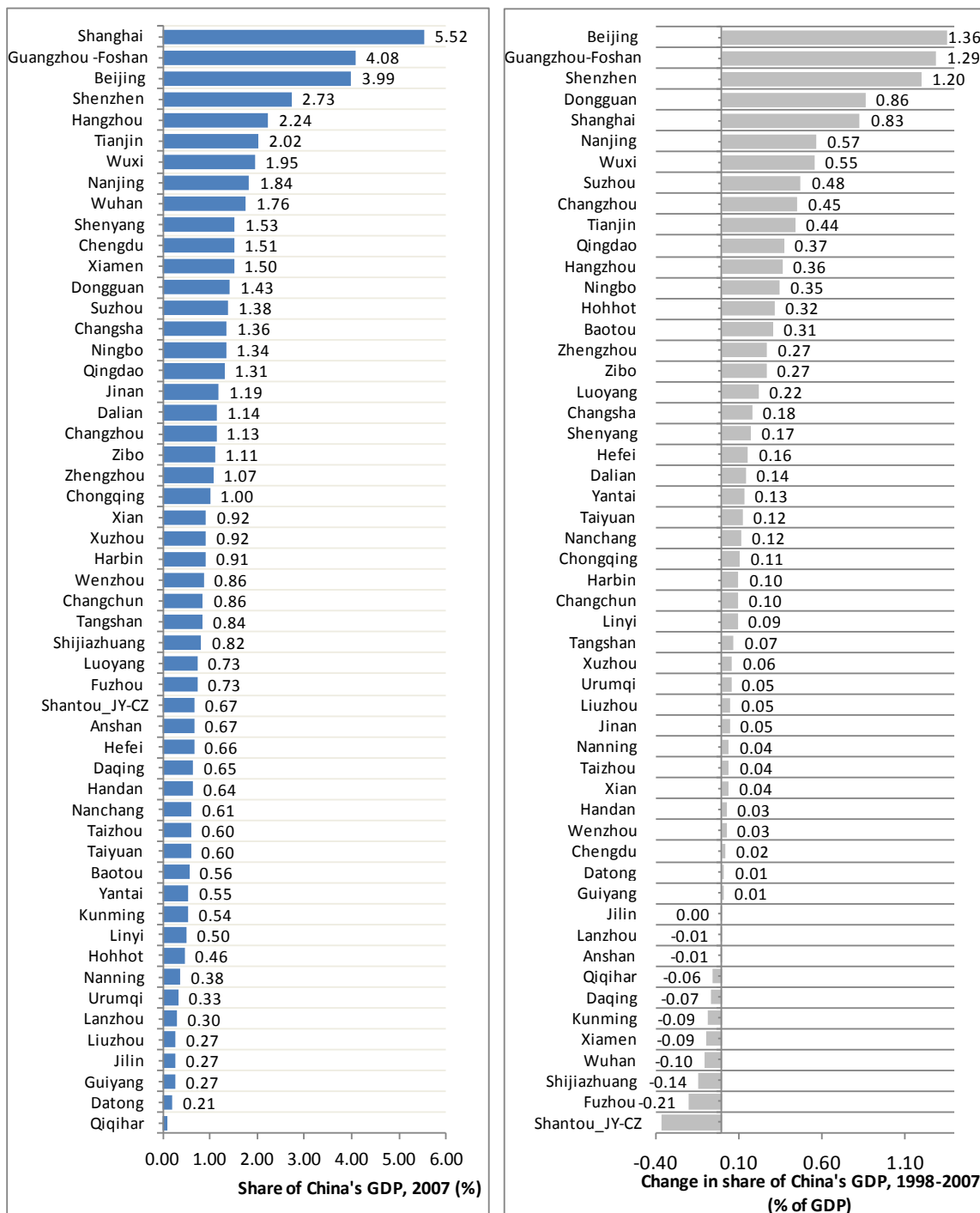
One of the main explanations of such mixed outcomes is linked with the existence of negative externalities, including congestion costs (centrifugal forces). Negative externalities associated with large concentrations in urban areas raise the question of whether the costs borne by society as a whole are expanding. As externalities, these negative attributes are not internalised by firms and households, and may only show up as direct costs in the long term. They include, for instance, high transportation costs (*i.e.* congested streets) and loss of productivity due to long commuting times, higher health costs, higher carbon emissions and environmental degradation. Estimations in several large Chinese cities indicate that the non-environmental costs of congestion amount to one-tenth of per capita income (OECD/CDRF, 2010). Taking into account the costs and benefits of agglomeration, it has been argued that urban concentration may entail a “privatisation of benefits and socialisation of costs” (OECD, 2009).

Agglomeration economies are significant and important, but public policy is needed to maximise their positive effects. Recent estimates suggest that doubling the size of a city-region is associated with a 3.5%-8% increase in total factor productivity (Rice *et al.*, 2006; Graham, 2007; and Graham and Kim, 2008). A recent survey concludes that these agglomeration economies apply as strongly in developing countries – such as India or China – as they do in OECD countries (Quigley, 2009).⁴ Successful policy would ensure

4. Such agglomeration economies, too, are a form of externality not taken into account by our hypothetical “additional” city resident. It could be that the gain in productivity and incomes generated for the existing inhabitants by the addition of one more resident more than offsets the increase in congestion and space costs imposed.

that urban expansion maximised the positive agglomeration gains from growth but minimised the impact on space costs and congestion (Kamal-Chaoui and Sánchez-Reaza, 2012).

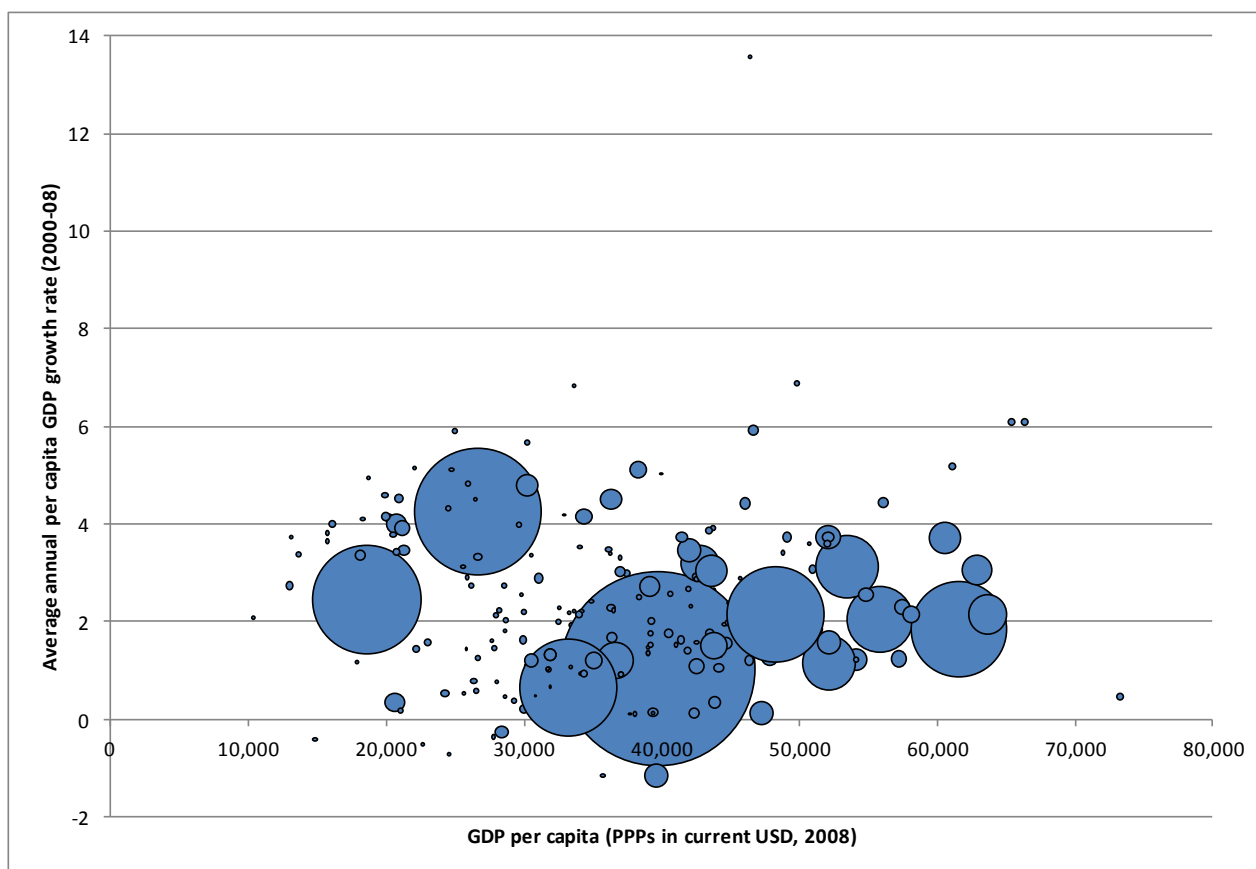
Figure 2.2. The performance of metropolitan regions in China, measured by shares of China's GDP, 1998-2007



Source: Kamal-Chaoui, L., E. Leeman and Z. Rufeï (2009), "Urban Trends and Policy in China", OECD Regional Development Working Papers, No. 2009/01, OECD, Paris; OECD/CDRF (2010), *Trends in Urbanisation and Urban Policies in OECD Countries: What Lessons for China?*, OECD, Paris, www.oecd.org/urban/roundtable/45159707.pdf.

Moreover, although agglomeration economies emerge with urban concentration and are crucial to improve productivity levels, the economic performance of cities is not *only* a function of city size. Agglomeration economies arise because workers and firms agglomerate and interact to produce gains related to *sharing, matching* and *learning*. Such agglomeration economies can arguably be internalised by firms in the form of higher productivity levels. Among all predominantly urban OECD areas, the richer the city, the faster it grows (Figure 2.3). Small, medium and large cities can grow slower or faster than the urban average (see size of the bubble in Figure 2.3). Other growth determinants such as physical capital (*e.g.* infrastructure), human capital and innovation might explain performance differentials (Kamal-Chaoui and Sánchez-Reaza, 2012).

Figure 2.3. Economic Performance in OECD Urban Areas



Note: PPPs stands for “purchasing power parity”.

Source: OECD Metropolitan Regional Database.

It seems that the potential of Chinese medium-sized cities has not yet been fully exploited. Besides the principle role of large metropolitan regions, small and medium cities are also important component to urban China. Officially defined as statutory cities with less than 500 000 non-agriculture inhabitants, these cities hold the second largest share of China’s urban population (Table 2.2). Despite policy directions to promote small and medium cities in the 1980-90s, economic performance of these cities has been lower than expected. In the national 8th FYP (1991-95), “urbanisation” was explicitly addressed for the first time, but involved a reiteration of the policy orientation of the 1980s: “control the big cities, moderate development to medium-sized cities, and encourage the growth of small cities”. The national 9th FYP (1996-2000) again repeated the previous orientation, but with a heavier emphasis on the control of large

cities: the nuance changed to “strictly control the growth of big cities, reasonably develop medium-sized cities and small cities”. Central policy direction, however, has not been translated into agglomeration and economic performance of small and medium cities. For instance, in 2007, 186 medium and small cities contributed only 8.2% of total national GDP (OECD/CRDF, 2010).

Table 2.2. China’s registered population in urban areas of statutory cities, 2005 and 2010

	2005			2010		
	#	Total population	Per cent of total urban population	#	Total population	Per cent of total urban population
Cities > 5 mn	8	71 564 000	12.7%	8	87 998 100	13.6%
Cities 1-5 mn	61	123 682 000	22.0%	63	128 734 900	20.0%
Cities 500t - 1 mn	90	64 367 400	11.5%	99	68 672 700	10.6%
Cities < 500t	495	103 451 700	18.4%	487	11 1834 000	17.3%
Total in statutory cities*	652	363 047 100	64.6%	657	397 239 700	59.3%
Others (mainly towns)		199 072 900	35.4%		272 540 300	40.7%
Total urban		562 120 000	100%		669 780 000	100%

Notes*: The total population figure is from the Ministry of Public Security, including registered hukou population and registered temporary population who stay in urban districts for over one year. In aggregate terms, the figure captures neither non-registered migrants nor urban population in towns.

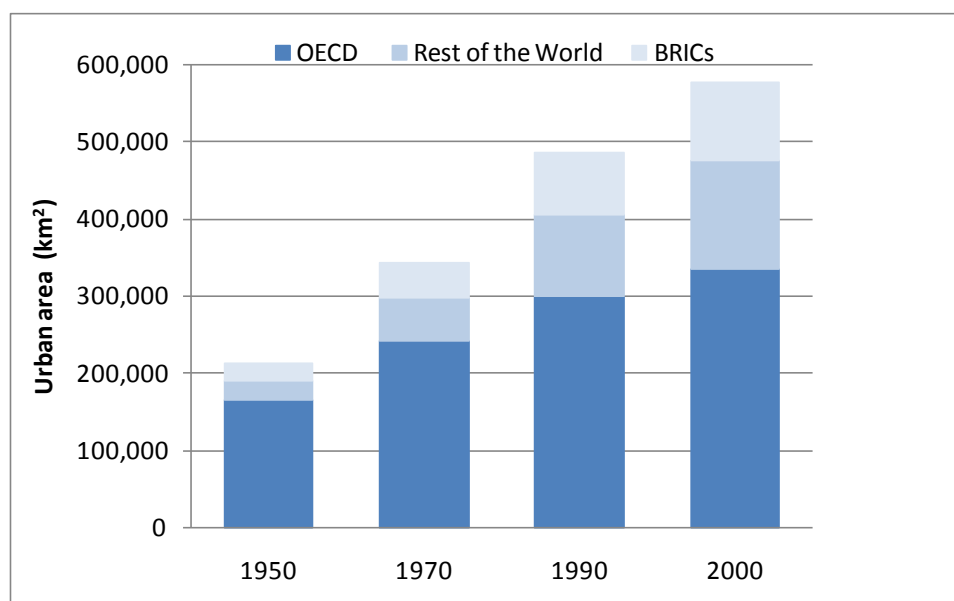
Source: For cities: MHURD (Ministry of Housing and Urban-Rural Development) (2007), China’s Urban Construction Statistical Yearbook 2006, China Building Industry Press, Beijing; MHURD (2011), China’s Urban Construction Statistical Yearbook 2010, China Plan to Press, Beijing. For total urban population, NBS (N.D.), “China Database”, NBS website, www.stats.gov.cn/english/statisticaldata/yearlydata.

China's scattered urbanisation calls for exploiting agglomeration economies, especially in its medium-sized cities. Large-scale rural-to-urban migration in China has involved limited long-distance migration. In the 1990s, reclassifying previous “rural” areas into statutory cities (based on administrative criteria) caused 50% of the increase in China's urbanisation rate. Urbanisation therefore occurred in a scattered manner: a large number of statutory cities were too small to exploit urban agglomeration economies. As China’s economy continues to globalise, the competitiveness of larger cities will increasingly be driven by the realisation of agglomeration economies intrinsic to metropolitan areas. This does not necessarily mean that urbanisation will solely focus on 10 million-plus cities (as in Japan). Rather, metropolitan areas with over 1 million residents will, depending on their location – especially their proximity to each other in wider urban systems – likely be the principal destination of rural migrants seeking non-farming employment choices as they skip over smaller cities with lower growth prospects (Kamal-Chaoui *et al.*, 2009).

2.3. Migration and urban expansion

Thanks to more efficient transportation systems that allowed for further concentration of human capital commuting from rural and intermediate regions into urban cores, urbanisation in OECD countries has resulted in a greater use of land. Urban land area in the OECD doubled in the second half of last century (Figure 2.4). More recently (1995-2005), in the majority of OECD metro-regions, the suburban belt grew faster than the urban core (Kamal-Chaoui and Sánchez-Reaza, 2012).

Figure 2.4. Trends in urban land expansion



Note: "BRIC countries" refers to Brazil, Russia, India and China.

Source: Kamal-Chaoui, L. and Sánchez-Reaza, J. (2012), "Urban Trends and Policies in OECD Countries", *OECD Regional Development Working Papers*, No. 2012/01, OECD, Paris, doi: 10.1787/5k9fhn1ctjr8-en, based on data from OECD (2008a), *OECD Environmental Outlook to 2030*, OECD Publishing, doi: 10.1787/9789264040519-en.

China faces a similar challenge but at a different order of magnitude. Chinese cities, particularly the large ones, face the challenge of accommodating a large and increasing influx of rural residents. Over the past decade, the number of migrant workers has grown exponentially. Up from just above 100 million in early 2000s, the *Migrant Worker Monitoring Report* conducted by the NBS (2012b) estimated 253 million migrant workers in 2011, including 159 million travelling to places other than their statutory towns (defined as out-migrating migrant workers). Large cities, roughly defined as the group of provincial level municipalities, provincial capitals and prefecture-level cities, attract the lion's share of out-migrating workers. In 2009, almost two in every three migrants chose to work in large cities, up from 57% in 2001 (CDRF, 2010). NBS (2012b) estimates that in 2011 over 65.4% of out-migrants moved into eastern provinces⁵, and over 43.2% into the coastal metropolitan regions of the Pearl River Delta (50.8 million) and Yangtze River Delta (58.2 million). More than 10 million rural inhabitants become urban residents each year (NBS, 2011a). Many large cities have long been concerned with their ability to manage large influxes of migrants and provide adequate public services in high-density cores. The further anticipated migration increase presents difficulties for authorities of large cities to allow migrant populations to acquire residency (CDRF, 2010).

The massive scale of ongoing urbanisation in China has major implications for the form and efficiency of urban areas. Sub-urbanisation and urban expansion are increasing in emerging economies and other non-OECD countries. In China, the Ministry of Land and Resources (MLR) reported that total urban construction land grew from 11 608 km² in 1990 to 40 058 km² in 2010, while its overall urban population density continued to decrease during the same period despite rural-urban migration (Yang, 2011). Urban land expansion speed has reached 11 km per year, as suggested by the national land survey of 93 statutory

5. Eastern provinces include: Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Guangdong and Hainan.

cities with above 500 000 inhabitants. Land consumption is particularly serious in large cities. During 2001-05, a higher-than-national-average increase in urban land use of 44% was recorded in the 30 largest cities. Nine of these registered over a 60% increase (OECD/CDRF, 2010).

Urban population growth has been slower than the increase of land consumption in Chinese cities. Over the past 30 years, urban population has increased by 1.6 times, but the total constructed urban area has increased by 4 times. Correspondingly, the density of total constructed urban area has decreased from around 20 000 people/km² in early 1980s to around 10 000 people/km² recently. This is occurring not only in major coastal metropolitan regions, such as Shanghai and Guangzhou, but also inland, in smaller regions such as Chengdu. Time-series analysis of satellite imagery shows that built-up land areas in large parts of suburban Chengdu grew by 300% in a six-year period (1996-2002) and built-up parts of large areas of suburban Shanghai expanded by 350% from 1988 to 2002 (Kamal-Chaoui *et al.*, 2009). From 1990 to 2000, built-up land area in the Inner Pearl River Delta, where Guangzhou is located, grew by over 300%, a rate of expansion that was hitherto unknown in China (OECD, 2010b). Given the high rates of density in the centre of Chinese cities, it may be expected that city territorial expansion would exceed city size to counterbalance dense urban cores and increase liveable space for urban dwellers. It is therefore important to consider strategies to decrease density without achieving sprawling, “leapfrog” development that would increase residents’ dependence on travel by private vehicle.

Over the past 20 years, Chinese cities have largely grown outwards, through location decisions by households or firms. Cities such as Suzhou, Qingdao, and Shenzhen are examples for predominantly centrifugal growth, while others – mainly large cities with over 1 million residents – experience both growth pressures, such as Shanghai, Beijing, Chongqing, Tianjin (Kamal-Chaoui *et al.*, 2009). While lower densities in residential areas can contribute to improved quality of life – up to a certain point – the low densities of industrial developments can be cause for concern. Suburban growth of townships and industrial parks has primarily been fuelled by industrial relocation of state-owned enterprises from the urban core, as well as through successful efforts by cities to attract industrial and real-estate development. In particular, a key driver is the proliferation of development zones and industrial parks. By 2011, there were more than 1 550 industrial parks or development zones designated by national and provincial governments, occupying 9949 km² of land (Yang, 2011). These figures would be much higher if the large number of industrial parks established by municipal, town, and township governments were taken into account. With the growth of industry in many semi-rural areas around towns, much of the farmland on the outskirts of urban districts transformed rapidly into *de facto* suburban precincts.

Land-related income, such as land leases, auctions and development rights are crucial to Chinese cities’ revenue streams and a major driver of spatial expansion. For most cities, revenues from leasing of land-use rights account for 30%-50% of annual fiscal revenues, and up to 80% in smaller cities (Huang, 2005). The contribution of land sales to local revenue for Guangzhou has been estimated at 55% in 2006, and at around 80% throughout the 1990s in the City of Shenzhen (Tian and Ma, 2009; Peterson, 2006). Decentralised industrial growth and the lack of a land management or monitoring system have also contributed to unchecked urban expansion and agricultural land conversion (Li and Yeh, 1999). Concerns over rampant conversion of agricultural land have triggered periodic inspections and clampdowns by the Ministry of Natural Resources and Lands, but the basic problems remain (OECD/CDRF, 2010).

The result of these trends has been large-scale suburban expansion in many cities, including in central and western regions of the country (Kamal-Chaoui *et al.*, 2009). It is beyond the scope of this study to determine the extent to which this expansion can be considered urban sprawl. Further research is needed on the impact of this rapid urban expansion and its relationship with an increase in liveable space.

2.4. Other negative externalities of urbanisation

Increased use of motor vehicles and lagging public transport systems

Rapid construction and expansion of metro systems have not been able keep pace with the rapid demand increase. City transport authorities have long responded to increasing mobility demands by building roads. Throughout the last decade, China's cities have invested massively in building and improving urban street and expressway networks: the length of roads built up in cities reached some 294 000 km in 2010, up from 160 000 in 2000 (NBS, 2011a). Lagging public transport and rising income levels have led to massive increases in the use of private vehicles, with the associated negative externalities. Urbanisation in China has occurred along with an unprecedented rate of car ownership, especially in large cities. The car fleet has been growing at a rate of 20%-30% per year, having reached 70 million vehicles in 2010, up from 16 million in 2000 (NBS, 2011a); the fleet roughly doubles every five years. With rising income levels, the growing numbers of middle class have been demanding enhanced personal mobility. By 2010, car ownership in many larger and richer cities had reached the level of more than 100 cars per 1 000 inhabitants (Table 2.3). Such demand was fuelled by the increasing car availability and relatively cheap gasoline prices (Darido *et al.*, 2009). This trend is likely to continue for the foreseeable future with further increases in household incomes, and given that national policies still recognise that private car ownership remains relatively low by the standards of other middle-income countries (World Bank and DRC, 2012).

Table 2.3. Population growth, motorisation and GDP in selected Chinese cities, 2000 and 2010

	2000			2010			
	Population '000	Total No. cars '000	GDP, CNY billion	Population '000	Total No. cars '000	GDP, CNY billion	No. of Cars per 1 000 people
Beijing	13 569	1 041	316	19 620	4 497	1 411	229.2
Shanghai	16 408	492	477	23 030	1 755	1 717	76.2
Guangzhou	9 948	389	238	12 710	1 599	1 060	125.8
Shenzhen	7 010	269	167	10 372	1 670	951	161.0
Tianjin	9 849	479	170	12 990	1 582	922	121.8
Hangzhou	6 879	411*	138	8 700	1 248	595	143.5
Suzhou	6 792		154	10 460	1 261	917	120.6
Nanning	6 314	41	29	6 662	1 333	180	200.1
Dongguan	6 448	154	49	8 225	921	425	111.9
Qingdao	7 494		115	8 719	976	567	111.9
Ningbo	5 963		118	7 600	877	513	115.5
Jinan	5 922		95	6 818	797	391	116.9
Kunming	5 781		63	6 432	851	212	132.3
Chengdu	11 109	318	131	14 048		555	
Xi'an	7 275		69	8 468	960	324	113.4
Shenyang	7 204		112	8 106	832	502	102.6
Taiyuan	3 344		35	4 202		178	
Nanjing	6 126		102	8 005	831	501	103.8
Foshan	5 341	217	96	7 199	912	565	126.7

Note: Cities here refer to the whole prefecture-level city; *Data for Hangzhou is from 2004.

