Cities and the Green Economy

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Abstract This chapter is a condensed version of the Cities Chapter of UNEP's seminal publication 'Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication'. It analyses the particular role that cities play in the context of a transition to a Green Economy. Cities account for a substantial proportion of global greenhouse gas emissions, mostly due to the intense concentration of people, economic activity and transport in urban centers. But just as cities are the source of many environmental problems, they offer many of the solutions. Firstly, this chapter assesses the particular potential of cities for a transition to a Green Economy. Secondly, it argues the case for greening cities, in terms of the economic, social and environmental benefits that a Green Economy can bring to cities and their inhabitants. It then analyses various urban sectors and how these should be greened in order to create a green city and a greener urban economy. Keys to achieving this are the required enabling conditions which are imperative in order to overcome institutional and financial barriers. Setting the required enabling strategies and a regulatory framework is the foremost challenge for national, regional and local governments in terms of greener cities.

Keywords Green cities • Greening urban sectors • Governance • Planning and regulation • Civic engagement

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1 Introduction

Green cities are defined as those that are environmentally friendly. They are cities that have adopted a green (urban) economy. Indicators measuring environmental performance can include: levels of pollution and carbon emissions, energy and water consumption levels, water quality, energy mix, waste volumes and recycling rates, green-space ratios, primary forests, and agricultural land loss (Meadows 1999; Brugmann 1999). Other indicators include urban density, motorization rates and modal share of transport. Furthermore, green cities are also those that have ambitious green policies, a range of green projects and a principal trajectory towards a better environmental performance such as Freiburg, Germany or Curitiba, Brazil. The latter has implemented policies to integrate land-use and transport planning, whereas Freiburg has long had a long tradition of sustainable building and investment in recycling, and has reduced CO_2 emissions per capita by 12% between 1992 and 2003 (Dünnhoff and Hertle 2005).

2 Challenges and Opportunities

2.1 Challenges

The global population living in urban areas is now over 50% and is expected to reach 69% by 2050 (UN Population Division 2006, 2010). In some regions, cities are expanding rapidly, while in others, rural areas are becoming more urban. In developing economies, rural urban migration and natural population growth is swelling cities and in rapidly urbanizing countries, particularly evident in China and India, the struggle to develop infrastructure, mobilize and manage resources has negative consequences for the environment.

Cities of different wealth levels impact the environment differently. Local environmental threats are most severe in poorer cities and relate to issues such as fresh water, sewage, health and the degradation of the living environment. As cities become more prosperous, with wider and deeper patterns of consumption and production, their environmental impacts are increasingly felt at the global level. Urban areas in prosperous economies concentrate wealth creation as well as resource consumption and CO_2 emissions. Globally, with a population share of just above 50% but occupying less than 2% of the earth's surface, urban areas concentrate 80% of economic output, between 60 and 80% of energy consumption, and approximately 75% of CO_2 emissions (Kamal-Chaoui and Robert 2009; UN Population Division 2010). Particular activities, for example buildings, transport, and industry – which are constituent components of cities and urban areas – contribute 25, 22, and 22% respectively of global GHG emissions (Herzog 2009).

Cities per se are neither drivers of climate change nor the source of ecosystem degradation; certain consumption and production patterns as well as certain population