Source: Compiled from Bulletins of socioeconomic development of each city, www.tjcn.org.

Rising energy consumption

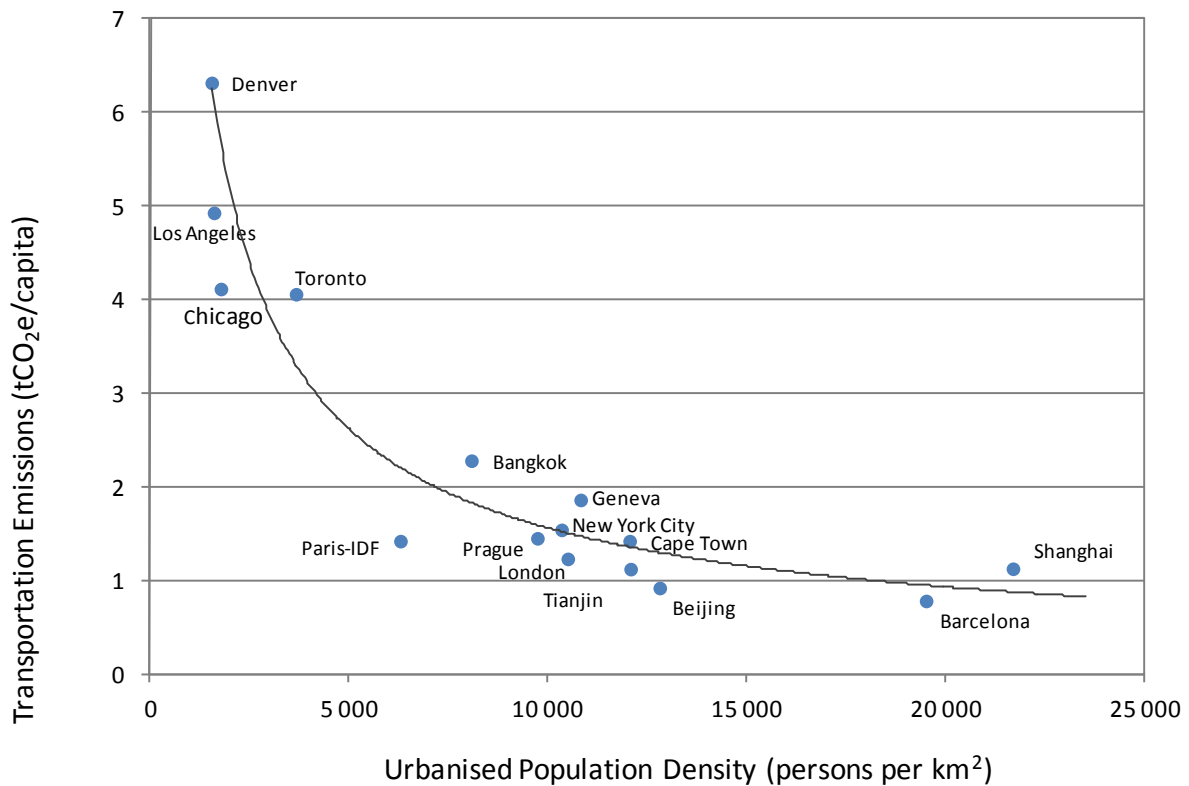
Chinese cities have experienced a massive increase in building construction over the past decades, and the growth momentum will continue along with further rural-urban migration. Total urban built-up land area (administrative definition) grew three times, up from less than 13 thousand km² in 1990 to over 40 thousand km² in 2010 (NBS, 2011a); that is, in 20 years built-up area experienced a threefold increase. In 2009, total floor area in cities and towns reached approximately 20.5 billion m², of which 13.4 billion m² were from residential buildings (MHURD, 2011a). While this represents very rapid growth in floor areas, per capita floor areas are still lower than the OECD average. The speed of urban construction has been astonishing, *e.g.* between 0.6 and 0.9 billion m² of residential building space was added each year over 1999-2010 (NBS, 2011a). The growing trend is likely to continue, given that Chinese urban areas, are expecting an increase of 300 million more dwellers throughout 2030 (Kamal-Chaoui *et al.*, 2009). Most of this new urban population will be unskilled and semi-skilled rural migrant workers with the low- and middle-income levels, who will be in need of housing assistance. With the price of commercial housing increasing greatly since 2005, municipal governments have been required by the central authority to increase the provision of affordable housing (commonly known as “economical and comfortable housing”) to middle- and low-income households (Man, 2011). The central government has also mandated that local governments build 36 million affordable housing units over the 12th FYP period (2011-15).

Energy consumption from buildings is on the rise in Chinese cities. Between 2007-09, energy consumed by buildings, both residential and commercial, represented more than one-quarter of total energy consumption (IEA, 2011a). If public services are also included (3.8% of total energy consumption), the figures by IEA (2011c) approach the ratio reported by MHURD (2007b): building energy consumption accounts for one-third of total energy consumption in China. Actual annual-average building-energy consumption grew from 309 million TOE over 2000-02 to 391 million TOE over 2007-09 (IEA, 2011a). Zhou *et al.* (2008) analysis pointed out that urban energy use accounted for the majority of total residential energy – most of the energy was used for space heating and water heating. The same study also projected further increase in residential building energy consumption throughout 2020, driven mainly by further growth of urban population together with the increase in living area. For instance, per capita floor areas in cities and towns grew from 13.7 m² in 1990 to 31.6 m² in 2010 (NBS, 2011b). This represents an improvement in quality of life. However, given rising household income level and living standards, reducing energy consumption per capita will likely continue to be a challenge (Zhou *et al.*, 2008).

The impact on air pollution and greenhouse emissions

There is an observable relationship between urban form and greenhouse gas emissions. Carbon dioxide emissions from transport are likely to be greater in less densely populated areas than in more densely populated areas (Figure 2.5). Sprawling urban form tends to be accompanied by high levels of private vehicle use, and also makes it difficult to build enough demand to efficiently deliver public transport and other services. For example, the cost savings by containing sprawl in the United States are estimated to be USD 12.6 billion for water and sewer infrastructure and USD 110 billion for road infrastructure (OECD, 2012c; OECD, 2002).

Figure 2.5. CO₂ emissions from ground transportation in large metropolises

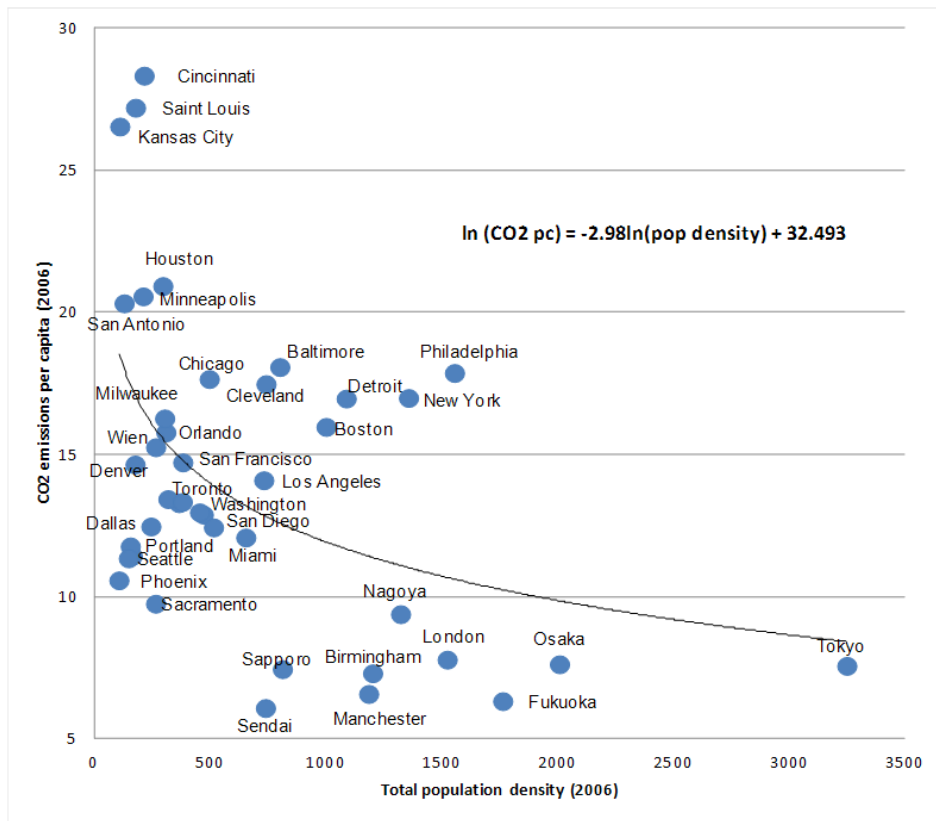


Notes: (1) The density of the urbanised land surface is calculated without including green areas. (2) Analytical units and reference years used for these calculations: Barcelona (city, 2006); Geneva (canton, 2005); London (Greater London, 2003); Paris-IDF (IDF region, 2005); Prague (Greater Prague, 2005); Chicago (Chicago Metropolitan Area, 2005); Denver (city and county, 2005); Los Angeles (county, including 88 towns or cities, 2000); New York (city, 2005); Toronto (Greater Toronto, 2005); Bangkok (city, 2005); Beijing (province, 2006); Shanghai (province, 2006); Tianjin (province, 2006), Cape Town (city, 2006).

Source: Kennedy, C. (2011), Calculations (personal communication) adapted by C. Kennedy, October 2011, using methodology from Kennedy, C., *et al.* (2009), "Greenhouse Gas Emissions from Global Cities", *Environmental Science and Technology*, Vol. 43, No. 19, American Chemical Society, Washington, D.C., pp. 7297-7302.

When OECD functional urban regions within the same bracket for GDP per capita and national energy prices are compared, CO₂ emissions for lower-density cities can range up to roughly three times more than for cities with higher density (Figure 2.6). While density is an important factor driving this trend, other factors such as availability of public transport, lifestyle choices, and the proximity to industry, power generation and other potential sources of greenhouse gas emissions also influence this finding.

Figure 2.6. Population density and estimated CO₂ emissions per capita in selected large metropolitan areas



Note: Figure shows estimates of per capita emission for all sectors, including industry; variations from the curve can partly be explained by differences in emissions from electricity consumption.

Source: OECD (2011), *Metropolitan Database 2011*, OECD website, <http://stats.oecd.org/Index.aspx?QueryId=23398>.

Urban areas can become less dense – to a point – without necessarily moving far up the CO₂ emissions curve, in part due to innovation. This is important because many Chinese cities are currently highly dense but may become less so over time. While density levels in Chinese cities still remain high compared to other cities globally, the relationship between density and CO₂ emissions per capita implies that how Chinese cities urbanise, *i.e.* following a low-density or a high-density model, will make a big difference in their future CO₂ emissions.

The increasing number of motor vehicles in China has become a major contributor to air pollution. Air pollution data for 31 key Chinese cities, comprising provincial capitals and provincial-level cities, is presented in Table 2.4. Figures are shown for 2010, as well as changes since 2005, for the three pollutants most closely monitored and widely reported in China: large particulate matter (PM₁₀), SO₂ and NO₂ (nitrogen dioxide). For all three pollutants average annual concentrations in 2010 were high. The average PM₁₀ observation for this sample of cities is around 95 µg/m³, lower than in 2005 but still well above the World Health Organisation (WHO) guidelines of 20 µg/m³. It also exceeds the WHO interim target level 1 of 70 µg/m³, a level associated with an approximately 15% higher long-term mortality risk relative to the guideline level. There is considerable inter-city variability within the sample, with pollution levels often highest in inland cities, reflecting the effects of local geography as well as other factors. In 2010, Lanzhou, in the north, and Urumqi, in the far west, ranked the worst, with Beijing also scoring poorly. In contrast, some cities along the coast, including Fuzhou and Shanghai, exhibit lower PM₁₀ levels, although even here pollution levels exceed the WHO interim target. Average levels of NO₂ in 2010 were around the

WHO guideline level of 40 µg/m³. Nevertheless, the situation was considerably worse in several cities, and average levels have risen by over 5% since 2005. It is also noteworthy that concentrations of the three main pollutants appear to be strongly correlated across cities. This is likely to reflect common, localised sources of pollution, especially thermal electricity generation and coal-fired boilers, as well as heavy industry and the transport sector.

Table 2.4. Air pollution in Chinese cities

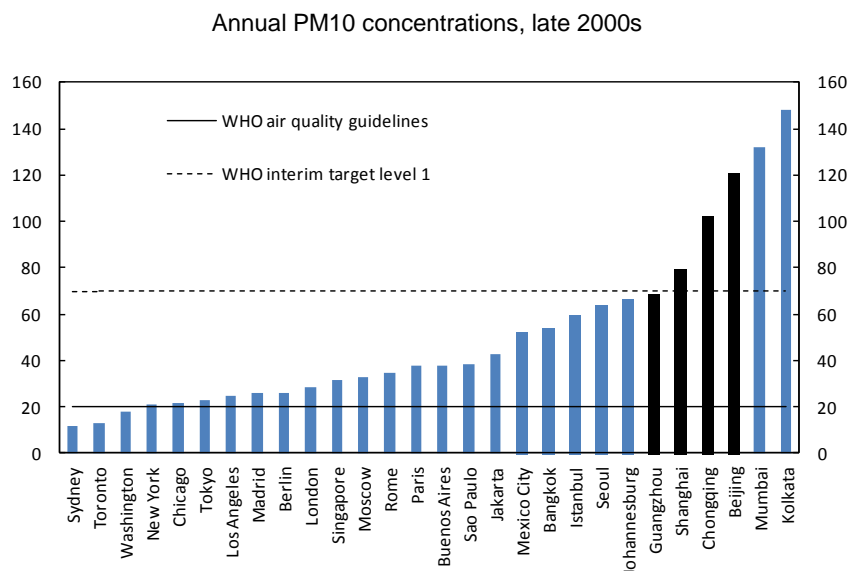
City	PM ₁₀		SO ₂		NO ₂	
	2010	% change 2005-2010	2010	% change 2005-10	2010	% change 2005-10
Beijing	121	-14.2	32	-36.0	57	-13.6
Changchun	89	-10.1	30	15.4	44	25.7
Changsha	83	-32.0	40	-50.6	46	27.8
Chengdu	104	-16.8	31	-59.7	51	-1.9
Chongqing	102	-15.0	48	-34.2	39	-18.8
Fuzhou	73	1.4	9	-43.8	32	-23.8
Guangzhou	69	-21.6	33	-37.7	53	-22.1
Guiyang	75	-1.3	57	-9.5	27	107.7
Harbin	101	-2.9	45	7.1	48	-14.3
Haikou	40	0.0	7	-41.7	15	0.0
Hangzhou	98	-12.5	34	-43.3	56	-3.4
Hefei	115	21.1	20	11.1	30	20.0
Hohhot	68	-29.9	46	-8.0	34	-17.1
Shijiazhuang	98	-25.8	54	0.0	41	0.0
Jinan	117	-8.6	45	-25.0	27	12.5
Kunming	72	-12.2	40	-27.3	46	21.1
Lanzhou	155	-1.9	57	-16.2	48	29.7
Lassa	48	-31.4	7	-30.0	21	-16.0
Nanchang	87	-2.2	55	10.0	42	35.5
Nanjing	114	3.6	36	-30.8	46	-14.8
Nanning	69	3.0	28	-51.7	30	-21.1
Shanghai	79	-10.2	29	-52.5	50	-18.0
Shenyang	101	-14.4	58	7.4	35	-2.8
Taiyuan	89	-36.0	68	-11.7	20	0.0
Tianjin	96	-9.4	54	-28.9	45	-4.3
Urumqi	133	16.7	89	-23.3	67	19.6
Wuhan	108	-9.2	41	-24.1	57	14.0
Xi'an	126	-2.3	43	-2.3	45	40.6
Xining	124	8.8	39	34.5	26	0.0
Yinchuan	93	3.3	39	-27.8	26	4.0
Zhengzhou	111	1.8	53	-10.2	46	17.9
Average	94.4	-8.4	40.9	-20.7	40.3	5.9

Source: NBS (N.D.), "China Database", NBS website, www.stats.gov.cn/english/statisticaldata/yearlydata.

A comparison of urban PM₁₀ levels in cities in China and other countries reveals that pollution levels in Chinese cities are also very high by international standards. Across large cities in other G20 and emerging countries, Chinese cities, even those reporting relatively low levels of pollution by Chinese

standards - such as Guangzhou – experience considerably higher average annual PM₁₀ levels than cities in most other countries except India (Figure 2.7).

Figure 2.7. International urban air pollution levels



Note: Figures refer to 2010 for Chinese cities figures and 2008 or 2009 for most other cities.

Source: WHO (2011), *Urban Outdoor Air Pollution Database*, WHO, Geneva. NBS (n.d.), "China Database", NBS website, www.stats.gov.cn/english/statisticaldata/yearlydata.

A dearth of official data on CO₂ emissions makes an assessment of the situation in Chinese cities difficult. As with other types of air pollution where there can be significant differences between the location of the primary source of the emissions, such as electricity generation, and the secondary activity associated with the emissions, such as the use of that electricity, assessing the origins of CO₂ emissions can be difficult. A city purchasing electricity that generates emissions from a neighbouring region should arguably be accountable for those emissions. One approach to estimating underlying city-level CO₂ emissions is to impute emissions based on city energy consumption. Such an exercise, however, presents considerable difficulties in China owing to an absence of detailed sub-national data on energy consumption, and the large share of energy consumption coming from industry.

In contrast, detailed energy data are available for the large provincial-level cities of Beijing, Chongqing, Shanghai and Tianjin. Dhakal (2009) uses the data to estimate CO₂ emissions over time for these cities. Data on energy consumption patterns is combined with carbon emissions factor assumptions for different fuel types to build up an aggregate estimate of emissions. The results show that rapid economic growth and rising energy consumption, heavily orientated towards fossil fuels, has seen total CO₂ emissions rise markedly. Estimates suggest that since the mid-1980s total emissions have grown by over two and half times in Beijing and five-fold in Shanghai. Although in per capita terms the increase is smaller, given strong population growth, per capita emissions for these cities are higher than found in some large OECD country cities, including London, New York and Tokyo. Overall, therefore, while limited to a small number of cities, these results indicate that CO₂ emissions from Chinese cities may already be high by international standards and continue to grow rapidly.

Water and wastewater provision and quality

Rapid urbanisation has put a strain on Chinese cities' ability to provide water services. Total available water resource in China is almost 2.7 trillion m³ per year, representing more than 2 thousand m³ per capita, which is less than a quarter of the world average (NBS, 2011a). Water use per capita is relatively low by OECD standards, but not the overall intensity of use (OECD, 2007a). In 2010, total water consumption amounted to over 600 billion m³, of which agriculture, industry and urban domestic (household in statutory cities and counties) accounted for 61%, 24% and 13%, respectively. While water consumption by rural households and agriculture has remained fairly stable from 1990 to 2010, water consumption from industry and urban domestic sectors has witnessed a steep increase over the same period (NBS, 2011a). Increasing urban population and living standards and dynamic industrial activities have driven these increases.

Table 2.5. Freshwater use, 2000-09

	Abstraction per capita, m ³ /capita		Intensity of use, abstraction as % of available resources (long-term annual average)
	2000	2009	2009
China	435	448	22.2%
Canada	1 376	1 105	1.1%
USA	1 690	1 573	19.6%
Japan	685	652	20.1%
Korea	554	598	40.5%
France	554	505	18.1%
Germany	494	394	27.6%
Italy	737	-	25.1%
United Kingdom	190	137	5.3%

Note: Canada, 1995; USA, 2005; Korea, 2005; data for China's long-term annual average is calculated based on 2000-10.

Source: OECD (2011), *Metropolitan Database 2011*, OECD website, <http://stats.oecd.org/Index.aspx?QueryId=23398>; NBS (n.d.), China Database, www.stats.gov.cn/english/statisticaldata/yearlydata.

Supplying enough safe drinking water to meet demand is a severe challenge in some of the most prosperous and populated Chinese cities, reflecting a large gap between demand and supply capacity. Partly as a result of major regional imbalances in water demand and supply, the problem is most acute in large cities in north and north-eastern regions, which hold only 5% of the country's water resources and 40% of the country's population (NBS, 2011a). Beijing and Tianjin, for instance, have been suffering from chronic severe water shortages, and groundwater has been abstracted for years much faster than the replenishment rate (NBS, 2011a). While current per capita average water consumption for domestic uses in urban China is still much lower than in developed countries (32 500 litres per person per year in China in 2010 versus 95 000 litres per person per year in the US in 2008) and decreased during the 11th FYP (500 litres per person per year less than in 2005), the expected quantity and concentration of water demand will continue to challenge supply (UCI, 2010).

The challenge of supplying adequate water resources will become even greater given the massive ongoing urbanisation and industrialisation. Water consumption from industry and urban domestic sectors and their share in total consumption are projected to increase through 2030 (China Academy of Science, 2007). During the 11th FYP period, industrial water use conservation (*i.e.* the rate of water recycling in industrial processes) rose constantly, driven by large investments in industrial water conservation equipment (NBS, 2011a); however, there is still considerable scope for further improvement. Industrial water recycling in China is only at 40%, while in Chinese Taipei it is at 60%, and in developed countries it is at 77% (World Bank and DRC, 2012). The water efficiency targets set in the 12th FYP, including for industry and agriculture, are likely to be outpaced through rising demands connected to urban migration (OECD, 2007a).

Despite constant improvements, China still faces serious water pollution problems, which have further reduced the availability of clean-water supply in water-scarce cities. While wastewater discharges from industry have declined over 2005-10, water pollution from urban residents has grown over the same period (NBS, 2011a, 2006). By and large, increases in per capita GDP correlate with increases in domestic wastewater discharges, *e.g.* Shanghai's domestic per capita wastewater discharges (92 t) were more than three times larger than Chongqing's (29 t). Households in cities with severe water scarcity, such as Beijing and Tianjin, also generated among the highest amount of domestic wastewater in China (NBS, 2011a). In 2010, 40% of the monitored sections of the seven key river systems in China had water quality at Class IV or worse, whereas in 2001 almost 53% were considered as heavily polluted, with a water quality at Class V or worse.⁶ However, some regions urgently need to improve water conditions: just over 37% of the monitored stretches of the Yellow River, over one-quarter of the Huai River system, more than half of the Hai River, and over 43% of the Liao River systems were Class V or worse (MEP, 2011a). Most of these river systems correspond to regions where cities face severe water shortage. In addition, it should be noted that comparative aggregated figures mask serious local water pollution problems in urban areas, which include urban areas that are considered to have abundant resources. For instance, a detailed assessment shows that virtually all of the Pearl River Delta in the Guangzhou metropolitan region is below Class V during the dry season (OECD, 2010b).

Further improvement is also required in water treatment to meet drinking water standards. Whereas attention is paid to nutrient pollution, toxic pollutants thus far are not sufficiently addressed. While every Chinese city has varying levels of water pollution, there is an overall shortage of water treatment facilities, which explains in part why many cities do not meet national drinking water standards. In 2009, only 82% of the water for consumption in Guangzhou met national standards. Interventions thus far have mainly tackled industrial and municipal point-source pollution. While those must be further reduced, the more difficult challenge of non-point sources of water pollution must be addressed. A successful approach to lower pollution from all sources must build on combined measures of monitoring, administrative control and economic incentives (World Bank and DRC, 2012).