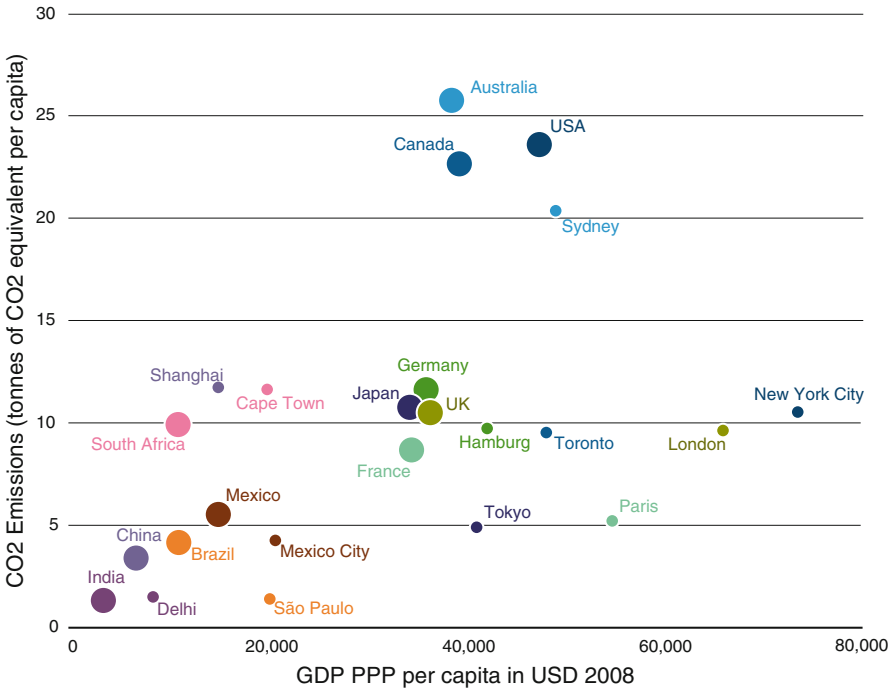

Fig. 1 Carbon emissions and income for selected countries and cities

groups within cities are. Carbon emissions are directly related to income. Per capita incomes are generally higher in cities than in rural areas, generating higher average per capita demand in major emissions sources. But this is the case only up to a certain income level, after which cities typically become more carbon-efficient compared with the average as can be seen by the relatively low levels of CO_2 emissions produced by high income cities like Tokyo or Paris (Fig. 1).

Patterns of urbanization in many areas also raise important social challenges. The traditional model of urban development – typical of rapidly urbanizing areas – is characterized by uncontrolled, often even incentivized, horizontal expansion. This leads to urban sprawl of affluent populations with lower development densities and increased dependency on the private car and to peripheralization of the urban poor, decreasing their access to the city and its workplaces, services and infrastructure. Typical developments further include the emergence of socially divisive neighborhoods in the form of gated communities, shopping centers and business districts, and a significant increase in the level of informal development with large swathes of slum housing with no access to basic services, infrastructure and sanitation. At a general level, the rapid growth of many cities coupled with insufficient resources and poor management compromises fresh water and electricity supply, waste treatment, transport, and other infrastructure provision, affecting the urban poor most.

2.2 Opportunities

2.2.1 Structural Capacity

The environmental performance of cities is dependent on a combination of effective green strategies and physical structure – urban form, size, density and configuration. They can be designed, planned and managed to limit resource consumption and carbon emissions. Or, they can be allowed to become voracious, land-hungry, all-consuming systems that ultimately damage the delicate global energy equation. More compact urban forms, reduced travel distances and investment in green transport modes lead to greater energy efficiency.

2.2.2 Technological Potential

Cities are incubators of innovation due to the close interaction of their residents and workers who benefit from the exchange of ideas and opportunities. In particular, they benefit from the concentration of diverse yet specialized skill-sets in research institutions, firms and service providers that can pilot and scale new technologies in an already highly networked environment. The OECD calculates for example, that there are ten times more renewable technologies patents in urban than rural areas and that 73% of OECD patents in renewable energy come from urban regions (Kamal-Chaoui and Robert 2009). The fast-growing 'cleantech' clusters in Silicon Valley and the North East of England are both examples of 'nursery cities', fostering innovative activity (Duranton and Puga 2001). Silicon Valley business leaders have been working for years to leverage the valley's 'innovation advantage' in the green economy (Joint Venture Silicon Valley Network 2009).

2.2.3 Urban Synergy and Integration Potential

Green cities can benefit greatly from synergies between their constituent parts. Recognizing, for example, the interrelationship of energy systems and city fabric can lead to particular synergies. An urban setting, which tends to support a diverse and compact pattern of production and consumption, is further advantageous to advance the notion of 'industrial ecology' (Lowe and Evans 1995). By optimizing and synergizing different industrial sectors and resource flows, outputs of one sector that become the input of another create a circular economy (McDonough and Braungart 2002). Principles of symbioses can also help cities minimize or recycle waste and improve overall resource efficiency.

3 The Case for Greening Cities

3.1 Economic Benefits

3.1.1 Agglomeration Economies

From an economic perspective, denser cities matter because they bring people and things closer together, help overcome information gaps, and enable idea flows (Glaeser 2008; Krugman 1991). It is for these reasons that 150 of the world's most significant metropolitan economies produce 46% of global GDP with only 12% of the global population (Berube et al. 2010). Agglomeration economies translate into productivity gains for firms and higher wages and employment rates for workers. Knowledge spillovers between firms and economic agents tend to be highly localized and die away within a few miles of the urban core (Rosenthal and Strange 2003).

There exists strong evidence that urbanization boosts productive efficiency by lowering transport and widening trade networks (Duranton 2008; Han 2009). Agglomeration economies can also be achieved by connecting several cities as in China's Pearl River Delta (Rigg et al. 2009), with the additional benefit of addressing inequality between leading and lagging regions in countries (Ghani 2010).

3.1.2 Lower Infrastructure and Operating Costs

Furthermore, densification reduces the capital and operating costs of linear infrastructure including streets, railway, water and sewage which can come at a considerably lower cost per unit in higher densities. Comparing smart growth areas and dispersed, car-dependent developments, Todd Litman suggests direct cost savings between US$5,000 and US$75,000 for building road and utility infrastructure per household unit (Litman 2009a) (Fig. 2).

Transport Infrastructure	Capacity [pers/h/d]	Capital costs [US$/km]	Capital costs/ capacity
Dual-lane highway	2,000	10m – 20m	5,000 – 10,000
Urban street (car use only)	800	2m – 5m	2,500 – 7,000
Bike path (2m)	3,500	100,000	30
Pedestrian walkway / pavement (2m)	4,500	100,000	20
Commuter Rail	20,000 – 40,000	40m – 80m	2,000
Metro Rail	20,000 – 70,000	40m – 350m	2,000 – 5,000
Light Rail	10,000 – 30,000	10m – 25m	800 – 1,000
Bus Rapid Transit	5,000 – 40,000	1m – 10m	200 – 250
Bus Lane	10,000	1m – 5m	300 – 500

Source: Rode and Gipp (2001), VTPI (2009), Wright (2002), Brilon (1994)

Fig. 2 Capacity and infrastructure costs of different transport systems

Cost savings are also derived from a shift away from car infrastructure towards public transport, walking and cycling. For example at similar capacity levels, bus rapid transit (BRT) offers significant cost savings compared to traditional metro and regional rail. Bogotá's TransMilenio infrastructure cost US$5.8 million per km, US$0.34 per passenger over 3 years compared with estimates for metro rail with US$101 million per km, US$2.36 per passenger (Menckhoff 2005).

3.1.3 Reduced Congestion Costs

Diamond (2005) suggest that the economic advantages of being in cities tend to mitigate even severe congestion problems and there also exist opportunities to deal with congestion through demand management, for example, via mechanisms such as congestion charges. London's congestion charge reduced congestion by 30% from February 2003 to February 2004 compared with previous years (Transport for London 2004a) and led to benefits such as the reduction in the number of trips by private vehicles entering central London (Transport for London 2004b) and a 19.5% drop in CO_2 emissions (Beevers and Carslaw 2005).