6. Water quality in China is graded in six levels, from Grade I to Grade VI, with Grade VI being the most polluted.

3. POLICIES FOR A GREEN ECONOMY IN URBAN CHINA

To respond to growing economic and environmental challenges in cities, the Chinese government has set ambitious economic and environmental targets in the 12th Five-Year Plan (FYP), many of them with urban implications. While much progress was made under the 11th FYP, more remains to be done in key urban sectors. The OECD defines urban green growth as fostering economic growth and development through urban activities that reduce environmental impact, and identifies six sectors of urban activities: *i*) land-use planning; *ii*) transport; *iii*) buildings; *iv*) energy; *v*) waste; and *vi*) water. Of these urban sectors, the ones that are the most relevant for meeting 12th FYP targets are: land use and transportation (mobility); buildings; water and air quality (pollution prevention, treatment and abatement); and green technology sectors and clusters (green services). This section considers the opportunities and challenges each of these sectors presents for fostering green growth in Chinese cities, and considers actions the national government could take to further cities' green growth potential.

3.1. Linking land-use and transportation policies to reduce congestion and environmental impacts

Efficient urban form and efficient and less polluting transport infrastructure are crucial to achieving sustainable growth and long-term efficiency in cities. Because the built environment typically lasts for several decades, the carbon intensity of current development will determine a city's carbon emissions for decades to come. As discussed in section 2, urban form affects environmental targets in terms of land consumption, greenhouse gas emissions, air pollution, and the cost of public service delivery. Public transit service can mitigate the effects of urban expansion by reducing congestion and increasing accessibility to homes, jobs and services. However, public transport investment has not yet kept up with the expansion of Chinese cities.

The national policy framework and challenges

In the 11th and 12th FYPs, the central government has begun to address challenges related to ongoing urban population increase and urban land expansion. The national policy framework includes strategies to promote "city clusters", strictly regulate land use and advance public transport infrastructure construction (Table 3.1). City clusters are described in the 12th FYP as large regions that include several large cities and their surrounding small and medium-sized cities and towns. The city clusters framework intends to link different urban areas with light rail, inter-city transit and other means of public transport and communication systems. The goal is to integrate different urban areas within a sensible transport radius, such as "one-hour or two-hour economic circles", in order to achieve the economies of scale of megacities. This framework expects big cities to mainly provide markets and jobs, while medium-sized cities and small towns pursue a transport radius that allows them to provide housing, education and health care services to urban dwellers and transferred rural workers (Liu, 2011).

Table 3.1. National policy frameworks on urban form and transport infrastructure

Framework	Programmes	Implementation scale
Advocating city clusters as the major spatial format for urbanisation	National specific urbanisation plan, with goals to promote over 20 city clusters in China	Nationwide
	Infrastructure investment for inter-city rail transit and highways	For all city clusters, in particular for city clusters in YRD and PRD
Regulating land use	Regulation for strict agriculture land protection	Nationwide
	National zoning plan (named as the Main Functional Plan)	Nationwide
Public transport infrastructure construction	State council guidelines on prioritising public transport in urban areas	Nationwide
	Infrastructure investment for public transport, e.g. light rail, metro lines, tram and BRT	Nationwide. But bus rapid transit (e.g. Guangzhou) has not received sufficient attention as rail transits (e.g. over 15 cities including Beijing, Shanghai and Guangzhou).

Note: Yangtze River Delta (YRD); Pearl River Delta (PRD).

Source: Government of China (2011), “中华人民共和国国民经济和社会发展第十二个五年规划纲要” (12th National Five-Year Plan on Social and Economic Development), news.xinhuanet.com/politics/2011-03/16/c_121193916.htm; Government of China (2006), 11th National Five-Year Plan on Social and Economic Development, www.gov.cn/english/special/115y_index.htm.

Both the city cluster strategy and agriculture land protection regulation reflects the national government’s great concerns over loss of farmland and urban expansion. The policy goal of the city cluster strategy is to promote the benefits of economic agglomeration and efficient land use as urban populations rise rapidly. In particular, national urbanisation guidelines will be provided in a forthcoming specific national urbanisation plan, which includes the following major elements: *i*) promoting the large spatial form of city clusters; *ii*) adopting instruments that affect urban spatial form: urban boundary, urban planning standards, and policies to increase density etc; *iii*) incorporating migrant workers into the urban *hukou*, enjoying equal public services like education and health care; *iv*) putting in place a better urban management governance mechanism (Yang, 2011). A major concern for the central government is the size and speed of farmland losses, which urgently need to be resolved, given the relatively limited availability of farmland.

A debate about the value of compact cities in China is ongoing, and has not yet been settled. Those in favour of more compact development argue that Chinese cities consume land at a higher rate per capita than the international average while those that do not see compact development as a solution argue that high population density has already put tremendous pressure on the urban environment (Qiu, 2006). Density in Chinese cities has been decreasing due in part to a concern about the negative effects of highly concentrated population and lack of liveable space in highly dense urban areas, but mechanisms for managing higher density development while preserving quality of life could be further explored. It is possible to pursue compact development while mitigating the negative effects of density and agglomeration. Compact cities are characterised by: *i*) dense and proximate development patterns (in which urban land is intensively utilised and agglomerations are contiguous or close together; *ii*) urban areas that are linked by public transport systems; and *iii*) accessibility to local services and jobs (land uses are mixed and most residents have access to local services either on foot or using public transport) (OECD, 2012c). Higher-density developments can take many forms, ranging from large buildings with space between them to lower buildings (maximum ten floors) that are attached or located in very close proximity to other buildings.

Public transport has been more directly addressed than compact urban form in both the 11th and 12th FYPs. Following the State Council document to prioritise public transport in cities (State Council, 2005), various cities have issued their respective plans to improve public transport infrastructure. In particular, the past several years have witnessed a boom in cities that plan to build rail transit. Until 1989, China had only three metro lines totalling 50 km (two in Beijing, one in Tianjin). Since the start of 11th FYP period, 36 urban rail lines with a total length of 1 500 route-km have been under construction in 15 cities, and will be completed in the next 10 years (Darido *et al.*, 2009). Nevertheless, rapid construction and expansion of metro systems have not been able keep pace with the rapid transport demand increase. The high construction costs of metro and light rail, typically USD 50-100 million per km, limits the extent and speed of development of such systems. Buses have made up the greatest share of public transit usage, even in major cities with metro systems, such as Beijing, Shanghai and Guanzhou, the share of public transit trips taken on buses is growing (Darido *et al.*, 2009). However, city transport authorities have long responded to increasing pressure on urban mobility by turning more attention to building roads than to developing public transit solutions. Throughout the last decade, China's cities have invested massively in building and improving urban street and expressway networks: the length of roads in cities reached some 294 000 km in 2010, up from 160 000 in 2000 (NBS, 2011a).

Increasing green growth in Chinese cities through linking urban form and transport

A key mechanism for better linking land use and public transport is through transport-oriented developments (TODs). Successful compact city policies are based on well-designed urban plans that consider the linkages between land use and transport planning to reduce dependency on private vehicle use and to increase public transport use. Of particular importance for an integrative transport system are transport linkages between residential zones and employment centres, as well as between different modes of transportation. To be successful, transit-orient developments need to link private development investment with public transit investment (OECD, 2012c). In combination with mixed-used development, different urban functions, such as home, work, and commercial activities and services can be brought closer together and in reach of public transit. Transport-oriented development is already being pursued in China, where it is well suited to the relatively higher densities and mixed land uses that tend to characterise Chinese cities (Chen, X., 2010). In a study of TOD in suburban Shanghai, people who lived within 1 km of developments around metro-rail stations had greater access to jobs than similar residents who lived farther from public transport (Cervero and Day, 2008). To increase the effectiveness of TOD in Chinese cities, the design of the developments need to ensure easy access to public transport stations, and TODs should not be considered as stand-alone projects but as rather part of larger networks of “transit-oriented corridors” (Cervero and Day, 2008; Chen, X., 2010).

Infill development, or the redevelopment of vacant or underdeveloped urban land is also a crucial means for aligning urban development with public transport. A two-rate or split-level property tax system that places proportionally higher tax on land than on built structures makes vacant or under-utilised centrally located sites in cities more costly. This provides incentives to develop vacant or underdeveloped lands in urban areas and discourages greenfield development. Such a system has been implemented in Sydney, Hong Kong (China), Pittsburgh, as well as in cities in Denmark and Finland. Another means to discourage peripheral development is to apply a special area tax to suburban properties, which can gradually increase the more one moves outward from the city centre. Brownfield redevelopment occurs on former industrial land, including polluted properties. Reusing former industrial sites has the advantage to avoid greenfield development at the same time as it revitalises abandoned urban areas and maximises the use of existing infrastructure. Infill development, including brownfield development, has been taking place in Chinese cities. According to the World Bank, brownfield development in China raises concerns about the level of pollution removal required, assignment of liability for public lands, the short deadlines often imposed on soil clean-up, and the extent to which residents are informed of pollution clean-up activities (World Bank, 2010). While the demolition or clean-up of former industrial sites can be costly, and land use

may be limited by existing zoning regulations, brownfield redevelopment usually increases the local tax base, creates employment, and increases the asset value of the site and surrounding areas. National governments can encourage brownfield redevelopment with grants and technical assistance to municipalities, or it can be driven by the private sector. In the US – with incentives from the federal superfund mechanism that supports the clean-up process and site activities – redevelopment has leveraged more than USD 6.6 billion in clean-up and development funding and created approximately 25 000 new jobs (OECD/CDRF, 2010).

Given the need to preserve accessibility in fast-growing cities and mitigate congestion, there is an urgent need to invest more in public transport. Funding for public transport in Chinese cities comes in part from land sales, which may contribute to the spatial expansion of cities and potentially make it more difficult to cover these areas through public transit. Furthermore, land sales may not be a sustainable source of income over the long run. Overreliance on land-related income, such as land sales, land auctions and land development rights for revenues can generate an oversupply of land for construction, unmanaged development and loss of cultivated land (OECD/CDRF, 2010). While government-owned leaseholds on land held by cities are now auctioned, there is evidence of distortions in the land-auctioning process. This is in part due to the formula normally used to compensate rural land contract holders, which tends to give rural land holders only a fraction of the final sale price (Cai *et al.*, 2009).

One alternative to generating revenue through land sales is to tax the increases in real-estate value that result from increased access to urban amenities such as public transport. Known as value-capture taxes or tax-increment financing, these mechanisms have been used in a number of OECD countries to fund public infrastructure investments, particularly for public transit. A meta-analysis of different studies of value increases related to proximity to public transport in a number of OECD countries found that real-estate value in zones within a quarter mile of a railway station increase by 4.2% for average residences, and about 16.4% for average commercial property (Debrezion *et al.*, 2007). Such value can be captured and taxed through either an ongoing annual charge or as a one-time tax. A range of cities has successfully applied value-capture taxes to finance transport infrastructure, including London, Milan and Bogotá (OECD, 2010c; Smith & Gihring, 2006). The rail system in Hong Kong (China) is entirely funded by land rents from development in station areas (Smith & Gihring, 2006 citing Meakin, 1990). Another method, based on the same principle of capturing increasing property value related to public transport infrastructure, is *versement transport*, which is implemented in France to finance metropolitan public transport infrastructure. In this approach, companies with at least nine employees pay a surcharge in the range of 1%-2.2% on the salaries to local transit authorities. While this cannot assure transport funding alone, in the case of the Paris-Ile-de-France region, the revenues from this tax account for around 70% of the STIF's (Syndicat des Transports d'Ile-de-France) finances (OECD, 2010d).

Congestion charges can significantly contribute to financing public transport expansion and maintenance while at the same time reducing congestion. Overloaded road networks and congestion are an expensive symptom of inefficient urban transport systems, and significantly contribute to environmental and health threats in urban regions. While systematic avoidance of congestion is tied to long-term decisions in land use and transportation planning, as noted above, immediate and effective reduction can be achieved through congestion charges (Box 3.1). Unlike fixed fees or tolls, congestion charges are road fees that vary with travel time and are most expensive at peak travel hours. Such charges are successfully implemented in a number of metro-regions, such as Singapore, London and Stockholm, and have shown to significantly influence travel behaviour. In some cases, such as Milan, they also vary according to the environmental performance of vehicles. Congestion charges are now planned to begin in Beijing in 2015, following efforts by the City of Beijing, as well as Guiyang and Guangzhou, to limit new car sales (Zhu, 2012). Congestion charges do not only reduce road congestion, but in some cities they can be used to finance public transport. The costs of operating the different types of scheme have fallen as technology has improved. For example, while the original London scheme cost roughly USD 4.10 per vehicle in

operational costs, the electronic Singapore system costs USD 0.12 per vehicle (OECD, 2011d). The success of congestion charges depends in part on their implementation with other policies, such as policies to improve alternatives to car use. For example, congestion fees worked well in London in part because they were combined with improvements in management of the road network and substantial enhancements in bus service (OECD, 2011d).

Box 3.1. Congestion charges

Congestion charging systems vary considerably based in part on when they were initiated, the technology available at the time, the geography of the city involved and the nature of its transportation system, and the political environment under which the scheme operates. In some cases, such as the schemes introduced in Norwegian cities, the primary objective was to raise revenues for infrastructure expansion rather than to control traffic congestion levels. The initial scheme in Singapore simply forced automobile users to show a daily license to enter congested parts of the city. The London scheme involves electronic pre-payment to enter the main urban area, whereas the more recent schemes in Singapore and Stockholm embrace variable charges by time of day, with the congestion price being collected electronically. There are also freeways with variable charging in California and Indiana, and specific facilities with congestion charges; e.g. on the Oakland-San Francisco Bay Bridge.

One of the main concerns of policy makers is that congestion charges will be unpopular, but experience shows that they tend to poll more favourably after their introduction than before. For example, in Stockholm, residents elected to maintain the congestion charge after a nine-month trial period. Measures can be taken to address concerns before establishing a congestion charging system. In London, for example, concerns about “political” use of congestion charge revenues were largely removed by national legislation that made it obligatory to use such revenues for regional transportation improvement over the decade of the scheme.

Congestion charges have been associated with environmental benefits. For example, estimates show that the Stockholm scheme reduced CO₂ emissions by 10%-14% in the inner-city area and by 2%-3% in the surrounding area, although it had little impact on noise levels. In London, the congestion charge scheme was linked to an annual USD 6 million benefit in terms of reduced CO₂ emissions, and USD 30 million in lower accident costs.

Source: Button, K. and H. Vega (2007), “The Costs of Setting up & Operating Electronic Road Pricing in Cities”, *Traffic Engineering & Control*, Vol. 48, No. 6; OECD (2012), *OECD Territorial Reviews: The Chicago Tri-State Metropolitan Area, United States 2012*, OECD Publishing, doi: 10.1787/9789264170315-en; OECD (2010), *Cities and Climate Change*, OECD Publishing, doi: 10.1787/9789264091375-en.

3.2. Managing rising energy consumption from the building sector

Energy consumption in the building sector, and related emissions and pollution from energy production, substantially contribute to increasing cities’ environmental impact. Building design, location and the energy performance of the built environment have a significant influence on energy consumption and greenhouse gas emissions in urban areas. The built environment is also vulnerable to the impacts of climate change, including urban heat-island effects and flooding. Globally, buildings are key energy consumers and contributors to greenhouse gas emissions. In the OECD, energy used in buildings accounts for 35%-40% of cities’ energy consumption. Globally, buildings account for about 32% of energy use, and 30% of end-use energy-related carbon dioxide emissions, including emissions from electricity generation and district heating. (OECD, 2008b; IEA, 2012).

The national policy framework and challenges

Building energy consumption has been increasingly recognised as a growing contributor to greenhouse gas emissions in China. The 11th and 12th FYP have placed increasing importance on making buildings more energy efficient through stricter building design standards and retrofitting programmes (Table 3.2). While there have been a number of policy successes, additional policy changes, particularly in

terms of financing, assuring compliance and pricing, could significantly advance progress towards more ambitious 12th FYP energy targets. While energy efficiency is unlikely to contribute much to emissions reduction if it is not accompanied by a high carbon price, it is still a necessary element of any policy to foster green growth (OECD, 2013a).⁷ Energy-efficiency initiatives can not only contribute to reducing energy consumption, but also have the potential for creating demand for construction and installation jobs that are higher up the value chain. In particular, demand for retrofitting activities in the form of Energy Service Companies (ESCOs) can contribute to the growth of the service sector, as well as for green products that are higher up the manufacturing value chain.

Table 3.2. National policy frameworks on building energy consumption

Framework	Programmes	Implementation scale
Building retrofit	Retrofit of existing buildings in northern China and reform of heat supply systems	Mainly northern Chinese cities
	Energy Management of Government Office Buildings and Large-Scale Public Buildings	Only for public buildings
	Guidelines to promote ESCOs	Nationwide
Energy efficiency in new buildings	Promoting energy-efficiency building codes/standards and strengthening enforcement	Nationwide
	Initiating building energy-efficiency labelling programmes	Nationwide
	Green building standards and supporting policies, e.g. tax breaks and specific funding for green buildings	Forthcoming

Source: Government of China (2011), “中华人民共和国国民经济和社会发展第十二个五年规划纲要” (12th National Five-Year Plan on Social and Economic Development), news.xinhuanet.com/politics/2011-03/16/c_121193916.htm; Government of China (2006), 11th National Five-Year Plan on Social and Economic Development, www.gov.cn/english/special/115y_index.htm.

Building energy efficiency improved during the 11th FYP, largely due to progress in enforcement of building codes. The 11th FYP mandated a 20% reduction of energy consumed per unit of GDP, allocating a reduction of 100 million tonnes of carbon equivalent (Mtce) to the building sector to be achieved mainly through strengthening building energy-efficiency codes, retrofitting existing buildings, reforming heat supply system and applying renewable energy in buildings (MHURD, 2007b). Within this target, 61.5 Mtce was expected to be achieved through strengthening the enforcement of building energy-efficiency

7. While energy efficiency measures in buildings can significantly lower energy consumption and thus public and private expenditure on energy, the environmental benefits of energy efficiency are less clear. If heat and electricity is provided by emission intensive energy production, cutting energy demand does not only reduce spending on energy, but – in the first instance – also emissions. However, the financial resources freed through energy efficiency measures might be spent on products and embedded emissions that exceed the amount of emission saved through energy efficiency. This substitution effect might lead to even higher emissions per unit of consumption than before the energy efficiency measures. Hence the need for energy efficiency measures to be implemented together with policies that directly or indirectly increase the price of carbon. On their own, then, energy efficiency measures must therefore be seen as – at best – a very imperfect substitute for demand reduction. Nevertheless, they are an indispensable element of any serious green growth strategy, since they can play a critical role in softening the impact of higher fuel prices (resulting from a carbon tax or some other price-based mechanism) on production and consumption. Moreover, programmes to help low-income households improve energy efficiency can also help mitigate the distributional consequences of many demand-reduction policies, as these can sometimes hit the poorest hardest.

codes, with the goal of 95% compliance rates at both design and construction phases (MHURD, 2011c). In 2005, just 57.5% of new buildings in large urban areas met the energy-saving standard during the design stage, and only 24.4% at the construction stage; while in 2010, this figure rose to 99.5% compliance at the design stage and 95.4% compliance at the construction phase (State Council, 2011). The sharp increase came after MHURD implemented a programme of systemic enforcement and monitoring, which included inspection and random verification at all levels of the government, from the county-city level to the central government (Levine, 2011). The Ministry of Housing and Urban-Rural Development's progress report (2011c) pointed out that the 11th FYP efforts to enforce building energy-efficiency codes delivered 46 Mtce in energy saving capacity, a notable achievement even though it falls short of the planned 61.5 Mtce.

There is a need in smaller cities to improve buildings codes and better assure their compliance. Within the 116 Mtce reduction target allocated to the building sector in the 12th FYP, promoting green building standards is expected to account for 45 Mtce, while reductions of 27 Mtce, 14 Mtce, and 30 Mtce were expected to be achieved through heating supply reform and retrofits, energy management of government office buildings and large-scale public buildings, and building renewable energy adoption, respectively (Qiu, 2011; MHURD, 2011b). The green buildings programme, "Implementation Opinion on Accelerating Green Building Development", aims to promote green standards in new buildings, mainly indicating an integrated solution to consider saving energy, water, materials and land in new buildings (Qiu, 2009; MHURD, 2012). Given the high enforcement rate and ongoing urban building construction, green building programmes are expected to continue to have an important energy saving role similar to what was demonstrated in the 11th FYP period. Nevertheless, while building code enforcement in large cities is generally considered strong, enforcement in secondary and tertiary cities may be less rigorous. This points to the opportunities to further reduce energy consumption by increasing compliance with building energy-efficiency standards. The local government carries out the majority of building inspections, while the central government commissioned expert teams mostly review documents. Given the lack of personnel and staff, and working hours responsible for inspections, there are concerns about inadequate performance on inspections, in particular ambiguous compliance rates for the small-county level cities (Levine, 2011; MHURD, 2011c). Smaller cities and rural provinces often do not have the necessary resources and human capacity to set up the agencies necessary to comprehensively inspect construction activities. Another contributing factor is that current building codes do not address energy issues in small buildings, but primarily target heating and cooling issues in larger buildings. Given this, building capacity to improve building code enforcement and compliance in smaller cities and rural areas, as well as extending more ambitious building codes to smaller buildings, would be crucial to yielding further energy efficiency improvements in the building stock (Evans *et al.*, 2010).

The 12th FYP contains ambitious targets for further reducing energy consumption, which may be possible through programmes that go beyond energy-efficiency codes for new buildings, in particular energy-efficiency building retrofits. Energy-efficiency building retrofits are considered an important means of meeting the 12th FYP targets for additional energy-efficiency gains, given the large number of existing building stocks. The 12th FYP set more ambitious retrofitting targets, to realise 41 Mtce reduction by 2015 through heating supply reform and retrofits (27 Mtce), and energy management and retrofit of public buildings (14 Mtce), up from 27 Mtce in the 11th FYP (MHURD, 2011b; MHURD, 2007b). For instance, total floor housing space to be retrofitted in northern heating areas was expected to reach 0.4 billion m² over the 12th FYP period, a substantial increase from the target of 0.15 billion m² set in the 11th FYP (MHURD, 2011b; MHURD, 2007b). This is a response to the fact that a total floor area of 2 billion m² is estimated to need energy-efficiency retrofitting in northern areas (Zhang S.C., 2011). In addition, the 12th FYP retrofitting work will also target 0.05 billion m² of residential floor areas with hot summers and cold winters, as well as 0.06 billion m² of public buildings. Major retrofitting measures include installing heat metering and temperature control equipment, retrofitting the heat supply network for heat balance, and energy-efficiency retrofit of building envelopes (Levine, 2011). Lawrence Berkeley National Laboratory's analysis also pointed out that large energy saving potential exists in space heating improvement in

commercial buildings, and could be realised through increasing market shares of different advanced space-heating technologies (Zhou and Lin, 2007).

Efforts to expand retrofits in China face a number of challenges, primarily in terms of financing. Retrofitting 0.18 billion m² of floor area retrofitted during the 11th FYP period cost CNY 24.4 billion. An additional CNY 300 billion would be needed to retrofit 2 billion m² of floor area in northern China (Zhang S.C., 2011). Of the CNY 24.4 billion spent in the 11th FYP, CNY 4.6 billion came from central government, CNY 9 billion came from local authorities, and the rest was mobilised from the private sector. Moving forward, a larger amount of resources will be required to perform the increased retrofitting floor area target mandated in the 12th FYP, which tripled the 11th FYP area. Considering the increasingly tightened fiscal conditions of local government, it will be difficult to mobilise matching funds at the sub-national level, despite strong calls at the central level (Zhang S.C., 2011).

Limited financing speaks to another major challenge, especially in residential buildings: retrofit quality. Policy incentives for retrofits were provided at around CNY 50 per m², usually one-third to one-seventh of the actual retrofitting cost, which prevented the majority of households from carrying out the full range of retrofit measures. Most only installed a heat meter (Levine, 2011). Without more extensive retrofits in the residential buildings sector, it will be difficult to realise further efficiency gains. Solutions are therefore necessary to raise public awareness and expand public education to ensure homeowners understand the need for efficiency improvements, and what they can do to achieve them. This is extremely important for multi-family buildings, but less of an issue for single family or single owner buildings (*e.g.* public building). Local Energy Conservation Supervision Centres can play a key role in supporting these outreach and capacity building efforts, but they cannot undertake extensive efforts without the provision of additional resources.