3.2 Social Benefits

3.2.1 Job Creation

Greening cities can create jobs on a number of fronts: (1) urban and peri-urban green agriculture; (2) public transport; (3) renewable energy; (4) waste management and recycling; and (5) green construction. Furthermore, green services will generally be more urban-orientated than green manufacturing or primary industry, although there will be some high-tech green manufacturing clusters in or close to urban cores, drawing on knowledge spillovers from universities and research labs. Overall, the green economy cannot be expected to create or destroy net jobs in the long run; the supply and demand for labor tend to equate in accordance with labor market conditions. In the short run, however, with unemployed resources, the net employment creation effect is likely to be larger.

3.2.2 Poverty Reduction and Social Equity

The World Development Report (2009) describes increasing economic density – one of the main features of a green city – as "a pathway out of poverty". Along similar lines, Nadvi and Barrientos (2004) assess the impact of clusters or agglomeration effects on poverty in several urban areas of developing countries. It is observed that these clusters are labor-intensive, informal in nature and also employ a lot of women as household-workers. Urbanization has reduced absolute poverty even though the number of people classified as urban poor is on the rise (Ravallion

et al. 2007). Innovative approaches to urban planning and management can make urbanization inclusive, pro-poor and responsive to threats posed by environmental degradation and global warming. For example, enhancing public transport use can reduce inequality in access to public services and other amenities, on top of reducing carbon emissions (Litman 2002).

Switching to cleaner fuels for cooking, transport and power generation can minimize local pollution and reduce health inequality (Haines et al. 2007). Poor urban households in low-income nations have to spend a large proportion of their income on energy needs including food and cooking fuel (Karekezi and Majoro 2002). Introducing cleaner and more efficient sources of energy offers the potential to both reduce direct expenditure and to lower health costs connected to indoor-air pollution (Bruce et al. 2002). Retro-fitting older buildings in lower-income neighborhoods can improve energy efficiency and resilience, reducing the vulnerability of poorer communities when energy prices rise (Jenkins 2010). In addition, improving sanitation and fresh water supply can reduce persistent poverty and the adverse impacts of water-borne disease (Sanctuary et al. 2005).

3.2.3 Improvement in Quality of Life

Improving the urban environment by promoting "walkability" and introducing public green spaces can help foster a sense of community (Frumkin 2003; Litman 2006). Kuo et al. (1998) observed that the more trees and greenery form part of inner-city public spaces, the more these spaces are used by residents. The study also found that, compared with residents living near barren spaces, those closer to greenery enjoy more social activities, have more visitors, know more of their neighbors, and have stronger feelings of belonging. A further dimension in the quality of life surrounds road safety. Road traffic accidents are the leading cause of death among young people between 15 and 19 years, according to a report published by the WHO in 2007 (Toroyan and Peden 2007).

There also exists a relationship between green cities and cities with a high quality of life. Among the top 20 'quality of living cities' identified by Mercer in 2009, at least half have particularly strong green credentials such as Vienna, Zurich (strong focus on city transport) (Ott 2002) and Vancouver. Similarly, the integration of green space and natural elements within the city significantly enhance the quality of living which is also essential for attracting companies and a workforce to a city.

3.3 Environmental and Health Benefits

3.3.1 Reducing Pollution and Improving Public Health

Air pollution in cities remains a major public health burden, particularly in the developing world. Furthermore, there is a broader set of public health issues around healthier lifestyles in cities. It is estimated that physical inactivity accounts for 3.3%

of all deaths globally and for 19 million disability-adjusted life-years (Bull et al. 2004). Green urban transport is a unique opportunity to link physical activity and emissions reduction by promoting walking and cycling.

It is no coincidence that cities with a long tradition of applying land-use planning, public transport strategies and a focus on public green space are among the healthiest cities in the world. Portland was rated number one of the 100 largest USA cities in meeting Healthy People 2000 goals (Geller 2003), Vancouver is first amongst the Canadian cities (Johnson 2009), Copenhagen and Munich rank amongst the top ten healthiest and safest cities and Melbourne among the healthiest and safest in Australia (Sassen 2009).

3.3.2 Ecosystem Services and Risk Reduction

Urban greenery and vegetation represent a range of 'ecosystem services' with significant wider welfare effects (TEEB 2010). Ecosystem services further play a critical role in risk reduction measures. Restoration of urban ecosystems is part of the city greening effort, which can reduce the impact of freak weather conditions. Coastal regions in particular can benefit both in terms of lives and money. Mangrove replanting in Vietnam, for example, saves US$7.3 million annually on dike maintenance while it costs only US$1.1 million (International Federation of the Red Cross and Red Crescent Societies 2002. More generally, an increase in the amount of green cover in urban areas not only increases a city's ability to reabsorb CO_2 but also ameliorates the urban heat island effect (McPherson et al. 1994).

4 Greening Urban Sectors

4.1 Transport

The most familiar green transport strategies in cities primarily focus on reducing car use. Instruments such as the congestion charge in London and Singapore contributes to reducing car use, therefore congestion, pollution and GHG emissions. In Central London, for example, the congestion charge reduced daily vehicles trips by 65,000–70,000 (Transport for London 2004b) and CO_2 emissions by 19.5% (Beevers and Carslaw 2005).

Across a diverse range of cities, emission standards and car sharing schemes (Schmauss 2009; Nobis 2006) have reduced car dependency while low-emission zones and timed delivery permits have helped reduce congestion and pollution (Geroliminis and Daganzo 2005). Provided reliable and efficient public transport options, particularly surface transit such as bus rapid transit and light rail; cities can further reduce private car use, as can the promotion of Eco Mobility options – walking and cycling as the greenest forms of transport.

4.2 Buildings

Tackling the energy demand of existing building stock is a priority for cities, and urban green building strategies also include more efficient use of other resources such as water and materials. Three principal green building strategies can be differentiated: design, technology, and behavior-related. Particularly in a developing world context, passive design solutions to improve environmental performance are by far the most cost-effective approaches. For example, housing projects on the coast in Puerto Princesa City, the Philippines, have been designed to reduce energy demand through increased natural light, improved ventilation, the cooling effect of the roofing material, and strategic planting (ICLEI, UNEP and UN-HABITAT 2009).

Stringent building codes, mandatory energy certificates, tax incentives and loans, have had a measurable impact on energy demand in a number of European and US cities (C40 Cities 2010a). Berlin requires a solar-thermal strategy for all new buildings and Freiburg's energy efficient housing standard has reduced average household energy consumption for space heating by up to 80 percent (von Weizsäcker et al. 2009). Furthermore, municipal authorities are able to 'set an example' by implementing green strategies on their own public building stock.

4.3 Energy

Cities have the potential to either dissipate the distribution of energy or optimize their efficiency by reducing energy consumption and adopting green energy systems including renewable micro-generation, district heating, and combined heat and energy plants (CHP). In Freiburg, PV systems, encouraged by Germany's generous feed-in tariff, now supply 1.1% of the 470 Cities city's electricity demand. A biomass CHP system and wind turbines provide for a further 1.3 and 6% respectively of the city's energy needs (IEA 2009).

Oslo and São Paulo have harnessed power generated by nearby hydro-electric facilities to gain a relatively high share of renewable energy. Grid-based, decentralized energy system, with district heating systems can provide space and water heating for large urban complexes (like hospitals, schools or universities) or residential neighborhoods. They can significantly reduce overall energy demand. Their efficiency further improves with combined heat and power energy generation systems. Copenhagen's district heating system, for example, supplies 97% of the city with waste heat (C40 Cities 2010b).

4.4 Vegetation and Landscape

Parks, protected green space and gardens, street trees and landscaping provide vital ecosystem services, acting as "green lungs" absorbing and filtering air pollution or

as acting as filters for waste water (TEEB 2010). They also provide a habitat for wildlife and offer recreational benefits to city dwellers.