Mobilising private sector involvement and further public sector support

Energy Service Companies (ESCOs) present a possible solution to financing and meeting energy targets, and have benefited from substantial government support. ESCOs guarantee that energy costs will be reduced by a certain percentage after energy improvements are made. Subsequent energy savings are then used to reimburse investment costs over an agreed pay-back period, which is typically 10 to 15 years (Hammer *et al.*, 2011). The number of ESCO firms registered in NDRC increased from around 80 in 2005 to more than 2 300 in 2012, employing almost 400 000 people (NDRC, 2012a). This progress is due in part to strong policy signals and incentives in the government programme, including awards and grants to ESCOs that demonstrated substantial energy savings amounting to CNY 240/tonne of coal equivalent (tce) from the central government, and CNY 60/tce from provincial governments (MoF and NDRC, 2010b). Moreover, the central government programme outlined various tax incentives (*e.g.* no sales tax applied to ESCOs; no income tax for the first three years of operation, and 50% reduction in income tax for years four to six) for ESCOs who satisfy certain conditions in performance contracting projects. The conditions require the ESCO to enter a “shared-savings” contract so that technologies used in the project meet government-defined technical requirements (MoF and NDRC, 2010a).

However, ESCO financing and quality remain major challenges, leading the government to promote “qualified” ESCOs. A lack of funding continues to be a major obstacle to further deployment of ESCOs in Chinese cities. Government subsidies could only cover 7% of the upfront cost, resulting in only a moderate impact on ESCO-related energy retrofit investments (China Greentech Initiative, 2011). Furthermore, banks are reluctant to lend to ESCOs given their limited understanding of energy-efficiency project lending, and poor risk assessment and lack of collateral (Yu and Li, 2011; Feng *et al.*, 2011). Furthermore, many smaller ESCOs offer the implementation of only one energy-efficiency technology, *e.g.* windows, HVAC systems, lighting, etc., rather than adapting a range of technologies capable of providing a comprehensive solution to building owners (Bodrenko *et al.*, 2010). In addition, Kostka and Shin (2011)

argued that most Chinese ESCOs tend to be small and private enterprises, which have had difficulty building trust among potential customers, in part because they were not connected to local business, social and political networks. Safety has also become a concern, in the wake of a tragic 2010 fire in a Shanghai apartment building, which was blamed in part on flammable retrofitting materials and poor oversight of the ESCO (Clem, 2010). The central government has responded by designating “qualified” ESCOs, which tend to be larger companies, having greater financing and implementation capacity, and offer a broader range of energy-efficiency services. Criteria for ESCOs to qualify for central government subsidies include meeting certain minimum energy savings requirements, *e.g.* holding capital greater than CNY 5 million, and contributing financially over 70% of the total investment in the energy saving contract. The purpose of the policy is to ensure that ESCOs are large enough in terms of capital to be attractive to bank lending. By early 2012, the government has published a list of more than 2 300 firms that met the minimum qualifications, with large numbers concentrated in several major cities, such as Beijing (329), Shanghai (142) and Shenzhen (90) (NDRC, 2012a).

Another challenge to the viability of ESCOs is the relatively short lifespan for buildings in China. The average life span of building in China is 20-30 years probably due to low quality in construction (Qiu, 2011). Many buildings are demolished and replaced due to deteriorating quality, although demand for newer styles and amenities, which is rising with income levels, also plays a role. Moreover, the rate of reuse of construction materials lowers the environmental impact of short building lifespans. This would argue for a focus on enforcing better standards for new buildings rather than on retrofits. However, energy-efficiency retrofits of existing buildings will likely need to remain a priority. First, the share of existing buildings in need of retrofitting is very large. Second, occupants of residential buildings in need of retrofitting tend to be low income, thus the retrofitting efforts could be carried out along with subsidised housing renovation. Finally, retrofitting is the preferred approach for buildings that should be preserved given their cultural significance (Zhang S.C., 2011).

Experience with ESCOs in OECD countries can inform the central government’s reforms of the sector. Increasingly mature ESCO markets can be found in Germany, Korea, US, France, Brazil and others, where favourable market conditions and public policy have allowed ESCOs to develop. For example, Germany is home to a diverse range of ESCOs, including small local companies, multinationals and former municipal utilities. The conditions for the successful development of ESCOs in Germany include four key factors: *i*) political and legal commitments to achieve the objectives of a national energy-efficiency action plan, which fulfils Germany’s obligations under the European energy service directive (2006/32/EC); *ii*) third-party financing, in particular through the public investment bank Kreditanstalt für Wiederaufbau (KfW); *iii*) firms and public-private partnerships (PPPs) offering a range of energy services, from project development to implementation of energy performance contracts; and *iv*) rising energy prices, which have made energy performance contracts more attractive. The focus on large government buildings, which represent a significant share of German building floor space, has allowed for bundling of energy saving projects, thus increasing the profitability of energy performance contracts (Box 3.2). The main contributors to successful ESCO markets are the introduction of compulsory energy audits, awareness raising among policy makers and customers, and access to capital (mainly via third-party financing).

Box 3.2. The Berlin Energy Agency, Energy Saving Partnerships (ESP), and the KfW bank

The Berliner Energieagentur (BEA) co-ordinates Energy Saving Partnerships (ESPs) for energy-efficiency projects in public sector buildings in Berlin. Energy Saving Partnerships were introduced in 1995 as a model of public-private partnerships between the City of Berlin, utility companies and the public investment bank Kreditanstalt für Wiederaufbau (KfW), in order to realise energy efficiency in the public sector and to reach the Berlin Senate's 1994 goal of reducing CO₂ emissions 25% by 2010, and 40% by 2020 (compared to 1990 levels). Focusing on large public buildings and creating synergies by handling a range of large energy-efficiency projects, the BEA prepares public tendering and implements Energy Performance Contracts (EPCs) with respective ESCOs and financial institutions, mainly the national investment bank KfW. In 2011, BEA had engaged 1 400 public buildings in ESPs, which account for annual savings of EUR 2.9 million in energy for the City of Berlin and 67 900 tons of CO₂ emission reductions (City of Berlin 2011, BEA, 2011). Soon, a majority of all public buildings in Berlin (for which retrofits are applicable) will be engaged in ESPs and new programmes – EPC *plus*, EPC *light*, and EPC *green* – have already been introduced to expand and optimise early retrofits, address buildings with suboptimal conditions for energy savings, or further integrate renewable energy technologies. The BEA also started advising other regions in Germany that have not yet tackled retrofits in the public sector.

For energy-efficiency measures in private buildings, tenants, landlords and housing corporations can access loans from the KfW via the energy-efficiency retrofit programme (Energieeffizienz Sanierung). In addition, local banks offer loans, such as the Investitionsbank Berlin (IBB) in Berlin. Since 1991, over 4 billion Euro have been invested into retrofits in Berlin, resulting in 631 000 tons of annual CO₂ savings for the city (City of Berlin, 2011). Legal rent increases of up to 11% annually help landlords to refinance loans. This model applies particularly well in cities with a large share of rental housing (only 40% of Germany's housing units are occupied by owner, while 60% are rented) (Power, 2011). Tenants balance rent increases through savings on heating and electricity bills. A particular obstacle for accelerating the process in Berlin, however, has been low rents – driven by low-income levels and high-vacancy rates – which in many cases do not allow for sufficient margins to refinance retrofit measures (IBB, 2011). Nonetheless, since the early 1990s around one-third of the residential buildings in Berlin have been retrofitted as a result of KfW programmes, including 273 000 prefabricated slab apartments, for which energy consumption has been reduced by 50% (City of Berlin, 2011).

Source: BEA (Berliner Energieagentur) (2011), *Energy Saving Partnership. Better Practice Exchange 2011*, Berliner Energieagentur, Berlin; City of Berlin (2011), *Climate Protection in Berlin*, Senatsverwaltung für Gesundheit, Umwelt und Verbraucherschutz, Berlin; IBB (Investitionsbank Berlin) (2011), *IBB Wohnungsmarktbarometer 2011*, www.ibb.de/desktopdefault.aspx/tabid-427/; Power, A. and M. Zulauf (2011), *Cutting Carbon Costs: Learning from Germany's Energy Saving Program*, WhatWorks Collaborative, Department of Housing and Communities, London School of Economics and Political Science, London.

Another potential solution for financing energy-efficiency retrofits is low-cost loans to property owners, provided or guaranteed by city governments. A number of cities across the OECD have experimented with financing mechanisms to reduce property owners' up-front costs of investing in renewable energy technologies. In the US, cities have introduced the concept of Property Assessed Clean Energy (PACE), in which cities provide low-interest loans to property owners for investments in energy efficiency or distributed renewable energy technologies. The cost of the loan is added to their property tax bill, meaning repayment occurs on a quarterly basis as part of the regular tax payment. This strategy eliminates the problem that property owners who intend to sell their property have – little incentive to invest in efficiency upgrades – because PACE passes the repayment obligation on to the new property owner. Under PACE, municipalities establish a funding pool to pay for the upfront installation costs, and the pool is repaid over time, allowing funds to be reused to support additional loans (OECD, 2012d). The future of these loan programmes is unclear, however, as most US PACE programmes are on hold until US federal legislation can address concerns about the potential risk of default on mortgages involved in PACE programmes (Speer, 2010).

A number of international examples offer a range of approaches of public sector involvement that provide viable solutions to finance energy-efficiency retrofits. The City of Toronto for example set up a Better Building Partnership in 1997 to provide building owners, managers and developers with expertise, resources and financial assistance to enhance the outcome of energy efficiency and renewable energy

projects. Over the first ten years, the energy performance of over 50m² of gross floor area was improved, and around 200 new projects were treated every year (BBP, 2009). The City of Melbourne established a programme to retrofit 70% of its non-residential building stock. The financial mechanisms and the operational delivery are managed by the Sustainable Melbourne Fund, which directly partners with property owners to realise their retrofit projects (SMF, 2012). In the UK, the Green Deal will provide a financing mechanism that allows private and commercial building owners and tenants to pay their energy-efficiency investments through their energy bill (DOECC, 2011). A “golden rule” guarantees that the payback is never higher than the actual savings realised on the energy bill. In addition, when tenants move or the building is sold, the financial obligation stays with the building, and the new owner or tenant only pays once he/she actually profits from energy savings. As part of the Green Deal, the Energy Company Obligation (ECO) makes sure that low-income homes, which have fewer margins to profit from energy savings, can equally profit from the Green Deal regulations (DOECC, 2012).

Pursuing complementary approaches

In addition to assuring compliance with building codes and expanding building energy-efficiency retrofits, other policy changes could decrease energy consumption in buildings, including heat-pricing reform. The current heat-pricing system undermines efforts to improve the energy efficiency of both existing and newly constructed buildings. As a legacy of the planned economy, households pay their district heating bill based on the size of their living space, rather than their level of heat energy consumption (OECD, 2009). There is thus little incentive to conserve energy. However, heating fuel supply companies have little incentive to support changes in heat pricing aimed at reducing energy consumption, as this will lower their revenues without necessarily reducing to a comparable degree the costs of delivery heating fuel (Levine, 2011). The central government committed to heat pricing reforms in the 11th FYP, but the rate structure in most cities has changed very little. Heat energy metres, which must be installed before heat prices can be pegged to consumption, have only been installed in 21 million m² of building floor space, which accounts for less than 1% of the floor area targeted under the heating supply measurement reform project for cities in northern China (Levine, 2011). By 2010, only some 40 cities have released policies on heat metering prices and charges, less than one-third of the total targeted cities (MHURD, 2011c).

The energy embedded in building materials also represents an opportunity for reducing the energy consumption of buildings. While construction accounts for only 2% of total life cycle building energy consumption, and building materials are often recycled, reducing the energy intensity of the cement industry would help reducing the energy intensity of concrete building materials. Over the last decade, China has become the world’s largest cement producer. China accounted for 36% of global production in 2000 and for over 50% in 2011 (IEA, 2012). The industry produces 1.88 billion tons of cement annually, and this is expected to rise to 2.2 billion by 2015. Government policies have resulted in closing inefficient shaft cement kilns and greatly increasing the share of cement produced by more efficient rotary kilns. However, implementing best available technologies and other options could still lead to an estimated 15%-20% additional efficiency gains. These could come in part from adopting alternative cement production processes to the most commonly used and highly energy intensive Portland cement. One possible alternative would be Sialite, which requires less energy to be produced (over 70% less than Portland cement), can draw 95% of its raw material from recycled industrial waste, and can be used in a wider range of applications (Feng *et al.*, 2006). However, it might take time to implement such changes in the cement and construction industries.

Installing renewable energy generators on buildings can further reduce operational building energy consumption. Renewable energy generation that is distributed among energy consumers will not replace the need for centralised, large-scale renewable energy generation, but it can serve to reduce individual building’s overall energy demand. This can be done through incentives or requirements for building

owners (including local governments) to invest in distributed renewable energy technologies, such as rooftop solar panels or small-scale wind generators. Requirements can come in the forms of building codes that require renewable energy production on site, such as the Merton rule in the UK, or Barcelona's "Solar-Thermal Ordinance", which requires all new buildings and major renovations to install solar thermal collectors to supply at least 60% of the energy used for water heating (OECD/CDRF, 2010). Low-cost, city-backed loans can be used to lower the costs of investment in distributed renewable energy technologies, similar to those used to enable property owners' investment in energy-efficiency technologies. Increasing distributed renewable energy production requires systemic solutions, such as a "smart" electricity grid, and heating and cooling networks that are compatible with a variety of energy sources, in order to increase flexibility and allow integrating variable renewable energy sources into the grid.

Finally, overall energy consumption from buildings can be further reduced through district heating and cooling systems. District heating systems are often used in combination with cogeneration and provide whole areas in cities with heat and warm water. District heating systems can also be supplied with heat from waste incineration, biomass or biofuels, geothermal energy, and excess heat from industrial processes. Examples for successful and large-scale district heating systems can be found in Copenhagen, Mannheim, or Stockholm. Of these, Copenhagen has the most comprehensive system, providing 97% of the city's total heating needs (OECD 2010d). Toronto has established a deep lake water cooling system that serves major downtown offices, and thus allowing for significant electricity savings in air conditioning. Paris has both large district cooling and heating systems, serving commercial buildings in the central business district and residential areas. The Paris district heating system is powered by geothermal energy and biomass. Whatever the source of energy, district heating and cooling systems reduce energy consumption in heating and cooling through more-efficient energy delivery. Large-scale planning and regulatory changes for buildings are required in order to systematically connect urban districts; in return, important and long-term energy-efficiency gains in the building sector can be achieved with district heating and cooling systems, resulting in tangible savings for a large number of consumers.

3.3. Addressing water and air pollution in cities

Ongoing urbanisation has both positive and negative environmental consequences pertinent to water and air quality. On the positive side, higher concentrations of people have generally increased access to modern and efficient infrastructure for the delivery of environmental services, *e.g.* wastewater treatment. On the negative side, a greater concentration of economic activities can also cause higher concentrations of wastewater discharge and outdoor air pollution, and therefore increase the population size exposed to pollution. Furthermore, the scale of further urban population increase, especially in the few large metropolises, creates tremendous pressure on the urban environment (*e.g.* water supply and wastewater treatment), unless more ambitious urban development and environmental management policies are in place (OECD 2012e).

Managing water sustainably

Sustainable water use can be an essential driver for economic growth. It is essential to ensure that natural assets, including water, continue to provide the resources and environmental services on which all human well-being relies. Water management can generate huge benefits for health, agricultural and industrial production, and a lack of water of appropriate quality can significantly hinder growth (Hammer *et al.*, 2011). Thus, water efficiency and water demand management are essential ingredients for green growth, along with water reuse and recycling. While most OECD countries have been able to ensure adequate access to a safe water supply for human needs, and significant efforts have been made to treat organic pollution from urban wastewater, considerable investments are needed to retrofit wastewater infrastructure. Insufficient progress has also been made to tackle pollution arising from agricultural runoff

and other non-point sources of pollution which can exert additional pressure on water resources and increase water purification costs. UNEP (2011) confirms that investments in infrastructure and operation of water-related services can provide high returns for both the economy and the environment.

The national policy framework and challenges

To address the serious problem of water quality, the national policy framework set ambitious binding targets. As in many OECD countries, China has adopted a range of policy approaches to address the water quality challenge, including regulatory approaches, economic instruments and information-based voluntary policy tools (Table 3.3) During the 11th FYP period, direct abatement measures, including upgrading industrial facilities and implementing well-established technical solutions, were the dominant contributor to some of the most significant reductions in water pollution. For instance, newly constructed sewage treatment plants accounted for 58.5% of the total water pollution COD reduction (CCICED, 2011a). Investments in wastewater treatment facilities have resulted in a sharp increase in treatment rate for both household and industrial wastewater. By the end of 2010, a total of 2 832 urban sewage treatment facilities were built in various cities and counties across China – an increase of around 2 000 during the 11th Five-year Plan – leading the sewage treatment rate in cities to increase from 52% in 2005 to 77% in 2010.

Table 3.3. National policy frameworks on water quality

Framework	Programmes	Implementation scale
Regulatory approaches (command and control)	Direct abatement measures, e.g. construct wastewater treatment plants	Nationwide for all cities
	Rules on water conservation in cities, 1988	Nationwide
	Wastewater discharge standards	Nationwide
Economic instruments	Charges (e.g. abstraction, pollution)	Nationwide and will be further increased in the 12 th FYP period
	User tariffs, Pilot tiered pricing in water, ongoing for many years	Pilot programmes have been ongoing for many years and the national framework is forthcoming
Others	Voluntary approaches: Recognition of national model water conservation city, 2001	Nationwide

Source: Government of China (2011), “中华人民共和国国民经济和社会发展第十二个五年规划纲要” (12th National Five-Year Plan on Social and Economic Development), news.xinhuanet.com/politics/2011-03/16/c_121193916.htm; Government of China (2006), 11th National Five-Year Plan on Social and Economic Development, www.gov.cn/english/special/115y_index.htm.

As the direct abatement solutions become exhausted, and as tackling pollutants becomes more complex, a broader approach will be required, in particular through more stringent standards and expanded economic instruments, including charges for discharging water pollutants, fines and penalties, payment of ecosystem services and tradable permits and subsidies. Both types of approaches were put in place in the 11th FYP and are further emphasised in the 12th FYP. Some local governments have also taken a lead in monitoring water pollution. Shandong province, for instance, has identified the 1 000 biggest polluters in the region in a public listing and has set ambitious waste-reduction targets for each company (UCI, 2010).

Water tariffs still do not promote water conservation, and in most cases do not reflect the entire costs of water supply, treatment and distribution. User charges for water and other resources have traditionally been low in their incidence and level, typically falling well below their economic value or opportunity cost, which often is below their societal and ecological value (OECD, 2007b). In many places (especially northern provinces) this has led to treating water as an abundant resource. Current tariff structures in most cases differentiate between user groups, charging industries and commerce higher rates than residential

users. There are some examples of increasing block tariffs (unit prices increase with consumption), however, in most cases water tariffs remain linear (*i.e.* a single price per unit of water). Central and local departments have released a series of pricing policies that opt for expanding water resource fees and increasing levy rates, as well as setting charges for water conservation works. Nevertheless, the majority of water pricing remains fixed and prices do not fully reflect the cost of raw water extraction, pre-treatment, water distribution and wastewater treatment (DRC-MWR, 2010). Although the conditions for introducing water pricing schemes are advancing. Universal metering has already reached an average of 90% in most Chinese cities, including highly populated apartment complexes (MWR, 2011).

Underfunded wastewater treatment systems hamper adequate responses to urban water quality concerns. Despite large investments in domestic wastewater infrastructure in urban areas directed by the State Council during the past decade, challenges to maintain surface and groundwater quality remain in many cities (OECD, 2012e; OECD/CDRF, 2010). While local governments can set wastewater tariffs without approval from higher-level authorities, many water bureaus still run losses, with prices in most cases being kept low, so as to not to upset public opinion (DRC-MWR, 2010).

Provide the right economic incentives for water quality

In both OECD and non-OECD cities, the governance challenges plaguing the water sector are most often the fragmented regulatory and policy setting, insufficient technical and human capacity within local governments to manage water resources, difficulties in cross-sectoral co-ordination (*e.g.* with the energy, agriculture, transportation and land-use planning sectors), and persistent financing challenges (including debates about water pricing and investment in system retrofits and innovative technologies) (see OECD, 2011c). A lack of cross-sectoral policy coherence poses problems in many OECD and non-OECD countries, with clear implications at the local level. The OECD has identified a preliminary set of guidelines for enhancing water governance that call for improvements at all levels of government. Recommendations include, among others, involving sub-national governments in water policy design, developing and improving water information systems and databases, encouraging performance measurement to measure and monitor policy outcomes and provide incentives for capacity-building, and improving horizontal and vertical co-ordination among different sectors and levels of government (OECD, 2011c).

Smart water policies that help achieve water conservation and efficiency goals include proper pricing of water to encourage efficiency, financial incentives for low-flow appliances, proper design of subsidy and rebate programmes, new state and national efficiency standards for appliances, education and information outreach, water metering programmes and more aggressive local efforts to promote conservation. The success of water pricing schemes depends to a large extent on an appropriate and optimised design. It is crucial that both the tariff level (how tariffs are paid) and the tariff structure (who pays what) are set appropriately with respect to local conditions. In all cases, tariffs must reflect the cost of raw water supply, hydraulic engineering and wastewater treatment, which includes the costs of sludge management. Tariffs should also be sensitive to seasonal water scarcities; and price structures need to be volumetric in order to incentivise water consumption reductions (OECD, 2011d). Local and regional governments can also enact regulations to increase the use of recycled water. For example, more than 40 000 homes in Melbourne, Australia, are required to use Class A recycled water, metered and delivered separately in a distinctive purple pipe, rather than potable water for toilet flushing, washing cars and watering outdoor landscaping (Box 3.3). In the context of quickly growing Chinese cities, where infrastructure in many cases is newly put in place with urban expansion, the installation of a recycling water infrastructure presents an important opportunity for balancing increasing future water demands with smart supply. Some cities have begun to shift to energy-efficient pumps and leak detection programmes to reduce the amount and cost of energy required to move water around the city. Best practices involve developing policy tools that put water efficiency on par with energy efficiency in buildings. While

municipal governments may have a limited role in advancing technological solutions and processes to achieve greater water efficiency (e.g. nanotechnologies, chemistry, recycled wastewater, and desalination of sea water), cities can implement these practices in public facilities and encourage wider use among citizens.

Box 3.3. Melbourne purple pipe infrastructure for recycled water

Melbourne regularly suffers severe droughts and chose to introduce water infrastructure that allows distribution of Class A recycled water via distinctive purple pipes. Class A recycled water is close to drinking water quality and can be used for various water-intensive applications and activities such as open space irrigation, toilet flushing, car washing, construction, fighting, or watering of vegetable or other gardens. Class A recycled water comes through a system of purple pipes that run in parallel to existing water pipes. Melbourne achieved its first target of recycling 20% of its wastewater, and the city is currently upgrading its Eastern Treatment Plant (which treats about 40% of Melbourne's wastewater) to provide 100 billion litres of Class A recycled water per year (DSE, 2011a). The state of Victoria's *Our Water Our Future* action plan included recycled water in its long-term Sustainable Water Strategy for the central region around Melbourne (DSE, 2011b). A number of new development projects in Victoria are building water infrastructure that integrates recycled water pipes, such as Werribee Plains, Cascades on Clyde, Eynesbury, The Hunt Club, Mariott Water, or Aurora (DSE, 2011c, Purplepipe, 2011). Estimates suggest that, 8.5 billion litres of Class A recycled water per year will be used in Werribee Plains; Eynesbury won the 2009 "savewater! award" for supplying households with almost 60% of recycled Class A recycled water via purple pipes. Current projects will provide over 40 000 people with Class A recycled water (DSE, 2011b; Savewater, 2009), and many more purple pipes are envisioned in the State of Victoria and in three other Australian states (New South Wales, South Australia and Queensland).

Source: DSE (Department of Sustainability and Environment of the state of Victoria) (2011), *Recycling*, www.water.vic.gov.au/initiatives/recycling; DSE (2011), *Sustainable Water Strategies*, www.water.vic.gov.au/initiatives/sws; DSE (2011c), *Werribee Irrigation District Recycled Water Scheme*, www.water.vic.gov.au/initiatives/recycling/werribee; Purplepipe (2011), *Australian Recycled Water Communities*, www.purplepipe.org.au/_/Communities.html; Savewater (2009), *Western Water wins national 2009 savewater! Award*, www.savewater.com.au/news-media/?newsid=345.

Sludge management is becoming an important challenge in China due to increasing levels of wastewater treatment. While more has to be done to increase wastewater treatment, current sludge management is unsustainable. Sludge is dealt with as hazardous waste and is either being burnt, composted, or applied to land, or used to cover landfills, often disposing high levels of toxic materials. . None of these methods present a sustainable solution for sludge handling, since toxic materials end up contaminating new land, often times re-entering back the water cycle. Experience with sludge management in OECD countries should be taken into consideration. Sludge can be processed into several products and by-products, up to almost 100%. Gas derived from sludge fermentation can be used to produce energy; parts of the sludge can be recycled and used for cement; and other parts can be dried and burned together with general waste in waste-to-energy facilities. The Eco-model city in Kitakyushu, Japan, for instance uses almost half of its sludge to produce material input for cement, the other half for energy production, and disposes the small residual that cannot be recycled or reused in special landfills for hazardous waste (OECD, 2013b). While enhancing sludge management is essential, the challenge of sludge management, as well as the overall cost of wastewater treatment, can be greatly reduced if toxic inputs into the wastewater stream are minimised.

Improving air quality

While the 12th FYP included goals to reduce nitrogen emissions, more actions are required to improve urban air quality (Table 3.4). This speaks to the gap between the targeted total pollutant reduction and the pollutant concentration in urban areas. In particular, the most serious types of outdoor air pollution for human health are airborne particulate matter (PM) and ground-level ozone. Particulate matter can be divided into two types: *i*) primary particulates: matter emitted directly to the atmosphere, such as black

carbon; and *ii*) secondary particulates: particulates formed in the atmosphere from a reaction involving precursor gases, primarily ammonia, nitrogen oxide (NO_x), sulphur dioxide (SO₂) and, to some degree, volatile organic compounds (VOCs). Ground-level or tropospheric ozone is formed in the atmosphere by a chemical reaction between precursor gases such as NO_x, VOCs and methane, and sunlight. The OECD projects that China already has the highest rate of premature deaths linked to PM pollution per million inhabitants; with the future ageing of the population, this rate is expected to more than double by 2050 if no new policies are implemented (OECD, 2012e). Therefore, urgent action is needed to reverse this trend.

The national policy framework and challenges

Subsidies given to the power sector, *e.g.* 1.5 cent per KWh to thermal electricity generators with desulphurisation equipment, contributed to rise in share of desulphurisation equipment installation, from 12% in 2005 to 82.6% in 2010. These direct abatement measures receive financial contribution from the national authority.

Table 3.4. National policy frameworks on air quality

Framework	Programmes	Implementation scale
Regulatory approaches (command and control)	Direct abatement measures, <i>e.g.</i> install desulphurisation equipment	Nationwide
	Ambient air quality standards	Currently, the year 2000 version is under revision
	Emission standards, <i>e.g.</i> industrial emission, automobile emission; fuel quality standards	Varies by city
Economic instruments	Fuel taxes	Varies by city
	Tradable permits schemes for air emission from stationary sources	Ten pilot provinces by 2012
Others	Voluntary approaches: national environmental model city recognition (1997), annual reports on cities' environmental performance (2004), guidelines on improving air quality (2010), and first semi-annual reporting on air quality of cities in (2011).	Nationwide

Source: Government of China (2011), “中华人民共和国国民经济和社会发展第十二个五年规划纲要” (12th National Five-Year Plan on Social and Economic Development), news.xinhuanet.com/politics/2011-03/16/c_121193916.htm; Government of China (2006), 11th National Five-Year Plan on Social and Economic Development, www.gov.cn/english/special/115y_index.htm.

Some air quality improvements have been only temporary. Ahead of the 2008 Olympic Games in China, air quality improved radically in a number of places, but only temporarily. In Beijing, air pollution significantly improved during and after the games, as shown on the air pollution index (API). However, by the end of October 2009, 60% of the effects had faded away. An aerosol optical depth (AOD) analysis with NASA data confirmed the improvements stated by API data (Chen *et al.*, 2011). However, the analysis also showed that much of the improvement was only temporary. The interpretation of this analysis suggests that the strong temporary improvements were mainly related to plant closure and traffic controls, which were called off after the games, since they were considered politically unsustainable (Chen *et al.*, 2011). While this shows that strong and quick improvements are possible, it also shows how dependent improvements are on political will and command-and-control measures in the current political context.

The current ambient air quality standard, which was passed in 2000, is now under a second-round revision to introduce more stringent targets. Emission trading pilots (mainly for SO₂) have been ongoing,

and covered ten provinces by 2012. While these approaches can surely contribute, monitoring air quality remains a challenge.

Stricter monitoring needed for air quality

With regard to reducing CO₂ emissions, stricter carbon emission standards and improved measures to monitor energy savings are needed. The NDRC's 2010 designation of eight cities and five provinces as low-carbon development pilots allowed for experiments on different low-carbon standards. Some have focused on performance (*e.g.* changes in per capita carbon emissions; carbon intensity per unit of GDP) while others have tested specific programmes, policies, or systems (*e.g.* cluster development, energy saving programmes; tree planting initiative, etc.). While the trial and error pilot programmes for policy reforms in China are an efficient approach, they do not yet provide clarity on the types of indicators and systems that present the best opportunities for monitoring and guiding low-carbon development. New approaches of low-carbon indicators are being studied, and experiences from other countries might offer viable options (Box 3.4). In addition to the need for ambitious national standards, prefectures and cities should be enabled to define stricter regulation, and might be given the authority to carry out independent monitoring and controls to enforce compliance, a measure that has proven to be successful in other OECD countries, such as in Japan.

Box 3.4. LBNL low-carbon indicator system for China

The Lawrence Berkeley National Laboratory (LBNL) developed an innovative new low-carbon indicator system for China that departs from using the standard macro-level indicators, such as CO₂ per unit of GDP or per capita, and works with end-use energy carbon intensity. The approach looks at end-use energy carbon intensity in five key sectors, residential and commercial buildings, industry, transportation and power generation, that include every aspect of China's modern living and activities, and account for all energy use and related CO₂ emissions in China. Using this approach, the methodology is able to indicate where identify energy-efficiency needs are in respective sectors at both the provincial and city level. Using the LBNL methodology and indicators would allow for much more targeted and effective policy interventions (Price *et al.*, 2011).

Source: Price, L., et al. (2011), "Development of a Low-Carbon Indicator System for China", Lawrence Berkeley National Laboratory Report, LBNL, Berkeley, CA.

Unlocking further potential in the energy and pollution abatement sectors will require better measurement and monitoring of progress. Better monitoring will be especially crucial for the growth of energy service companies, so as to ensure the smooth execution of energy performance contracts and to reduce transaction costs. Owing to a national commitment to reduce energy consumption and carbon intensity, investments from both the public and the private sector have been rising. Over the 11th FYP (2006-10), over CNY 30 billion, including investment from the central budget and central fiscal funding, was allocated to support "Ten Key Projects", one of the major components in the national energy saving programmes (NDRC, 2012b). A venture capital report also indicated that in 2009-10 the energy saving and new energy sectors attracted among the highest amounts of venture capital investment (Wang *et al.*, 2010). As a result, production and services related to energy conservation have gained exponential growth. While the low-hanging fruits of early improvements and growth in the and pollution abatement sectors might be harvested soon, comprehensive measuring and monitoring of pollution and energy consumption will be crucial to sustain the business opportunities that result from reducing carbon intensity.

3.4. Fostering the growth of green sectors

Green industrial sectors can play an important role in enhancing urban environmental conditions and present a promising source of growth. While the definition of green sectors is still in constant development,

for the case of China, key sectors that will be treated below are the circular economy (including pollution abatement), energy-saving equipment and services, and renewable energy technologies. Developing these sectors will on the one hand improve the aforementioned urban assets, such as constructed land areas and transport infrastructure, the urban built environment and urban air and water quality. On the other hand, these sectors significantly contribute to China's economic growth.

China enjoys a number of crucial conditions and assets to harness the growth potential of green sectors. Chief among them are abundant capital (both physical and human), a large domestic market, attractive conditions for foreign investment, and a large potential for commercialisation and R&D (World Bank and DRC, 2012). Key drivers for developing green sectors in China are internal environmental challenges and vast export potential for green technologies and services. During the past few years, green industries have expanded rapidly. In 2008, total value added from energy saving and environmental protection industries combined amounted to CNY 1.41 trillion, or 4.7% of national GDP. By 2008, 25 million people were employed in that sector, 18 million of whom were employed in the *circular economy sector* (CAIEECP, 2010). Rapid growth was also recorded for the renewable energy sector, particularly for wind energy technology. Installed wind power capacity in China grew from 2.6 GW in 2006 to more than 40 GW in 2010, driving up not only component manufacturing and turbine assembly industries, but also technology R&D, testing and certification, wind farm development and associated service activities (IEA and ERI, 2011). Renewable energy industries – wind, solar PV, solar thermal, and biomass – are estimated to employ close to one million workers, most of whom are in solar-thermal (600 000 jobs), followed by biomass (266 000) (UNEP/ILO/IOE/ITUC, 2008).

Beyond green sectors, green clusters have emerged in Chinese cities and could be an ideal target for promoting further development. A cluster is commonly defined as firms and other knowledge-producing agents in a geographically concentrated area with strong inter-linkages among them (OECD, 2007c). Quantitative evidence shows that many industries remain relatively concentrated in specific regions and that firms and research generators in proximity can outperform their counterparts located in less advantaged environments (OECD, 2007c). Ample discussion can also be found on the key role of cluster development in China. Zeng (2011), for instance, has estimated that 122 national designated development zones – *i.e.* a tract of green field land allocated to local governments to attract industrial investment and promote cluster development – accounted for 11.1% of China's total GDP and 29.8% of total exports. Green clusters have been on the surge over the past few years, due to strong production capacity along the value chain, *e.g.* a key characteristic of solar PV clusters. A PV cluster hosted in the Wuxi high-tech industrial development zone (Jiangsu), for instance, includes firms engaged in the entire industrial value chain, from polysilicon production to solar cell production and solar power application (Wu and Huang, 2010).

Industrial Parks and development zones, under the administration of related city governments, are the main levers that cities use to promote cluster development, including green clusters. In China, an industrial park or a development zone is a tract of land established within the jurisdiction of a prefecture and administered by a single city, which also administers the respective prefecture. Both industrial parks and development zones are considered as economic policies tools for similar objectives: to attract investment and support clusters. Development zones are usually designated by the national government and tend to be larger than IPs, which are normally designated by sub-national authorities. Various incentives (*e.g.* tax credits, cheaper land, and better physical infrastructure) are offered by the different entities (development zones and industrial parks) with varying levels of autonomy (*e.g.* flexible administrative procedures, specific supporting regulations), depending on the level at which they were designated; *i.e.* a national designation offers more incentives and allows for a higher degree of autonomy (OECD, 2010b). Until now, more than 200 national development zones and 1 300 provincial IPs, ranging from 1-15 square kilometres in size, have been set up (Yang, 2011; NDRC, 2007b). These figures would be much higher if the large number of industrial parks established by municipal, town, and township governments would be taken into

account. Green economic opportunities have motivated many local governments to establish various industrial parks and development zones in the aspiration to attract green investment and promote targeted green clusters. Table 3.5 and 3.6 present a (non-exhaustive) list of national and sub-national (Guangdong) development zones and industrial parks for promotion as green clusters. While all four clusters types have demonstrated considerable potential, policies have given particular importance to the circular economy and alternative energy related industrial parks.

Table 3.5. Examples of national designated development zones and industrial parks for green sectors

Green sectors	National industrial park
Pollution treatment	Eco-industrial parks (total number: 59 by end 2011, and plan to add another 50 by 2015) ISO14000 industrial park (total number: 32 by 2007) Environment protection industry park (total number: 8 by 2007)
Recycling (circular economy)	Circular economy industrial park (total number: 33 by 2011) Urban treasure demonstrative park (total number: 22 by 2011) Venous industrial park (total number: 2 by 2011)
Energy saving & alternative energy	No national designated park yet, but the pilot low-carbon programme has designated five provinces and eight cities to develop low-carbon economies

Source: NDRC (2012b), *NDRC website*, www.ndrc.gov.cn, accessed 24 February 2012; MEP (2012), *MEP website*, www.mep.gov.cn, accessed 24 February 2012.

Table 3.6. Selected green industrial parks, Guangdong province

Region	City	Industrial park name	Main investment attraction focus
Pearl River Delta	Foshan	Xinguangyuan demonstration base	R&D and production of green lightening
		Mingjie environmental tech cluster	Recycle and reuse, e.g. household electronic appliance, cars, metal and plastics
		Nanhai environmental tech base	Pollution abatement tech and equipment
		Nanhai energy saving service clusters	Energy service companies (ESCOs)
	Dongguan	Green energy industrial park	Producing solar panel and energy saving glass
		Tangsha environmental tech and equipment R&D and production base	R&D and production of pollution abatement equipment, recycling and dismantling equipment
	Shenzhen	Environment protection high-tech industrial base	R&D and incubators for enterprises in the environmental protection sector
	Jiangmen	Green lightening industrial base	Manufacturing MOCVD (metal organic chemical vapour deposition) and related products and LED
		Recycling and processing base	Recycle and process waste metals and plastics
	Zhaoqing	Asian metal re-processing base	Recycle and process waste metals and plastics
Huizhou	Recycling industrial base	Recycle and process waste cars, plastics, metals, paper, electronic appliances and hazardous waste	
Non-Pearl River Delta	Jieyang	Energy saving and environmental protection industrial park	Tire retreading
	Qingyuan	Circular economy industrial base	Recycling activities

Source: Guangdong Provincial government (2011), “广东省“十二五”节能环保产业发展规划 (2011 - 2015年)” (Guangdong's 12th Five-Year Plan on energy saving and environmental protection industries (2011-15), available at www.gdei.gov.cn/flxx/jnjh/zcfg/201111/t20111107_106085.html).

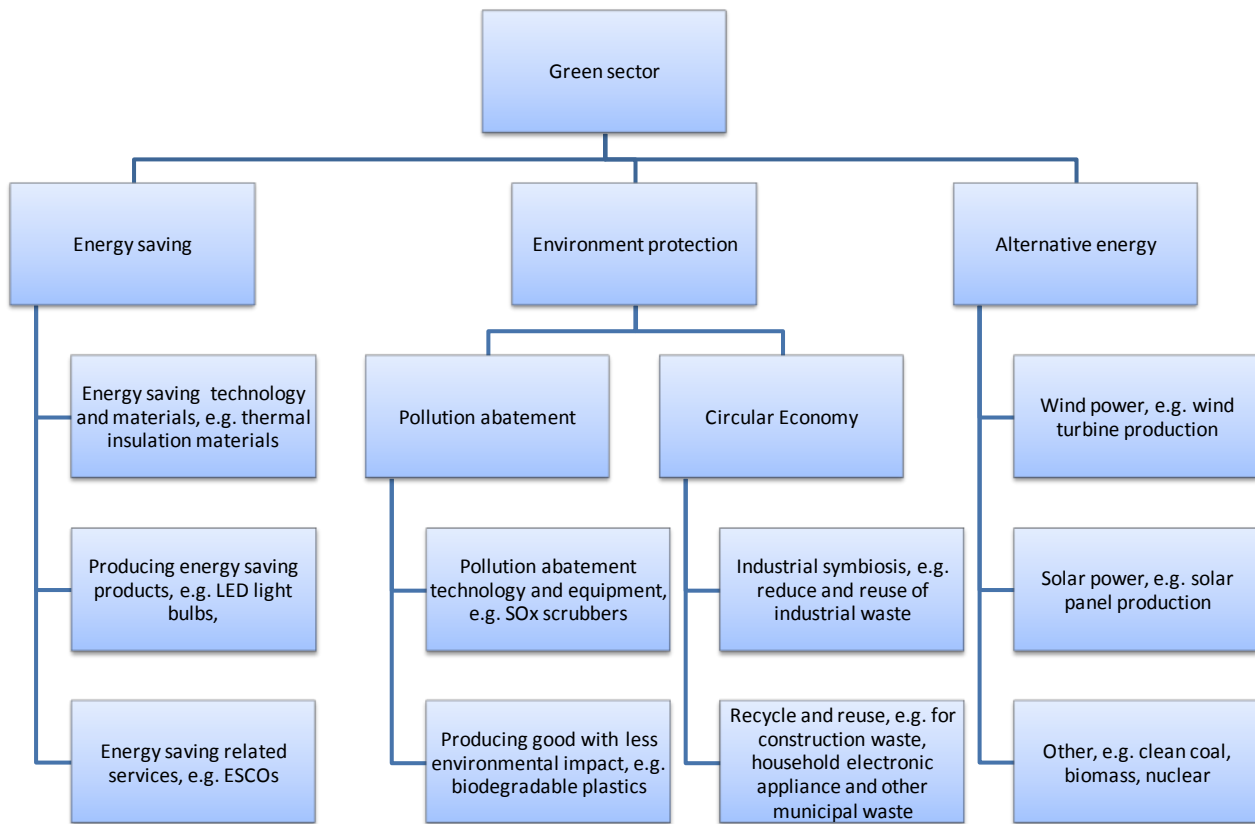
Besides cluster development, green industrial parks and development zones could become crucial elements of larger urban development plans. First, successful techniques and policy experiences from pilot

green zones could be replicated to a larger number of existing development zones and industrial parks. Good examples of resource saving, environmentally friendly national eco-industrial parks (*e.g.* Guitang Group park and Suzhou Industrial park) can provide valuable experiences for further establishment of similar parks (Zhang L. *et al.*, 2010). Nationally designated economic and technological development zones, have, for instance, borrowed eco-industrial park indicators to develop their environmental assessment criteria, as required by the Chinese Ministry of Commerce (Qiao, 2011). Green zones could also be integrated into functional urban areas. Initially, most development zones and industrial parks were set up far away and economically separated from their related urban core. Recently, however, an increasing number of these zones have become part of the new urban districts that have grown at the periphery of urban cores as a result of continuing influx of migrants over the past 30 years. The Tianjin Economic-Technological Development Area (TEDA), for instance, was established in 1984, 40 km east of the urban core. Since 2009, TEDA has been administered as a part of Tianjin's "Bin Hai New Area" district (State Council, 2009). In 2008, TEDA was one of the first five nationally recognised eco-industrial parks, due to its progress in eco-industrial development (Zhang, L. *et al.*, 2010). It shows the potential to integrate ongoing urbanisation and industrialisation via green industrial parks and development zones in urban functional areas.

The national framework provides guidance

National policy frameworks play a crucial role in exploiting the potential of green sectors (Figure 3.1), and green industrial sectors in China have received increasing attention in national strategies. The 12th national FYP (2011-15) defined seven targeted strategic industrial sectors, including green industries, among which are energy saving, environmental protection and alternative energy. Within these sectors the focus is on energy-efficient technologies and products (*e.g.* clean coal technologies), ESCOs, environmental protection industries, circular economy industries (*e.g.* recycling and reuse), renewable energy and production (*e.g.* wind and solar PV) and clean energy vehicles. Numerous policies and regulations have been promulgated relating to each specific sector. This "policy push" is expected to generate rapid growth in green sectors, *e.g.* 15%-20% annual growth in the energy saving and emissions reduction sector is estimated to occur over the 12th FYP period (CCICED, 2011b). This growth is also a result of previous investments China had made into green sectors through a national stimulus package, which included the world's largest green stimulus programme, accounting for almost 40% of the total USD 586 billion package (OECD, 2010e). These trends confirm China's aspiration to become the largest market for energy saving and emission reduction technologies and services, by scaling up and the diffusing green technologies and innovations, and by providing a basis for greener infrastructure and urbanisation processes (CCICED, 2011b).

Figure 3.1. Green sectors in China



Source: Adapted from CAIEECP (China's Association for Industrial Energy Efficiency and Cleaner Production) and China Energy Conservation Environmental Protection Group (CECEP) (2010), *Development Report of Chinese Energy-Saving and Emission-Reduction Industries*, China Water Power Press, Beijing.

Sectoral challenges and opportunities

One area presenting un-realised opportunities for green technologies is the waste and recycling sector. The recycling and reuse activities operated by a large informal scavenging sector are performing well, but raise concerns over unmanaged pollution problems. With rapid urbanisation and rising living standards, solid waste generation in many cities has grown rapidly. For example, municipal solid waste increased from 31.3 million tonnes in 1980 to approximately 212 million tonnes in 2006 (Zhang, D.Q. *et al.*, 2010).⁸ Massive construction and demolition activities have resulted in large amounts of urban construction and demolition waste, representing 30%–40% of total urban waste generation (Zhang, D.Q. *et al.*, 2010). Big parts of the solid waste consist of materials that could be recycled (*e.g.* steel, nonferrous metals, rare metals, plastics, rubber) or re-used (*e.g.* mechanical and electronic equipment, wires and cables, household appliance, automobiles, electronic products). Since privatisation efforts of waste services in 2002, the diversion of reusable and recyclable materials and products from the waste stream has contributed to one of the world's most robust informal scavenging markets, employing an estimated 18 million people across the country (CAIEECP, 2010). Individuals, households and businesses routinely divert valuable commodities from their own waste stream or public waste bins, selling scavenged materials to both formal

8. Most Chinese Municipal Solid Waste includes residential, institutional, commercial, street cleaning and non-process waste from industries, as illustrated by the World Bank (2005).

and informal networks of buyers. Thanks to the success of these private sector-driven initiatives, local and central governments tend to downplay the need for a formal curbside recycling programme. At the same time, the informal scavenging sector generates serious pollution problems. For instance, low-tech recycling methods in electronic waste have caused severe environmental pollution, causing high concentration levels of lead, poly brominated diphenyl ethers, polychlorinated dioxins and furans, as well as poly brominated dioxins and furans in air, bottom ash, dust, soil, water and sediments in the recycling areas (Sepúlveda *et al.*, 2010). The contaminated sites, in particular those in southern China, affect both the ecosystems and the people living within or near the main recycling areas, causing potential health risks (Wang *et al.*, 2011).

Government programmes that aim to strengthen the potential of the circular economy are facing the challenge of managing the large informal scavenging sector. Concerns over the scavenging sector's pollution as well as the potential revenue stream of solid waste management programmes have led to new policies and regulations. While a legal foundation was provided with the national Circular Economy Promotion Law in 2009, specialised industrial parks had already been put in place to promote recycling and reuse industries for over a decade. Three major types of industrial parks have been established, including i) the Venous Industrial Park, overseen by the Ministry of Environment Protection since 2001; ii) a resource recovery park where coexisting environmental technology companies produce "green products"; iii) the Circular Economy Park, overseen by the National Development and Reform Commission (NDRC) since 2005, aims at improving resource productivity and eco-efficiency, and focuses on building a resource-conserving, environment-friendly society; the Urban Minerals Park, overseen by the NDRC since 2010, targets materials that could be recycled and re-used (Zhao *et al.*, 2010). All these efforts address the environmental impact of waste generation, and aim to manage the informal scavenging activities while promoting recycling and stronger clusters. In reality, however, the informal scavenging sector has long been undercutting the business of industrial parks, *i.e.* diverting waste that could go to official industrial parks (Zhu and Zhang, 2008). While the desired effect of these growing programmes is to prevent the "theft" of materials from city-owned collection bins, they might also result in public backlash from the loss of scavenging jobs and declining incomes from waste commodities sales.