Green landscaped areas help regulate natural processes, including the mitigation of local temperature extremes. Vegetation and "soft" open space also play a role in decreasing storm-water volumes, thus helping cities to manage the consequences of heavy rainfall etc. Measures for protecting green areas are of particular importance along the city fringe, where urban growth boundaries in cities such as Portland and London restrict development. In Stockholm, thanks to the protection of green areas, almost the entire population lives within 300 m of parks and green areas (City of Stockholm 2009).

New design strategies have pioneered the use of green roofs and facades on buildings, to add to the quantity of natural (as opposed to man-made) surfaces in cities and to reduce cooling energy demand. For example, Itabashi City in Tokyo is promoting climbing plants as "Green Curtains" around public buildings and private homes to avoid buildings overheating in summer and to reduce the use of air conditioning (ICLEI 2009b).

4.5 Water

Cities require significant transfers of water from rural to urban areas with water leakage being a major concern. Upgrading and replacement of pipes has contributed to net savings of 20% of potable water in many industrialized cities. Over the last 10 years alone, Tokyo's new water system has reduced water waste by 50% (C40 Cities 2010c). Volumetric charging has proven most effective in incentivizing more efficient water use. Many cities are introducing water meters and are shifting away from simple water-access fees.

To further reduce water consumption and provide alternatives to piped water supply, rain can be harvested and used as drinking and non-drinking water. To counter severe water shortages in Delhi, the Municipal Corporation made rainwater harvesting a requirement for all buildings with a roof area above 100 m^2 and a plot area greater than 1,000 m^2. It is estimated that 76,500 million liters of water per year will be made available for groundwater recharge (ICLEI, UNEP and UN-HABITAT 2009).

4.6 Food

The "food footprint" of a city has significant impacts on its green credentials, especially if one takes into account the energy use generated by transporting food from remote locations to urban marketplaces (Garnett 1996). For example, the food supply of European cities accounts for approximately 30% of their total ecological

footprint (Steel 2008). Some cities do benefit from the location and have strong links with their regions; regarding food production and consumption.

Approximately 15–20% of the world's food is produced in urban areas. The extensive role of food production in cities is a common feature of many developing-world cities. Estimates suggest that 35% of households of Nakuru, Kenya were engaged in urban agriculture in 1998 (Foeken 2006; David et al. 2010). Furthermore, successful urban agriculture projects are scattered across some Western cities, albeit usually on a small scale, making use of communal gardens, roof spaces and unused urban spaces.

4.7 Waste

A waste economy plays a dominant role in a city's ecological footprint. Yet, cities can and have demonstrated considerable resilience in finding green solutions that reduce overall waste through new forms of environmentally friendly treatment of unavoidable waste. In developing world cities, which typically suffer from insufficient formal waste collection, informal recyclers and declaimers provide an essential service that often remains unrecognized.

In many European cities, recycling levels are in the region of 50%, while Copenhagen only sends 3% of its waste to landfills (C40 Cities 2010d). Composting is a further critical component for greening waste. Positive examples range from Dhaka's decentralized composting to San Francisco's municipal food composting programs (Zurbrügg et al. 2005).

4.8 Infrastructure and Digital Technology

A growing body of knowledge suggests that cities are the natural sites for investments in smart infrastructure to deliver more sustainable environments. The digital infrastructure of the internet and data centers creates an 'intelligent' infrastructure that connects people to people, people to city systems and city systems to each other, allowing cities and their residents to respond to changing circumstances by adapting in near real-time and to recognize patterns to help make informed decisions.

In addition, smart transport systems are being used to tackle congestion, facilitate road user charges or supply real-time information on traffic problems. Examples include Stockholm's congestion tax and Singapore's electronic road pricing. They also facilitate bike sharing schemes that are increasingly becoming an important component of urban transport worldwide, Amsterdam currently trials smart work centers that allow workers to use local office facilities rather than commuting to their main office (Connected Urban Development 2008).