Renewable energy technologies have experienced exponential growth during the past few years, and prospects for future growth considerably drive further cluster development. The renewable energy sector has recently encountered problems arise from overlaps and duplications, as well as shrinking global demand (Xinhua, 2012). Nevertheless, the renewable energy sector, in particular solar PV and wind, still deserves attention due to its significant potential for emissions reduction and as a new source of growth. The IEA (2011a) foresees that wind power capacity will reach 200 GW by 2020, 400 GW by 2030 and 1 000 GW by 2050, meeting 17% of electricity demand. To achieve the above targets, total investments of CNY 12 000 billion in wind power are needed; this shift to and investment in wind will also result in considerable environmental and social benefits. Annual CO₂ emission cuts will amount to 1.5 billion tonnes in 2050, and an estimated 720 000 jobs will be created (IEA, 2011a). China's solar PV industry has grown rapidly over the past five years, and the country now ranks first in the world in exports of PV cells. Domestic output of PV cells expanded from less than 100 MW in 2005 to 4GW in 2009, accounting for more than 40% of global PV cell production. This is the result of a strong demand from the international PV market, especially from Germany and Japan. While the PV market in China remains still small, and more than 95% of the country's PV-cell products are exported, the 12th FYP includes a revised target for domestic PV capacity of 20 GW in 2020, up from the 1.8 GW target for 2020 fixed in the 2007 Renewable Energy Development Plan (IEA, 2010). In 2008, China's cumulative PV installed capacity was 150 MW (NEA, 2009). The spectacular growth of solar PV production has been performed by a relative small number of clusters, for instance the PV cells production in Wuxi High-tech industrial zone where the World's largest producer Suntech Power is located, and also the Turbine production in Urumqi Economic and Technology Development Zone where the world's third largest producer Goldwind is located (NDRC, 2012b).

With a growing number of industrial parks targeting renewable energy sectors, mainly solar PV and wind, competition among parks has been increasing. Although the scope for future growth of solar PV and wind is considerable, not all industrial parks are equipped with the necessary assets to become a competitive solar PV or wind technology clusters. The NDRC's 2010 designation of eight cities and five provinces as low-carbon development pilots initiated a boom of industrial parks targeting renewable energy sectors. All eight cities have announced or already implemented pilot projects with priority plans for the PV and wind industries. Solar PV and wind labelled industrial parks have been established not only in low-carbon pilot projects, but also in a large number of other cities. The industrial park initiative to attract renewable energy sectors is no different from the conventional approach to boost production and related supply chain companies through investment attraction, which in turn boosts jobs and contributes to fiscal revenue. While this rational explains why each city tries to develop local industries through establishing new green industrial parks, many cities seem to overestimate their ability to attract one or a few of the limited number of wind and solar PV firms in the currently highly competitive environment.

Intense competition between industrial park developments might cause overlaps and duplications, calling for improved co-ordination of industrial parks at the regional level. Given that each city, county or township authority wants to attract green industries to their managed industrial parks, there are in fact a number of planned or existing industrial parks specialised in similar activities located close within close proximity. In order to attract investment, these parks are competing with one another by building up infrastructure (*e.g.* roads, access to water and electricity) and targeting industrial sectors that could generate fiscal revenue and jobs. Solar PV and wind turbine production are the most targeted green sectors; however, since not all green industrial parks are able to attract the desired green industries, investments in infrastructure might result in inefficient overlaps and "duplications" at regional scale. Other duplications happen when small industrial parks work in the same sector and concentrate on the same phase of the production process (*e.g.* from the manufacturing of machineries to the production of specific parts and the assembly of the final products and commercial services) (OECD, 2010b). Better regional co-ordination could help avoid such duplications and contribute to healthier and more effective intra-regional competition.

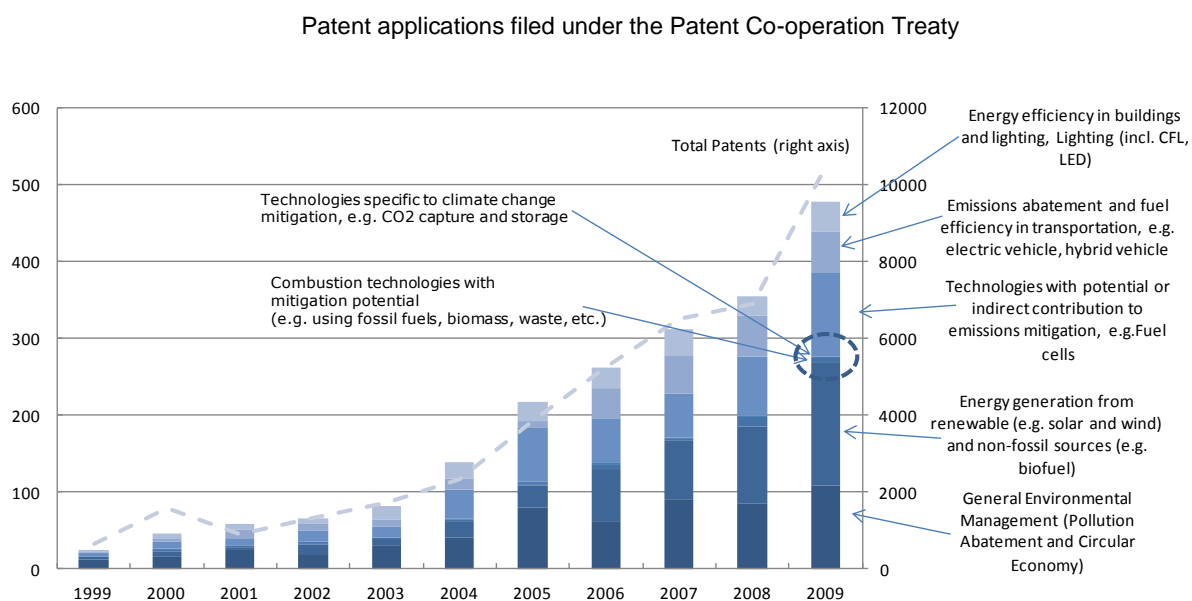
Eco-industry clusters have been growing alongside other relevant industrial parks, but have the potential to grow more within existing industrial parks and development zones. Eco-industry practices adopt the concept of industrial symbiosis, which operates by co-operative management of the resource flows of geographically clustered firms, in order to improve environmental performance and simultaneously decrease overall production costs (Zhang, L. *et al.*, 2010). The concept has been applied in several Chinese industrial parks, most notably through the eco-industrial park (EIP) programme. The EIP started in the late 1990s, with the main objectives to improve waste utilisation and strengthen pollution abatement during the process of industry development, and to guide the green transformation of industrial parks (Zhang, L. *et al.*, 2010). In a first step, the EIP programme designates candidates as "approved to construct an Eco-industrial Park". If the parks show sufficient progress, and successfully pass an acceptance test, they are nominated as an "Eco-industrial Demonstration Park". The first "Eco-industrial Demonstration Park" was approved for construction in 2001, and at the end 2011 the programme had awarded the title to 59 industrial parks, including 45 "approved to construct an "Eco-industrial park" titles and 14 "Eco-industrial Demonstration Park". While these trial practices have made good progress, efforts are needed to expand them. Moreover, this practice could also stimulate the greening of traditional industries, *e.g.* through SO₂ pollution abatement. Relocating scattered industries to industrial parks and treating pollution at the same site could offer opportunities for further investment in pollution abatement technologies, products and services.

However, moving these efforts forward face will not be without challenge: weak monitoring and enforcement of standards, especially at the level of authorities that manage development zones and industrial parks need to be addressed. At present, performance evaluation of local government leaders is

done via GDP growth related criteria, which are placed over environmental performance that in turn is only a minimum requirement (see Section 4). The OECD (2007a) found that local authorities sometimes colluded with firms to get around environmental requirements. For example, enterprises in China are able to escape the supervision of local Environmental Protection Bodies by asking local officials to sign permit documents without the approval of environmental administrations. Some local governments set up “umbrella” schemes, prohibiting the environmental enforcement authorities to inspect and impose/collect fees and fines from firms that are seriously polluting but are considered as being important to the local economy (e.g. providing tax revenue or employment). Such interference renders environmental enforcement ineffective and reduces the likelihood of compliance. On the other hand, weak institutions will discourage enterprises that hope to meet environmental requirements through investment in green technological or managerial innovation, hindering progress towards green growth. Market-based instruments are not substitutes for strong monitoring and enforcement, and successful implementation needs to be co-ordinated across levels of government (OECD, 2007a).

While the aspiration to develop green clusters is obvious, the difficulties lie in how to turn these green industrial parks and development zones into genuinely competitive clusters driven by innovation. Chinese clusters could become emerging global green innovation hubs, owing to two major factors: a supporting framework for green innovation, and a desirable destination for technology transfer and commercialisation. R&D expenditure in China accounted for 12% of global R&D expenditure in 2010 (CCICED, 2011b), and considerable research efforts have gone toward environmental innovation in recent years, as demonstrated by the rapid growth rate of patented environmental inventions (Figure 3.2). China has been forming a comprehensive policy framework for green innovation capacity building, even though it did not actually meet its R&D expenditure target, i.e. 2% of GDP (CCICED, 2011b). Three-quarters of the climate-mitigation technology transfers from the OECD area to the non-OECD area have been to China, and the transfer is greatest for solar PV and wind power technologies (OECD, 2011e; Hašičič *et al.*, 2010). This is particularly related to China's large market size, which makes China a favourable destination for investments in green technology applications and commercialisation (World Bank and DRC, 2012; CCICED, 2011b).

Figure 3.2. Green patents for selected climate mitigation technologies in China



Source: OECD patent database, accessed 24 February 2012.

Although national frameworks and funding mechanisms are often essential to foster sustainable green innovation, cities and regions can also catalyse green innovation. Sub-national governments are well placed to support green industrial parks and development zones and build up their innovation capacity. Policy measures include establishing eco-innovation networking platforms, promoting small pilot R&D projects, redesigning incentives mechanisms to target innovation in SMEs, developing green regional clusters and supporting research partnerships with universities (Hammer *et al.*, 2011). While limited literature is available to evaluate the innovation performance of green clusters, a number of Chinese cluster developments face the challenge of moving beyond production and up the value chain, as well as beyond relatively low technology levels and innovation capability (OECD, 2010b). Best practices from OECD countries might offer possible approaches to China for moving closer towards establishing well functioning regional eco-innovation system.

Local governments are best placed to identify local demand and adopt demand side policies to encourage green clusters to serve local markets, which in turn is likely to stimulate activities beyond production. While Chinese green clusters have made remarkable progress in boosting production capacity, not many are building capacities yet to go beyond production. The solar PV sector, for example, is focussed on producing first generation PV panels, and is almost entirely export oriented due the difference in profit margin levels between the domestic (lower) and international markets (US and EU; higher). This focus could prevent existing opportunities in the local market to serve as a catalyst for testing and adapting new products and services, stimulating innovation, increasing sophistication and scale. In order to tap the potential of the local market, demand side policies could help to bridge current gaps through public spending on green technologies, procurement policies that incorporate environmental conditions, government standards and labelling that guides individual and private sector consumption. Further, it could, raise awareness and provide incentives that lower barriers to green consumption (Hammer *et al.*, 2011). Local governments are best placed to choose appropriate policy instruments with regard to local conditions and respective technologies (Box 3.5).

Box 3.5. Some guidelines for demand side policies to support technologies

According to the OECD (2010a), the type of policy instrument most appropriate for supporting innovation will vary depending on where a technology is in its life cycle.

- For promising but immature technologies, government can support research and large-scale demonstration projects and assess the infrastructure and regulatory changes necessary to facilitate or hasten deployment. For example, microgrids (*i.e.* small-scale smart grid systems) are now being integrated into the grid in new ways at the neighbourhood level. Several pilot programmes – many with the active involvement of local government – have been established that will help inform technology standards and determine whether any regulatory reforms are required (Hyams *et al.*, 2011).
- For proven technologies that have yet to acquire significant private financing, governments may wish to provide technology-specific support mechanisms (*e.g.* feed-in tariffs) to jumpstart the market. Both Gainesville, Florida and the City of Los Angeles have begun to provide feed-in-tariffs to help boost deployment of solar PV technology on local rooftops.
- For alternative energy technologies that have become locally cost competitive but still lack market share, government can play a supportive role by promoting public acceptance/adoption and addressing other informational barriers. San Francisco's solar map website has been instrumental in documenting the efficacy of rooftop solar technology around the city, in addition to providing helpful information on subsidy programmes and the names of installers doing business in the city.

Source: Hammer, S. *et al.* (2011), "Cities and Green Growth: a Conceptual Framework", *OECD Regional Development Working Papers*, No. 2011/08, OECD, Paris; Hyams, M. *et al.* (2011), *Microgrids: An Assessment of the Value, Opportunities and Barriers to Deployment in New York State*. Prepared for the New York State Energy Research and Development Authority.

With China being a desirable destination for green technology transfer, sub-national governments could better harness technology spillovers. In order to do so, building sufficient absorptive capacity is crucial to enable both a wider pool of firms that innovate outside of big Chinese innovative companies and to harness spillovers from foreign companies that plan to commercialise their technologies in China. Small and medium-sized enterprises (SMEs) are still an undervalued source of innovation in China. A large number of sub-contracting SMEs have developed high productivity and technological capacities in specific manufacturing processes; however, they are reluctant to invest limited profits into R&D. Boosting the innovation capacity of SMEs will be essential for their survival and in order to create an innovation ecosystem. Innovation vouchers would be one way to help firms financing specific innovations. Such vouchers could also be targeted to foster university-industry collaborations. Collaboration between private sector and public research institutions might offer a problem-solving oriented approach to specific technical challenges. Also, vouchers could be used to promote knowledge transfers between the research and business community and speed up commercialisation of experimental research, *e.g.* in energy efficiency. Currently, spillovers and inter-firm exchanges are promoted via public knowledge centres, which still need to be improved, however, given the lack of financial and personnel resources and insufficient technical knowledge, motivation and awareness (OECD, 2010b). Models from OECD countries might give insights on how to expand the concept of knowledge centres (Box 3.6).

Box 3.6. Knowledge Transfer Networks in the United Kingdom

Main functions of the Knowledge Transfer Networks (KTNs) in the UK are to monitor and report on technologies, applications and markets to provide quality network opportunities and identify and prioritise key innovation-related issues and challenges. Knowledge Transfer Networks co-ordinated by a Technology Strategy Board build capacity for innovation by promoting exchange of knowledge within and between sectors, helping SMEs access funding and stimulating innovation in their communities. Knowledge Transfer Networks exist in the fields of technology and business application, including environmental fields such as resource efficiency and fuel cells.

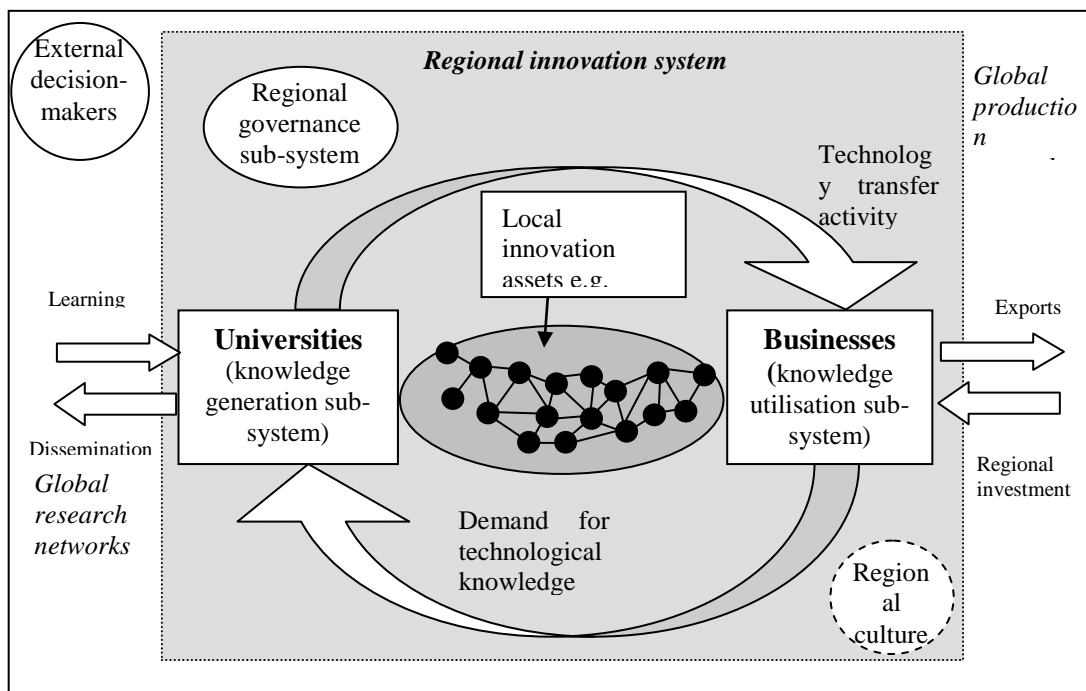
The activities of KTNs are increasing the depth and breadth of transfer of professional knowledge into UK-based businesses. A review of the KTNs in the UK found that 75% of business respondents rated KTN services as effective; 50% developed new R&D and commercial relationships with people met through these networks; and 25% made a change to their innovative activities as a result of their engagement within KTNs (OECD, 2010f). In view of the increasingly global nature of innovation, there will be an increase in the support given by KTNs to international activities.

Source: OECD (2010), *Eco-Innovation in Industry: Enabling Green Growth*, OECD Publishing, doi: 10.1787/9789264077225-en.

Chinese green clusters have the potential to facilitate eco-innovation and could develop into well functioning innovation ecosystems. In particular for green growth clusters, it is important to integrate a range of interconnected sectors rather than focussing on narrow sectoral definitions. There is evidence that innovations increasingly happen at the convergence of scientific fields and technologies. This convergence requires spaces for interaction and cross-fertilisation of different knowledge domains. This is integrated into the concept of an *innovation ecosystem*. Therein, innovation is considered to be a result of the interaction between a series of public and private actors, both individual (entrepreneurs) and institutional (universities, research centres, big firms, small start-ups, governments) in a given geographic space. The necessary linkages are usually sustained through *innovation networks*, which also extend to related actors in other ecosystems, beyond the boundary of a given geography (Figure 3.3). These clusters successfully bring together the following into a functioning system: excellence in education, frontier research in environmental technologies and job creation through spin-offs, venture capital and integration of enterprises. Within the cluster, proximity and complementarities generate the critical mass to sustain

industrial development in novel and risky fields (Hammer *et al.*, 2011). In the OECD, clusters specialised in eco-innovation are not yet as common as in other industries, despite their viability in the context of very promising market commercialisation opportunities, as demonstrated in a few successful examples (Box 3.7).

Figure 3.3. Regional innovation ecosystems



Source: OECD (2012), *OECD Territorial Reviews: The Chicago Tri-State Metropolitan Area, United States 2012*, OECD Publishing, doi: 10.1787/9789264170315-en.

Box 3.7. Successful eco-innovation clusters

The Milwaukee Water Council demonstrates the value of thinking in terms of an innovation ecosystem as it operates under the premise that gains in one aspect of the water sector (e.g. water distribution and treatment) could have significant knock-on benefits in other related business sectors (e.g. pump and pipe manufacturers) and even in areas where there might be a much more tangential relationship (e.g. water-related toys/recreation). Similarly, one could imagine in the buildings sector a situation where the Energy Impact Illinois programme is expanded to serve as a convening mechanism, bringing together architects, engineers, financial institutions, university researchers, energy technology firms and installers to systematically examine how retrofit projects could promote made-in-Illinois technology or building materials. All would theoretically benefit from a comprehensive strategy promoting new green building construction or building retrofits, but the level of growth in any individual sector would obviously depend on the particular green building policies that are pursued.

The Lahti Cleantech cluster in Finland encourages innovation and development of environmental technologies by bringing together small and large enterprises, educational organisations and regional authorities. As a result, 20 new clean-tech companies have set up in the Lahti region, and the project has attracted more than EUR 30 million in total investment. In the Rhône-Alpes Region of France, regional and national investments in R&D were instrumental to the development of the Tenerrdis competitiveness cluster, which promotes scientific collaboration to develop clean technologies applied to construction, transport and energy production. Tenerrdis brings together 185 stakeholders, who developed 226 R&D projects between 2005-08 for a total of EUR 440 million of investments, of which EUR 200 million came from public funding.

The Solar Valley Mitteldeutschland is a solar industry cluster in central Germany, which combines industry, research institutions and universities working on solar PV. The cluster unites 35 global firms, 9 well known research institutions, 5 universities, as well as colleges and other education institutions; together they work on the whole PV value chain. The cluster is part of three states – Saxony, Saxony-Anhalt and Thuringa – that have been awarded with “cluster of excellence” label and receive funding from the Ministry of Research and Education. The cluster is headed by a “cluster board”, which co-ordinates all solar PV activities in the region and decides on strategic issues, including the allocation of resources. The objectives of the cluster are to reduce the cost of solar electricity through technological innovation, to offer high-level education, and to attract national and international investments. In view of providing the growing solar PV industry with qualified workforce, the focus is on research, and in particular on the link between education and professional formation. Several masters’ courses and eight academic chairs have been established with the help of private foundations, as well as a centre of excellence for professional higher education. In addition, a Solar Valley Graduate School for Photovoltaics was launched in co-operation with multiple universities and research institutions, and a first Solar Valley summer school for graduate and PhD students was organised in September 2011.

Source: OECD (2012), *OECD Territorial Reviews: The Chicago Tri-State Metropolitan Area, United States 2012*, OECD Publishing, doi: 10.1787/9789264170315-en.

3.5 Policy conclusions

The 12th FYP sets out ambitious targets for green development and urbanisation. Four key urban sectors – land use and transportation, buildings, water and air quality, and green technology sectors and clusters – can play an important role in meeting these targets. To make the most of this potential, national government officials could take the following into consideration:

- *Addressing the role land sales play as main source of local government revenue.* Cities should consider diversifying their revenue streams to become more independent from land sales and leases. This will not only make public finances more sustainable, but also allow for taking a more active role in spatial urban planning. Possible funding sources could be congestion charges or value-capture taxes. The central government can also play an important role in providing funding and technical assistance to cities and regions.
- *Lowering the barriers to residential energy-efficiency retrofits.* Thus far, in part for logistical reasons, the bulk of government subsidies for retrofits have been oriented at public buildings.

Expanded public education is needed to ensure homeowners understand the need for efficiency improvements, and what they can do to achieve them. Local Energy Conservation Supervision Centres can play a key role in supporting these efforts, but will likely require additional resources to do so. Applying common standards to ESCOs (in terms of services offered and minimum energy savings achieved), by drawing on lessons learned from pilot projects and international best practices, could increase consumer confidence in this sector and thus result in a wider deployment of energy-efficiency retrofits.