5 Enabling a Green City

5.1 Barriers

- **Fragmented governance** – lack of coordination between policy frameworks that promote green economy measures at supra-national, national, regional and metropolitan levels;
- **Affordability** – even cost-effective green measures may be out of the reach of poorer cities, leaving them saddled with more wasteful urban infrastructure;
- **Lack of investment** – private and public sector have not prioritized green investment in basic city infrastructure (such as green planning, public transport and housing strategies);
- **Negative tradeoffs** – without effective policy intervention and infrastructure investment, green city strategies can lead to greater congestion, higher land values and costs of living;
- **Consumer preferences** – when given a choice consumers may not be willing to adopt new models of urban living that require changes in individual and collective patterns of consumption (e.g. high-density apartment living, public transport use);
- **Switching costs** – high short-term transition (welfare and capital) costs for businesses that shift from brown to green, leave many companies without adequate compensation to make the investment;
- **Vested business interests** – industry dynamics in construction, road-building and infrastructure are resistant to change that challenges existing business models and threatens the potential of short-term return on investment;
- **Risk aversion** – individuals, corporate and government organizations are resistant to any change that does not demonstrate immediate improvement in economic well-being, quality of life or enhanced status within the community; and
- **Behavioral response and the rebound effect** – consumers may respond to reduced energy costs (generated by energy efficiency measures) by either increasing per (Fig. 3)

5.2 Enabling Strategies

Overcoming this set of barriers and constraints requires a multi-faceted response across different sectors, which are addressed in turn, from governance and planning to incentives and financing. Enabling conditions, institutional strength and democratic maturity illustrates the breadth of policy instruments and tools that can promote investment in greening cities. Importantly, it correlates their effectiveness over time in relation to the strength of local institutions and the strength of the democratic system in different urban contexts. By plotting the enabling conditions available in systems with both ‘strong’ and ‘weak’ institutions against weaker and more

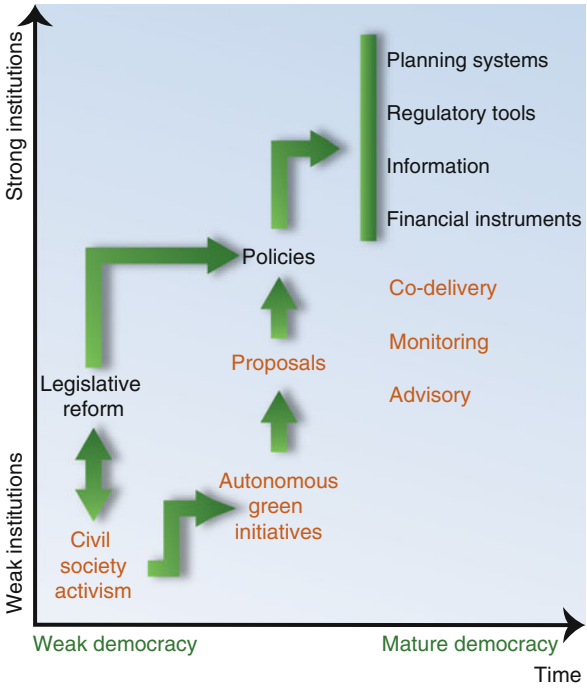

Fig. 3 Enabling conditions, institutional strength and democratic maturity

mature democracies, it suggests that the process of change is in most cases a long one, and requires the development of 'mature' institutions before long-term change can be implemented, whilst recognizing that civil-society, activism and autonomous green initiatives can be effective in the short-to-medium term, especially in weaker institutions and less mature democracies.

5.3 Governance

Governance encompasses the formal and informal relationships linking the various institutions involved in the urban system – the local, metropolitan, regional, state, civil society and private-sector actors – and its quality depends on the depth of reciprocity, trust, and legitimacy. These are enhanced by mechanisms and opportunities to facilitate meaningful dialogue, and by well-structured organizations in civil society, the business sector and the relevant government level. The practical imperatives of debating trade-offs and priorities in pursuing green city development can contribute to the maturing of governance relationships.