- *Improving overall building quality.* While green development targets have focused on increasing the energy-efficiency requirements in building codes, the central government could consider reviewing quality requirements in building codes, with the goal of increasing building lifespans. This would significantly reduce the energy and waste associated with construction and demolition activities.
- *Focusing on water demand management.* While current efforts to improve water quality and to avoid scarcity through supply-side measures such as water treatment are crucial, much more could be achieved if such measures were jointly implemented with effective demand-side policies. High-income countries have successfully reduced their consumption through economic instruments (pricing, new allocation mechanisms, switching from abstraction to consumption), technical measures (water metering, saving, and reuse), and information dissemination (public awareness campaigns and education). Chinese regional and local governments should design appropriate schemes and introduce energy saving products to meet the challenge of rising demand. Tariffs should be designed with respect to low-income groups, and possibly include subsidies for the poorest part of the population.
- *Further experimenting with regional trading schemes and encouraging cities to go beyond national standards and targets.* In a context of a comprehensive and ambitious national framework, regional trading schemes should be further experimented with and scaled up if successful. Market instruments hold the potential to be more powerful and dynamic than command-and-control measures, and might be more effective in triggering innovation.
- *Offering incentives to reduce emissions.* The central government is in a position to stimulate a “race to the top” with respect to environmental performance, by providing incentives to cities to exceed emissions targets. Local governments might be more effective if they have more authority to monitor and enforce local standards to attain compliance.
- *Adopting targeted demand-side policies for renewable energy exploitation.* In addition to national programmes and incentive frameworks, local governments could consider introducing additional regional standards, targeted measures and incentives to exploit regional renewable energy potential and to harness the benefits of green technologies to spur dynamic local markets. Possible measures and policies could include public spending, green procurement policies that incorporate environmental conditions, government standards and labelling that guide individual and private sector consumption, and information and incentives that lower barriers to green consumption.
- *Accelerating the application of eco-industrial park best practices in industrial parks and development zones.* Several measures could be considered to scale up eco-industrial park approaches to all industrial parks and development zones, including the introduction of pollution abatement technology, stricter environmental standards, ambitious energy-efficiency targets, and promotion of circular economy approaches. Also, a strategy for relocating small, scattered firms into eco-industrial parks could lower costs of monitoring and assuring compliance with standards, improve environmental efficiency and allow for synergy effects. An appropriate tool for implementing coherent standards may be a roadmap, outlining different increasingly ambitious standards and phases of implementation.

4. STRENGTHENING GOVERNANCE TO ADVANCE AN URBAN GREEN GROWTH AGENDA

Governance is essential to help advance an urban green growth agenda, by directly addressing the environmental challenges and harnessing growth opportunities that are concentrated in rapidly urbanising cities. The 12th Five-Year Plan (FYP) includes more environmental targets compared with earlier plans, and attaining the targets will require implementation at the sub-national levels, which will require the introduction of effective governance mechanisms, including: providing guidance on national targets to sub-national stakeholders, providing adequate funding to support implementation, streamlining inter-department co-ordination to promote better policy integration, instituting monitoring and reporting systems, ensuring sufficient local official capacity to carry out implementation, and encouraging inter-jurisdictional collaboration. This section will first briefly describe the institutional mechanisms across government levels, followed by a detailed diagnosis of six governance gaps that may hinder implementation. Recommendations to help national governments improve the governance mechanisms are provided at the end of the section.

4.1. Policy guidance and resource allocation are the central government's main tools for assuring compliance

In China's hierarchical power structure, power is shared across multiple levels of government through ongoing negotiations over changes to functional responsibilities. Functional responsibilities are delegated from the central government (first tier) to:

- Provincial governments (second tier)
- Prefecture-level cities (third tier)
- Districts (which only exist in prefecture-level cities), counties and county-level cities (fourth tier)
- Towns, townships, and neighbourhood committees (fifth tier) (Box 4.1).

Provincial governments, in particular, have wide formal regulatory powers (*e.g.* policy, standards, oversight), and city governments (at the prefecture and county level) provide services that implement most functional responsibilities (Table 4.1). Changes to functional responsibilities come when the scale of public service provision needs to be increased (*e.g.* population increase due to large influx of migrants) or new types of services need to be provided (*e.g.* infrastructure to reduce vulnerabilities to climate change). The allocation of additional functional responsibilities requires negotiations between central and provincial tiers, and subsequently between the provincial and municipal levels. The negotiating process enables the additional responsibilities proposed by the central government to reflect the interests of sub-national governments, making it easier to obtain their compliance.

Box 4.1. The institutional mechanism in China

China has been a unitary centralised state since 1949, with four sub-national levels. These include provinces; prefectures; counties/districts; and towns, townships and sub-districts.

Since the 1990s, the central government has devolved authority to lower local levels of government, resulting in a shared governance structure. Provincial-level governments oversee regions with populations similar to that of a large European county. Provincial governments enjoy substantial power: they set up the provincial development plan and budget, and exercise control over the economy, education, sciences and culture, public health, finances, and public security, among other responsibilities. City governments (at the prefecture and county level) carry out more concrete responsibilities, including urban planning, market supervision, granting land-use rights, education, infrastructure construction, street cleaning, collection of solid waste, and the operation of local government-owned enterprises. In addition, China's administrative structure is also represented through its legislative bodies: a People's Congress exists at each government level and provides guidance and supervision to the corresponding government. For instance, the People's Congress in each prefecture-level and county-level city, together with its standing committee, is responsible for approving the decision of major local affairs (including budgeting), and for the appointment and removal of mayors.

Relationships between different tiers of government agencies in China are largely structured along sectoral lines. There is almost a complete replication of functional agencies from the central to provincial and municipal levels: central ministries have their counterparts at the provincial level, which are mirrored in prefecture-level and county-level cities (e.g. a City Finance Bureau communicates with relevant Provincial Finance Bureau, which in turn communicates with the Ministry of Finance). While these agencies are expected to respond to directions from senior government executives at the same level, they are also required to comply with the decisions and guidelines of higher-level agencies. Despite this multi-tiered authority, all levels of government and agencies are subordinate to the State Council, as set out in the Chinese Constitution. In particular, only the State Council can approve the establishment of a new district, county or city governments.

Source: Kamal-Chaoui, L., E. Leeman and Z. Rufeï (2009), "Urban Trends and Policy in China", *OECD Regional Development Working Papers*, No. 2009/01, OECD, Paris; OECD (2010), *OECD Territorial Reviews: Guangdong, China 2010*, OECD Publishing, doi: 10.1787/9789264090088-en.

Table 4.1. Generalised functional responsibilities related to green development in China's cities

	Central government	Provincial government	City government
A. Financial Management			
Revenue Generation			
1. Tax Base & Rate Definition			
2. Setting Charges			
3. Tax Collection			
4. Grants			
Budgeting			
1. Budget Setting			
2. Budget Approval			
B. Economic Development			
1. Policy and Planning			
2. Development Zones			
3. Subsidies			
C. Land and Buildings			
1. Land use planning, leasing, allocation, etc.			
D. Transportation Infrastructure			
1. Inter-city roads and bridges			
2. Inner city roads and bridges			
3. Parking			
4. Public transit services			
5. Traffic management			
E. Power and Gas Infrastructure			
1. Power generation			
2. Power distribution			
3. Gas supply			
F. Environmental Infrastructure			
1. Water treatment & distribution			
2. Wastewater collection & treatment			
3. Drainage + flood control			
4. Solid waste collection & disposal			
G. Environmental Management			
1. Environmental planning, pollution monitoring, enforcement			
	Policy, Standards, oversight		
	Provision of service		
	Both types		

Source: OECD, adapted from Figure 21 in Kamal-Chaoui, et al. (2009), "Urban Trends and Policy in China", *OECD Regional Development Working Papers*, No. 2009/1, OECD, Paris.

The central government has four main mechanisms to influence sub-national governments. The first two are the most important and will be covered in more detail below.

1. *Policy targets*: These are central government directions that all levels government are required to follow. The main vehicle for policy targets is the FYP, which usually sets both binding and voluntary targets.
2. *Resource allocation*: Higher levels of government can intervene in local development by providing direct investment, transferring funds (e.g. grants and subsidies), and allocating constructed land quotas.
3. *Personnel appointment and removal*: Through the local People's Congress, the head of a lower level of government is usually proposed and appointed by its counterpart (and Party Committee) in the next-higher level of government. Therefore, the intentions of the higher tier must be taken into consideration to some extent.
4. *Administrative orders*: Higher-level decisions and commands are required to transfer or withdraw powers. For instance, the central government has the administrative power to disapprove and stop local investment decisions in high energy-consuming and high polluting industries. The aim is to adjust industrial structure to switch to industries with low level of either energy consumption or pollution.

Policy targets are the most influential means that central government adopts to promote green development. Environmental targets (binding and voluntary) are set in the national FYPs. The effectiveness of binding targets is guaranteed by personnel appointment and removal, which is referred to as the target responsibility mechanism. The central government allocates targets in national FYPs to sub-national levels through negotiations. Once agreed upon, the targets are used as a "one-vote veto": failing to achieve the targets will result in the removal of the local government's leading officials. This provides strong incentives for local governments to meet targets. For instance, the allocated energy-saving targets (reduction in energy consumed per unit of GDP) in the 11th national FYP motivated provincial governments to integrate the targets into their provincial FYPs, which were approved by the provincial People's Congresses (State Council, 2007). Likewise, provincial governments allocate their respective targets to the prefecture level by signing similar target responsibility agreements that allow the provincial governments to remove mayors who fail to meet the targets. During 11th FYP period, the Guangdong provincial government received the energy-saving target of 16% and allocated differentiated targets to its 21 prefecture-level cities (PLCs), with the highest targets of 20% allocated to Guangzhou, Foshan, Shaoguan and Dongguan, and the lowest targets of 13% allocated to Shenzhen, Huizhou and Zhanjiang (Guangdong Provincial Government, 2006). The target responsibility mechanism can also apply to enterprises, as in the case of the "A Thousand Enterprise Programme", which targeted energy savings in about 1 000 of the top energy-consuming firms in China. Awards are given to top performers, and firms failing to meet the targets could expect to have difficulties in getting approval for bank loans or land for expansion.

A second key mechanism for assuring compliance is resource allocation, which complements the policy targets. To support the development of a green economy, the central government provides direct investments to local government projects meeting certain criteria, and allocates specific funds for which local governments can apply. During the 11th FYP, the central government allocated CNY 89.4 billion for direct investments and CNY 133.8 billion in specific funds for energy saving and pollution abatement (Xinhua News, 2011). Central government direct investment has been mainly used to subsidise local government investments, such as covering 6%-8% of the investment cost to renovate coal-fired industrial boilers (kilns). Specific funds are granted as rewards rather than subsidies. For example, retrofit and

metering reform projects in northern China were rewarded using specific funds at a rate of CNY 45-50 per m² (Xinhua News, 2011). In both cases, the central government money only covered a portion of project costs. The remaining costs must be paid for by local government matching funds, bank loans or private-sector investment. Nonetheless, central government funding of building retrofits (for changing metering equipment and installing insulation, energy efficiency, and renewable energy technologies) over the 11th FYP period (CNY 15.2 billion) exceeded the combined funding provided by provincial governments (CNY 6.9 billion) and prefecture-level governments (CNY 6.5 billion) (MHURD, 2011c).

4.2. Addressing potential gaps in the multi-level governance of green urban development in China

National government policies can support or undermine urban green growth initiatives. It is important to identify and remove perverse incentives so as to encourage urban policies that are in line with national goals. The need for policy coherence implies a need to understand the distinct contributions to green growth policies that different levels of government can make. The national framework is particularly important for setting the pricing signals to discourage environmental externalities, such as greenhouse gas emissions. Concerns about distributional consequences should be addressed through national regulations, particularly the tax and benefit system, rather than trying to ensure that each individual policy measure fulfils both environmental and equity objectives. A strong national framework based on a carbon tax or price will broaden the range of environmentally effective options available to cities. If national policy settings are not supportive, some seemingly desirable city-level initiatives may have limited effect or even generate perverse outcomes. With a strong national framework in place, much can often still be done most efficiently at the level of regions or cities. For example, policies to ensure adequate skills in making existing buildings more energy efficient or for encouraging clusters of green industry are probably best designed at city level. Even if there is a national framework in place, there must still be considerable scope for place-specific adaptations, since information about local conditions can be crucial to the effectiveness of such efforts. The same is true of policies dealing with urban form and the built environment: while national standards may be needed, much depends on the nature of the existing buildings in a given place, the materials available and the framework for zoning and land use (OECD, 2013a).

The Chinese central government has been paying increasing attention to environmental issues, and adopted different instruments to enforce or facilitate local implementation. Nevertheless, the Chinese institutional structure presents governance challenges that may hinder delivering a coherent response to current economic and environmental pressures. According to the OECD Multi-level Governance Framework for Green Growth (Hammer *et al.*, 2011; Charbit, 2011), six major governance gaps can be observed and diagnosed in the context of green development in cities, in terms of objectives, funding, policy, capacity, information and administrative boundaries (Table 4.2). The governance gaps are analysed in each field and policy recommendations for gap are identified following the table.

Table 4.2. Governance "gaps" for delivering green growth in Chinese cities

Type of gap	Description	Occurrence in China
<i>Objective gap (vertical)</i>	Occurs when diverging or contradictory objectives between levels of government or departments/ministries compromise the adoption of convergent targets over the long run.	The dual economic and environmental development aims can lead to conflicting objectives, especially between national and sub-national levels. This has been primarily the result of the performance evaluation of local officials, which emphasises economic and industrial development.
<i>Funding (or fiscal) gap</i>	Unstable or insufficient revenues discourage sustainable investment and undermine co-ordinated governance. Mobilising private capital could be difficult given the possible disconnect related to the return on green investment requirements and the actual payback.	Most green development initiatives have been heavily financed by the central government. Local governments are facing increasing pressure as spending assignments tend to outweigh fiscal revenues. Without clear national standards or price signals on carbon and other resources, the private sector is wary of green investment or participation in the emissions trading market.
<i>Policy and administrative gaps (horizontal)</i>	Horizontal fragmentation of green development tasks amongst government ministries and agencies hinders integrated policy development. A geographical mismatch exists between functional economic linkages and geopolitical/ administrative boundaries.	Fragmentation of urban policies in general exists at the central level in China. For example, three national ministries have overlapping responsibilities in spatial planning. This applies also to green development related tasks involving different ministries and agencies, such as those related to transportation infrastructure and planning. At the urban scale, there is also a need to harmonise emerging green development policies, and integrate separate plans for municipal economic development, spatial development and sectoral development. The problem is particularly acute in rapidly urbanising China with the emergence of large metropolitan regions and regional urban systems. Existing administrative boundaries do not always correspond to functionally integrated economic regions and the environment impact, e.g. making it difficult to address water (e.g. upstream and downstream) and air pollution sources (e.g. in the transportation sector) that are generated across administrative boundaries.
<i>Information gap</i>	Lack of systematic information sharing across ministries, between levels of government and across local actors involved in specific policy areas.	Inconsistent or non-existent methodologies for establishing local emissions inventories (e.g. carbon) or monitoring pollution levels and resource use hamper the ability of cities to assess progress toward green development over time and across locations.
<i>Capacity gap</i>	The capacity gap is particularly acute to issues related to environment and green growth. There could be insufficient scientific and technical expertise, know-how and infrastructure to design and implement policy.	A lack of expertise in integrating environment and economic policies at the local level (especially in small and medium-sized cities) hinders the effective implementation of green growth strategies at the urban scale.

Source: OECD, adapted from Hammer, *et al.* (2011), "Cities and Green Growth: A Conceptual Framework", *OECD Regional Development Working Papers*, No. 2011/08, OECD, Paris.

Addressing the objective gap: the need to better assure compliance with environmental targets and to incentivise “a race to the top”

The negotiations over additional green responsibilities reflect the mismatch between the socio-economic development objectives of the central government and the sub-national stakeholders. The central government has attached increasing importance to environmental issues, through introducing ambitious environmental targets, promulgating regulations and providing economic incentives. On the other hand, local governments perceive a conflict between economic growth and environmental targets. For instance, industrial development and urban construction are drivers of urban economic growth, but they are also major energy-intensive consumers; introducing an energy-saving target will place constraints on the two sectors thereby potentially limiting their contribution to local economic development. Therefore, many local authorities seek an energy-savings target lower than the national average. During the target allocation period of the 12th FYP, the central government had to negotiate endlessly with provincial authorities to ensure that provincial targets were in line with tougher national energy-saving targets and slower national GDP growth targets. Similar issues re-occurred when provincial governments allocated targets to prefecture-level cities. (ISPRES, 2012)

The performance evaluation of local officials is in large part responsible for the mismatch between economic and environmental objectives at the sub-national level. The past performance evaluation metrics for local officials were centred solely on economic growth and job creation, the results of which were linked to the careers of local government officials. For example, opportunities for promotion increased significantly with good economic performance (OECD, 2007a; Li & Zhou, 2005). Such political incentives generated dynamic regional competition for economic growth and investment attraction, while local governments tended to ignore or violate national environmental regulations (Marquis *et al.*, 2011; Zhang, J. 2008; OECD/CDRF, 2010).

Despite recent changes in the 11th and 12th FYPs to include more environmental priorities, economic performance still holds a predominant role in performance evaluation of local officials. Performance metrics of local officials have started to include environmental targets, especially after the ratification of the *Scientific Development Concept* in the Chinese Communist Party's Constitution in 2007. For instance, the *Comprehensive Evaluation Method for the Leading Party and Government Officials (pilot)* (2009) categorised quantifiable performance evaluation into three pillars: economic development, socio-development and sustainable development (Table 4.3). However, while environmental indicators have been included, economic development indicators have a greater impact on officials' performance ratings. While officials must meet energy-saving and pollution abatement targets to remain in office, exceeding these targets would not improve their performance rating, nor would it compensate for poor GDP growth (Li *et al.*, 2011).

Table 4.3. Quantifiable performance evaluation metrics for local officials (pilot programme)

	Performance evaluation factors	Examples of indicators
Economic development	Level of economic development	GDP
	Economic development comprehensive benefits	Percentage of tertiary sector
	Urban and rural household incomes	Urban household disposal income
	Regional economic development disparities	Gini coefficient
	Cost of development	Total energy consumption
Socio-development	Basic education	Coverage rate of secondary education
	Urban employment	Urban unemployment rate
	Health care	Universal health care coverage
	Cultural life in urban and rural areas	Number of cultural activities
	Social Stability	Crime rate
Sustainable development	Energy saving and environmental protection	The completion of allocated energy saving target
	Ecological construction and farmland resources protection	Total amount of arable land
	Population growth and family planning	Following one child policy target
	Science & technology investment and innovation	R&D investment as a share of GDP

Note: this table only includes indicators that can be quantified and does not include evaluation factors based on surveys of the general public that cannot be quantified.

Source: OECD adaptation from the Organization Department of the CPC Central Committee (2009), "Comprehensive Performance Evaluation Method for the Leading Local Party and Government Officials", Document No. 2009.13, Organization Department of the CPC Central Committee, Beijing.

Practices that promote economic growth at the cost of environment can be found in particular in the areas of land use, energy saving and pollution abatement. For example, the national *Decisions of Deepening the Reform of Land Administration* allows local governments to convert agriculture land into industrial/construction purposes (typically at the urban fringe) if they provide compensation through cultivating new agriculture land or converting collective residential land to agriculture land (known as "balanced occupation and compensation"). However, local governments have insufficiently complied with or actively violated national guidelines in numerous instances, e.g. not compensating a sufficient amount or compensating only less fertile agriculture land in remote areas (MLR, 2008; MLR, 2010). Regarding assuring compliance with energy savings targets, some provincial and city governments have provided preferential electricity prices to high-energy consuming firms without the permission of the central government (State Electricity Regulatory Commission, 2010). Efforts to assure compliance with environmental laws and assess environmental impacts have also been weak in some economically lagging small cities. In particular, implementation officers face the possibility of being removed from their posts if the environmental regulation enforcement seriously affects high-polluting firms that are closely linked with local leading officials (OECD, 2007a). On some occasions, particularly during the 2008 stimulus package period, the environmental impact assessment has not been fully enforced, or it has been bypassed for large-scale projects that generate tax revenue and create jobs (NAO, 2011; ISPRES, 2012).

Improving compliance with environmental targets would require overcoming personnel and funding challenges, and discouraging short-term fixes. Despite recent improvement (Table 4.4) there has long been a severe lack of implementing officers at the sub-provincial levels, which weakens the enforcement and implementation of environmental targets in the target responsibility system (MEP, 2010; OECD, 2007a; Li *et al.*, 2011). For instance, in Wuxi city (6.4 million inhabitants), only one part-time officer is responsible for the implementation of 11th FYP energy target (Li *et al.*, 2011). In addition, economically lagging cities and counties also do not have the financial capacity to provide matching funds to support the technical upgrade of firms, especially small and medium-sized enterprises that are most in need of energy-efficiency improvements. In addition, these city and county governments tend to relax the targets for the large firms that constitute the pillar for local economic development. Finally, the target responsibility system

encourages local governments to prioritise short-term solutions that might have long-term negative effects. For example, during the 11th FYP period, cities facing difficulties in meeting the energy-saving targets adopted short-run measures such as cutting the electric power supply to factories, residents, hospitals and even traffic lights. These kinds of approaches may only result in short-term achievements but not long-run solutions.

Table 4.4. Environmental implementation capacity at different government levels, 2005-10

Measured by the number of agencies and personnel

	Number of agencies		Number of personnel		Number of personnel per agency	
	2005	2010	2005	2010	2005	2010
National	41	43	2 452	2 584	59.8	60.1
Provincial	344	371	10 616	12 427	30.9	33.5
Prefecture-level city	2 019	1 937	42 880	42 462	21.2	21.9
County	7 655	8 606	106 339	12 9284	13.9	15.0
Township	1 469	1 892	4 487	7 154	3.1	3.8

Source: MEP (Ministry of Environmental Protection) (2011), 2010 Annual Statistic Report on Environment in China, China Environmental Science Press; MEP (2006), 2005 Annual Statistic Report on Environment in China, China Environmental Science Press, Beijing.

Differentiated evaluation represents one promising change to the target responsibility system. The National Comprehensive Spatial Plan was introduced in late 2010 and classifies all land in China into four different types of “functional classified zones” according to the region’s resources, environmental carrying capacity, development intensity and up-tapped potential: i) “optimised development zone”, ii) “key development zone”, iii) “restricted development zone”, and iv) “prohibited development zone”. Each zone is assigned different development targets. One of the driving concerns behind the differentiation of these zones is to ensure that local governments respond to different sets of incentives, rather than just the objective of promoting GDP growth. The National Comprehensive Spatial Plan (State Council, 2010) states that regional policies and performance evaluation will be determined according to the principal functional classification. For example, restricted development zones emphasise environmental protection targets and de-emphasise economic growth, industrialisation and urbanisation targets. Moreover, the functional zoning classifications can serve as the platform to co-ordinate different sectoral policies, such as financial policy, investment policy, industrial policy, land policy, and population management policy. However, the system of differentiated targets for different zones has not yet been implemented, and therefore compliance with them cannot yet be evaluated.

The central government could further reform the target responsibility system to promote a “race to the top” on environmental targets. The Chinese central government may consider creating the conditions within which cities can compete based on environmental targets. For example, the Japanese government has introduced the recognition of an “Environment-Friendly Model City” as a means to share best practices relating to the promotion of compact urban form and lower greenhouse emissions among urban centres across Japan. The first urban centre to receive the designation was Kitakyushu city in 2006 (OECD, 2010d). In the United States, state-level governments are pursuing Renewable Portfolio Standards, which provide targets for the share of electricity coming from renewable sources, because they are seen as an economic development strategy for increasing renewable energy jobs and energy security (Rabe, 2006).

Addressing the financial gap: diversifying funding sources and fine-tuning economic incentives for the private sector

Sub-national governments in China are struggling to meet the funding demands of green urbanisation targets. Chinese local governments, especially those at prefecture-level city and county levels, face

financing gaps and are heavily responsible for providing basic public services (e.g. education and health care) (Table 4.5; OECD, 2013b). Limited financial capacity constrains local governments' fiscal autonomy and their ability to respond to higher-level policy priorities. Financing gaps are generally compensated by central government transfers, which include direct investment and specific funds for energy savings and pollution abatement. However, central government funds only covers a portion of project costs, and local governments are required to provide matching funds. Therefore, expanding expenditure to support green projects poses a challenge for sub-national government tiers already under financial stress. For example, the central government not only encouraged local governments to enhance financial support for energy-efficiency retrofitting of existing buildings, but also intensively praised locals governments that offered more matching funds (Zhang, S.C., 2011). The effectiveness of this approach was nevertheless limited, as evidenced by the continuing slow pace of building energy-efficiency retrofits since local governments do not have the capacity to provide sufficient matching funds (Levine, 2011).

Table 4.5. Total government expenditure and revenue of different tiers, % of national GDP, 2009

	Central	Sub-national				
		Total	Provincial	Prefecture	County	Township
Total Government Expenditure	5.3%	24.1%	5.1%	7.4%	10.3%	1.3%
Total Government Revenue	11.4%	16.3%	3.6%	6.1%	5.4%	1.2%
Difference between Expenditure and Revenue	6.1%	-7.9%	-1.5%	-1.3%	-4.9%	-0.1%

Note: The difference represented by negative percentages is financed by transfers. The larger the gap, the more a sub-national government relies on transfers, thereby potentially limiting their fiscal autonomy.

Source: Ministry of Finance (2011), *Local Fiscal statistical yearbook of China 2009*.

Cities have responded to budget constraints and increasing environmental responsibilities by pursuing land sales, which has contributed to urban spatial expansion and undermined environmental targets. The revenue from the one-time lease of land-use rights and the mortgaging of municipal landholdings has provided a major source of financing for urban infrastructure and new development zones (Kamal-Chaoui *et al.*, 2009). Due to the importance of the manufacturing sector in generating local GDP and employment, local governments have a strong incentive to lease manufacturing land at very low prices, resulting in the loss of prime agriculture land (Lichtenberg & Ding, 2009; Cao *et al.*, 2008). Therefore, despite quotas limiting land conversion, municipalities have a strong fiscal incentive for urban expansion. This can undermine environmental targets, particularly those related to vehicle emissions.

Pricing environmental resources and externalities could increase the funding available to meet green urbanisation targets, but current environmental taxes are too low to account for the costs of service delivery and negative externalities. Mechanisms to price pollution and natural resources, such as taxes or tradable permits, are among the most cost-effective of policy instruments (OECD, 2011e). However, over 1995-2007, environmental taxes in China consistently remained at 0.80%-0.96% of GDP, even as their absolute amount increased (ISPRES, 2012). In contrast, in OECD countries, environmentally related taxes accounted for 1.65% GDP on weighted average, as measured by revenue, and were primarily related to energy. In a number of OECD countries, energy tax revenues exceed 2% of GDP (OECD, 2010g).

The low level of environmental levies also hinders efforts to incentivise pollution abatement and energy efficiency. For a long time, China has applied a set of environmental levies to waste, sewage, noise and various pollutants from industrial production. However, the rate has been too low to match the environmental damage or to induce behaviour change. For instance, current pollution charge rate for SO₂ emission is CNY 0.21-0.63 per kg, much lower than the desulphurisation cost of CNY 0.88-2.79 per kg (ISPRES, 2012). Rates do not rise even if the emitted amount exceeds the emission standard. The current environmental protection law (1998) also provides that the maximum amount of penalty could be applied is CNY 1 million by the national environmental authority and CNY 100 000 by a sub-national

environmental authority. In many cases, this ceiling is insufficient to impose sanctions or to deter enterprises from violating environmental protection laws. As a result, many enterprises would rather choose to pay pollution charges, or illegally discharge pollutants, thus paying a penalty, than to purchase pollutant-control facilities or to initiate technical renovation. The recently released 2012 draft of the *National Environmental Protection Law (amendment)* sets a higher charge for emissions that exceed standards, which represents a step in the right direction, *i.e.* 2-3 times of the charge level within the emission standard.

Pollutants trading (SO₂ and COD) present an opportunity to set clear environmental price signals, but pilot projects reveal challenges to establishing proper price signals and functioning markets. Since the start of pilot emission trading programmes in late 1990s, most successful transactions of pollution permits have been mainly initiated and co-ordinated by local authorities (Box 4.2). The government sector has been carrying out both the "match making" and "guided price setting" role. Strong administrative intervention has hindered market development. As local authorities manage pilot cases, they set the initial permit prices and generally allocated them to firms at very low prices. Firms are strongly against high initial prices for overburden claims and have been using all possible methods to lobby for lower prices. The first two pilot trading cases have both used free allocation: Taiyuan City freely distributed the quota for the emission of SO₂ over 2001-05, with only a 10%-15% quota left for newly established enterprises; the pilot emission trading programme in Jiaying city started with free allocation of emission rights before November 2007 (ISPRES, 2012). Therefore, firms have been reluctant to engage in emission trading: most firms would not sell their additional permits because they were planning on future expansions or were concerned about the future costs of pollution-abatement technologies. Another challenge hinders emission trading concerns firms' perceived uncertainty in the government established market, *i.e.* whether the pilot will be applied nationwide affects how firms value the emission rights (ISPRES, 2012).

Box 4.2. A brief history of SO₂ and COD emissions trading pilots in China

The number of pilot pollutant emissions trading projects has grown rapidly in recent years, partly as a result of introducing more stringent total emission control targets in the 11th FYP. The State Environment Protection Agency (now the Ministry of Environmental Protection) initiated studies on emissions trading in the 1990s, and later started pilot trading cases related to SO₂ emissions in the coal-fire power generation industry and the discharge of organic pollutants (COD) in river basins. By early 2012, ten provinces had been selected as national pilot emission trading provinces: Jiangsu, Zhejiang, Tianjin, Hubei, Hunan, Inner Mongolia, Shanxi, Chongqing, Shaanxi and Hebei. The emissions trading pilot process in China has been characterised by the following milestones:

1. Feasibility studies and seminars, e.g. the International Forum on Feasibility of SO₂ Emissions Trading in China, held by SEPA and US EPA in 1999.
2. The national strategic direction to encourage pilot emissions trading issued by SEPA, entitled "Notice on Plans for Demonstrative Enforcement of Policies on Total Emission Control and Emission Trading of SO₂" in 2002.
3. The start of trial pilot policies (rules or management methods on emissions trading) at city and provincial levels, e.g. Taiyuan City of Shanxi for SO₂ (2002), Jiaying city of Zhejiang for COD and SO₂ (2007), Tai Lake Drainage Area in Jiangsu province for COD, ammonia nitrogen and total phosphorous (2008), Zhejiang for COD and SO₂ (2007 and 2010), Shaanxi province for all four targeted pollutants COD, SO₂, NO_x and ammonia nitrogen (2012).
4. The emergence of pilot trading cases, mostly led by the government, e.g. two power plants in Jiangsu province reached an agreement to trade SO₂ allowances to meet total emission limits (2003); 882 transaction cases in Zhejiang with total volume amounting to CNY 290 million by end 2010.

The national policy makers plan to consider scaling the pilot policies into nationwide policies when sufficient experiences have been obtained from the pilot process. This logic will be applied in carbon trading, which is likely to be piloted in 2012, as laid out in the State Council's policy document, "Viewpoints on the Major Work of Deepening Economic System Reform in 2012".

Source: OECD compilation from the Ministry of Environmental Protection website, www.mep.gov.cn, accessed 30 March 2012. Wang *et al.* (2008), *Practices and Prospects of Emission Trading Programmes in China*, Chinese Academy For Environmental Planning, Beijing, www.caep.org.cn/english/paper/The-Updated-Progress-of-Emission-Trading-Programmes-in-China.pdf.

China's experience with local emissions trading projects highlights several governance challenges that call for national government standards and guidance. The key governance challenges are inadequate national laws and regulations; the need to strengthen efforts in monitoring, supervising and managing emission trading; and unclear relationship with the existing environmental policies. These challenges call for establishing supporting systems and mechanisms in order to let the market to function smoothly (Wang *et al.*, 2008). First, while pilot cases started in 1990s, there has not been nationwide technical guidance on emissions trading, let alone on a national policy framework. The absence of a national umbrella presents uncertainty to the future of emissions trading, despite continued national encouragement of local pilot programmes. While it is the nature of pilot programmes to have various local experiments first, a roadmap towards a nationwide framework could give more confidence to local initiatives and participants. Second, emission trading also needs nationally supported monitoring and enforcement. In particular, inadequate monitoring has made it difficult for local environmental authorities to obtain the accurate emission data from pollution sources and to track and verify transactions. Third, the current environmental policy package includes a range of instruments that are disconnected from one another. The pilot programmes appear to not take into account the linkages between emissions trading and pollution fines, wastewater treatment fees, environmental impact assessments, total emission controls, emission permits, or the environmental tax to be introduced in the 12th FYP (Wang *et al.*, 2008).

Addressing the policy gap: the need for improved horizontal policy coherence and collaboration

In order for sub-national authorities to effectively implement the 12th FYP Urbanisation and Green Development pillars, the central government will need to provide a clearer and more coherent policy message across all sectors and levels of government. This would entail: *i*) resolving inter-ministerial conflicts that have led to policy fragmentation; *ii*) addressing fragmentation and inconsistencies of planning instruments at the regional and local levels; and *iii*) fostering collaboration across jurisdictions.

A comprehensive and horizontally co-ordinated spatial approach to urban development is needed at the national level to overcome inter-ministerial conflicts. Generally speaking, China has not yet established an institutionalised mechanism for inter-department collaboration. An effective spatial planning framework requires a clear definition of roles among different departments, and the current series of plans are not sufficiently connected to one another (OECD, 2010b). Urban policy mandates are fragmented across many ministries, with key responsibilities assigned to the National Development and Reform Commission (NDRC), the Ministry of Housing and Urban-Rural Development (MHURD), and the Ministry of Land and Resources (MLR). All three ministries have roles in the spatial dimension of urban development policies: NDRC is responsible for national comprehensive spatial planning (the "main functional zones") and regional economic development planning; MHURD oversees the urban plans that focus on a single city and urban cluster plans looking at the networks of cities and towns; and MLR carries out territorial planning to address land-centred spatial development issues.

Clear guidelines from the central level could be beneficial to encourage coherent implementation of integrated planning. An inadequate degree of connectivity among spatial plans limits local governments' ability to pursue more integrated spatial development at the smaller local scale. Spatial planning could be used to co-ordinate various sectoral policies in pursuit of common spatial development objectives, including land-use development, economic development, environment protection, natural resource management, human settlement and etc. Local-level plans are critical as they are more specific and more focused on implementation than larger-scale, general plans. Prefecture-level city or county-level authorities could pursue an integrated spatial plan that incorporates urban cluster plans, land-use plans, environmental protection plans and urban-rural construction plans. However, without national-level guidance, provincial or municipal departments are likely to respond mainly to requests from their counterparts at the national level, rather than request from other national ministries. The central government could consider providing technical assistance or the development of integrated instruments at the national level. These could draw on the experiences of OECD countries, such as *Chartes d'objectifs* and *Contrats de Villes* (France) or the creation of a Secretariat for Cities (Canada).

Co-ordination across ministries is particularly critical for environmental policy implementation. The field of green development covers broader responsibilities that go beyond the role of the environmental agencies. Environmental departments need to request the collaboration with other agencies in order to advance policy implementation. Environmental policy implementation could be hindered by the lack of collaboration from other agencies, such as power, water supply and urban construction, which tend to support economic priorities. The lack of institutionalised mechanism has made it difficult for environmental agencies to charge environmental fees on firms or to enforce sanctions on illegal behaviours.

At the local level, the rapid emergence of large metropolitan regions and *urban clusters* (regional urban system) presents both challenges and opportunities for managing urban environment and economic development in a co-ordinated manner. However, co-operation among local governments remains limited in China. Local governments at all tiers tend to see each other as competitors, since they perceive investment attraction, in particular FDI attraction, as a crucial source of economic growth, and hence compete with their neighbouring jurisdictions for business attraction. Cross-regional competition increased

after decentralisation, for instance after fiscal reform in 1994, when local governments become more dependent on revenues produced by their own enterprises. Increased competition has also constrained the consideration for regional co-ordinated planning that could harness green development at the larger scale. National programmes like the green development demonstration projects can further exacerbate competition among local authorities, as municipalities compete to become one of the selected projects.

Enhanced horizontal co-ordination among local governments would help local authorities to meet urbanisation and green development targets, particularly related to tackling congestion, air pollution, health problems and greenhouse gas emissions (OECD/CDRF, 2010). Until very recently, the central government has largely not kept pace with the emergence of functional market regions in China: regional development policy has been formulated at a very coarse scale, defining “regions” as large aggregates of administratively-defined provinces that do not differentiate functional market regions. Since 2008, China has been approaching the inter-municipal collaboration problem through central and provincial government intervention. The State Council has recently issued quite a number of strategies for regions at sub-national spatial scale that cross administrative boundaries of provinces (*e.g.* Yangtze River Delta region) and municipalities (Pearl River Delta region). In 2009, Guangzhou and Foshan signed a co-operation agreement, the first inter-municipal co-operation agreement in China, as encouraged by the provincial authority. With varying levels of fiscal and technical capacity to respond to green development, local leaders can assist each other. Knowledge spillovers could be enhanced by collaborative inter-urban frameworks to combat climate change and promote low-carbon development. For instance, Hanover, a German metropolitan region with about 4 million inhabitants, benefits from a regional approach to mitigation and adaptation strategies with its Regional Climate Protection Agency (*Klimaschutzagentur Region Hannover*), which co-ordinates all climate protection activities throughout the region (OECD/CDRF, 2010).

The central government could also consider encouraging voluntary inter-municipal co-operation agreements. A number of OECD countries have implemented these agreements, often through the use of fiscal and legal instruments (OECD/CDRF, 2010). For example, in Canada, much of the federal infrastructure programming requires that contiguous municipalities in a functional region, either urban or rural, partner on joint infrastructure projects where appropriate. Each municipality, rather than ask for its own funding, pools its efforts with others to maximise investment efficiency in the functional region (for waste management or transit, for instance). This approach could be implemented in China through existing national grants for green development, with programming terms and conditions, including bonus schemes conditional to funding to both infrastructure and strategic policy planning. In particular, the central government could develop incentives to facilitate co-operation between metropolitan cities and provinces. Metropolitan cities and provinces could in turn encourage all-sized municipalities within or across their administrative boundaries to co-operate with each other. Co-operation would be rewarded based on conditionality principle. Another solution to encourage voluntary modes of co-operation among adjacent municipalities could be to adopt a city-region policy framework to guide policymaking, particularly with respect to inter-municipal partnerships.

Addressing the information and capacity gap: developing measuring and monitoring tools

Another major cause of the gaps between national green development and urbanisation targets is the lack of capacity for implementing them, lack of access to the most up-to-date technical information, and the lack of standard methods for monitoring urban environmental indicators. Clear standards, and the technical assistance and guidance to meet them, is lacking, particularly at the local level.

Capacity gaps at the local level may hinder progress on green development and urbanisation targets. While national guidelines appears to be broad, local authorities in China, who are responsible for designing and implementing programmes, may not have the sufficient knowledge without adequate training.

Bridging the capacity gap calls for enhanced training and capacity building of local-level officials, in particular in integrated urban green growth policies. The large-scale officials training programme implemented by the Organization Department of the CPC Central Committee from 2008-12 provides training for leading officials and bureaucrats ranging from all national and sub-national levels, and sets standards on the minimum number of study hours. Different national ministries have launched their tailored training programmes, including the fields of land management, energy saving, pollution abatement, and climate change. For instance, the MEP started its environmental sector large-scale official training programme in 2009, aiming at providing training for all environmental sector officials, *e.g.* to complete training in five years for all provincial and prefecture level environmental bureau leaders and environmental monitoring station directors. The intermediate results have been encouraging: 161 848 local officials and bureaucrats at county or township levels in charge of land management received training by 2010 (Lu, 2010).

Monitoring progress on green development and urbanisation targets also poses a real challenge to environmental targets. There is still no clear definition put forth by the central government that formally explains what exactly it means to be a low-carbon city. This concept is naturally challenging, because what is relevant in one part of the country may be very different in another part of China, reflecting a different geography, economic base, climate, or energy supply. Lacking such a common definition, the pilot cities and provinces appear to be employing different standards, varying in whether they focus on performance (*e.g.* changes in per capita carbon emissions, carbon intensity per unit of GDP, etc.) or in terms of the presence of specific programmes, policies and systems (*e.g.* a bus rapid transit system; requirements that buildings satisfy a portion of their energy needs through on-site renewables deployment; a significant tree-planting initiative). To ensure consistent improvement, a common definition of low-carbon development would also need to include guidance on how frequently environmental performance should be revisited. Central government could also provide guidance on which infrastructure systems should make progress – earlier or later – based on varying levels of complexity. Such guidance to local authorities would clarify that progress will be easier and seen earlier in some areas than in others.

Harmonised urban greenhouse gas emissions inventories are crucial to monitoring the progress of low-carbon initiatives. Further, harmonised urban inventory methods and reporting is essential to enable performance assessment and comparison across urban locations. The current green development metrics tracking energy saving and pollution abatement performance in China bear little relationship to whether a city is successful at cutting its CO₂ emission levels. The carbon target put forward in the national 12th FYP that establishes the city-level emission benchmark provides an opportunity to clarify the type of indicators that should be used for monitoring or guiding low-carbon development in a city. The OECD is currently contributing to international efforts to develop a harmonised urban greenhouse emissions inventory (see OECD, 2010d), although the adoption of a single international protocol is likely years away.

At the international level, there is also a need for cities to bring rigour and structure into their efforts to measure progress in achieving their mitigation and green development goals (Hammer *et al.*, 2011). The OECD is currently working to expand its metropolitan database to include a range of economic and environmental statistics for metropolitan regions. The environmental indicators under development measure i) *urban density* (high density development index, densification index); ii) *land cover and changes in land cover* (percentage of area covered by urbanised, agricultural and forested land; growth of urbanised, agricultural and forested land over time); iii) *forest ecosystem and carbon absorption* (net primary productivity of regional vegetation); iv) *CO₂ emissions* (CO₂ emissions *per capita*, CO₂ efficiency of production); and v) *air quality* (average population exposure to PM 2.5, percentage of population exposed to health-damaging PM 2.5) (Table 4.6).

Table 4.6. OECD environmental indicators developed for regions and metropolitan areas

Indicator	Unit of measure	Geographical unit of analysis	Data sources
Urban density			
High density development index	Proportion of people living in highly densely inhabited residential units (1 sq km grids) within the metropolitan area	metro	Gridded population data: LandScan 2009 Global Population dataset
Densification index	Ratio of population change (in metro, core and hinterland), with respect to the increase in urbanised land, <i>i.e.</i> the surface that is categorised as urban.	metro	Census data; EU Corine Land Cover dataset; US National Land Cover Database; Japan National Land Information Service; MODIS Land Cover Database
Land use and changes in land cover			
Share of area covered by urbanised land	Percentage of total surface area categorised as "urban"	TL2; TL3, metro	EU Corine Land Cover dataset; US National Land Cover Database; Japan National Land Information Service; MODIS Land Cover Database
Share of area covered by agricultural land	Percentage of total surface area categorised as "agricultural"	TL2; TL3, metro	
Share of area covered by forested land	Percentage of total surface area categorised as "forested"	TL2; TL3, metro	
Growth of urbanised land	Amount of land converted to urban land cover minus the urban land converted to other classes, as a fraction of the urban land in the starting year	TL3, metro	
Growth of agricultural land	Amount of land converted to agricultural land cover minus the agricultural land converted to other classes, as a fraction of the agricultural land in the starting year	TL3, metro	
Growth of forested land	Amount of land converted to forested land cover minus the forested land converted to other classes, as a fraction of the forested land in the starting year	TL3, metro	
Forest ecosystem and carbon absorption			
Net primary productivity of regional vegetation	Difference between the gross primary productivity (GPP, calculated as the sum total of light energy that is converted to plant biomass) and energy lost during plant respiration	TL2	MOD17 (MODIS database)
CO₂ emissions			
CO ₂ emissions <i>per capita</i>	<i>Per capita</i> CO ₂ levels	TL2; metro	Emission Database for Global Atmospheric Research (EDGAR)
CO ₂ efficiency of production	Ratio between GDP and CO ₂ values	TL2; metro	Emission Database for Global Atmospheric Research (EDGAR)
Air quality			
Average population exposure to PM2.5		TL2; metro	Satellite-based measures of PM2.5 concentrations 0
Percentage of population exposed to health damaging PM2.5	Estimated levels benchmarked to the thresholds specified in the WHO Air Quality Guidelines for PM	TL2; metro	Satellite-based measures of PM2.5 concentrations 0

Note: Based on the work of Aaron van Donkelaar and Randall Martin from Department of Physics and Atmospheric Science, Dalhousie University, Halifax, Nova Scotia, Canada, which combines satellite data from NASA's MODIS and MISR instruments and GEOS-Chem global chemical transport model.

Source: OECD (2011), "Measuring the Environmental Performance of Metropolitan Areas with Geographic Information Sources", paper presented during the 22nd session of the Working Party on Territorial Indicators, OECD, Paris, 7 December.

4.3. Governance conclusions

While China has achieved significant progress in energy saving and pollution abatement during its 11th FYP period, much remains to be achieved in the transition to green development. Progress has thus far been made primarily through the target responsibility mechanism and fiscal resource allocation, coupled with administrative measures. However, the marginal returns might start to decrease as the easiest solutions are implemented. The private sector could take a greater role in stimulating green growth, but it needs clearer pricing signals from the government. A way forward could include a sound policy and regulatory framework, well-designed incentive mechanism, and strengthened monitoring and enforcement capacity. All of these will help to make green growth more attractive to the private sector, thus increasing opportunities for green investment, business and innovation. Transition will be a gradual process, especially since assuring compliance at the local level is still a challenge. National government officials could take the following into consideration:

- *Making commitments* to advance an urban green growth agenda: with many of the major strategic decisions and steps set out in the 12th FYP to encourage green development priorities, the emphasis is now local enforcement. Enforcement is becoming crucial to ensuring that the major regulatory reforms are successfully complied with over time. Moreover, a degree of political courage is important despite local lobbying. Constraints can be significant if particular interest groups have retained sufficient power or cohesiveness to influence the future course of policy.
- *Re-examining incentive mechanisms* to encourage local governments and the private sector to engage in a “race to the top” on green development and urbanisation targets. The central government could further encourage local authorities to pursue green initiatives, and adopt the concept that environmental attractiveness can contribute to high value added urban economic growth. The private sector also needs clear signals (regulations, price, and obstacles for green investment), which requires co-ordinated efforts by both national and sub-national authorities to assure compliance.
- *Land sales and national urban policies need to be better co-ordinated and address compact urban development.* The current fragmented and overlapping urban policy responsibilities in national urban policy making need to be addressed in order to promote integrated considerations to better manage urban expansion and promote efficient land management practices. A further necessary step is to incorporate the concept of making cities compact into the national urban policy framework. There is also a need to review national-level urbanisation policies to increase coherence with other environmental policy priorities.
- *Improving compliance with environmental targets* through greater political commitment and increased funding from the central government. To date, many of the major strategic decisions and steps taken (e.g. 12th FYP) encourage green development priorities, shifting the emphasis to local enforcement. Enforcement is becoming crucial to ensure that major regulatory forms are successfully sustained over time. Moreover, a degree of political courage is important despite lobbying from local governments. Constraints can be significant if particular interest groups have retained sufficient power or cohesiveness to influence the future course of policy.
- *Diversifying funding sources for green priorities by setting appropriate environmental taxes and fees.* The current environmental charges and taxes are still low compared to OECD countries. As some local governments are facing increasing pressures – as spending responsibilities tend to outweigh fiscal revenues – they will need financing support from the central government. This is particularly relevant for urban areas with a large share of “restricted development zones” and “prohibited development zones”, which need to focus on ecological preservation rather than

economic development. Cap-and-trade systems, still in pilot stage, may also result in greater private sector funding for environmental improvements.

- *Improving horizontal policy co-ordination and possibly integrating it at the urban level.* Urban level complementarities could also be encouraged for urban green growth practices and to pave the way for combined green development and urbanisation policy targets. Moreover, there is considerable room to integrate economic, environment and construction policies in the urban level administrative structure. Finally, cross-municipal collaboration needs to be encouraged by the central and provincial governments.
- *Enhancing monitoring, enforcement and implementation capacity.* Data collection and provision on key urban environmental indicators needs to be improved so as to better inform policy makers and other stakeholders. Capacity building for local officials needs to be further improved to support local efforts to assure compliance with environmental targets. Moreover, Chinese cities could encourage a greater role for the general public in monitoring pollution through better information advocacy and public participation.

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