In contexts with strong local government it is possible to envisage a range of planning, regulatory and financing instruments to advance a multitrack approach to greater urban sustainability, however due to issues of mistrust and corruption, this may prove difficult for local governments. In countries where local government is weak or marked

by mistrust and disinterest due to its inefficiency and/or corruption, it is important to underscore that unless broad-based cultural movements are fostered that can shift the aspirational horizons of ordinary people, it will prove very difficult to promote and institutionalize the numerous green city reforms that are usually proposed.

Effective governance can also include the promotion of the idea of a long-term strategic plan for the city complementing the more conventional spatial and environmental planning instruments. For example, the internationally-based Cities Alliance (Cities 2006) promotes so called City Development Strategies (CDS), as appropriate tools to address the nexus between sustainable economic growth and ecological preservation and restoration. This should be backed up by effective resource allocation and decision-making systems that demonstrate to everyone in the city that systematic progress is being achieved towards the long-term goal of becoming a green city.

5.4 Planning and Regulation

While the large proportion of informal practices make planning and regulation less relevant in some cities in developing nations, they are the most common policy instruments that shape urban development in more complex and mature political environments. Urban planning can divert development to a desired course whereby, denser urban forms allow for economies of scale and sustainable service provisions.

To maximize synergies across different urban sectors, integrated planning that combines land use and urban development with other policies and cuts across the urban functional region of cities is critical in achieving greater environmental performance, as well as economic viability. The recently launched World Bank Eco2 Cities program, for example, demonstrates why planning, finance and infrastructure imperatives are inextricably linked in a low-carbon world (Suzuki et al. 2010). This program argues for a one-system approach to: "realize the benefits of integration by planning, designing and managing the whole urban system." On a practical level this implies that all cities need to understand their urban form and the nature and patterning of material resource flows through the urban system.

The intersections of infrastructure and the dynamics, resilience or vulnerability of urban form are crucial. As described previously, it is not untypical for poor people to live without access to various infrastructure networks in the most climate-vulnerable areas of a city (Moser and Satterthwaite 2008). Possible impacts on urban form and resource flows need to be considered when planning infrastructure investments, especially given the enormous sums required for capital expenditure in rapidly urbanizing areas. More than anything else, urban sustainability will depend upon how these sums are going to be allocated.

A combined understanding of urban form and resource flows helps isolate effective actions to achieve greater overall resource efficiency. It also forces a longer-term horizon for understanding trends, the most strategic intervention points, and how to weigh up trade-offs between various spaces of an urban region. If it is

based on sound data, it will hold the potential to provide a shared basis for understanding what is going on in a city, where it may be leading and what needs to be done to change the efficiency of the overall system (Crane et al. 2010). It is only when this kind of analysis and political discussion becomes commonplace, that one can achieve a broad-based commitment to effective long term strategic planning.

5.5 Information, Awareness and Civic Engagement

Effective planning and governance across different administrative levels requires high-quality information to raise awareness amongst urban residents to promote behavior change, especially in terms of consumer choice. In addition, given that cities contain large consumer markets which are potentially valuable to producers of green goods and services, information is also an essential tool to influence consumer choice. But consumer preferences, in developed and developing nations, are not always green. For example, very dense urban development is not always popular in many parts of the UK and Europe (Cheshire 2008) and the North American propensity for suburbanization is well documented. At the same time, information and active communication on the potential benefits of greener lifestyles in cities can enable consumers to make more informed decisions. For example, in Munich new residents are given an information package on green mobility opportunities.

5.6 Incentives

Information alone is insufficient to change behavior patterns; it needs to be supplemented by incentives to bring about lasting change. For example, firms and workers in 'brown industries' may face higher prices as cities shift their industrial structures towards greener models. National and city-level policy makers need to compensate these short-term losers while recalibrating urban economies. Incentives may be within the tax system (e.g. tax breaks or taxing environmental "bads"), other types of charges (e.g. road pricing) or payments (e.g. targeted subsidies). Subsidies were successfully used as part of the policy mix in the Bavarian example where Munich now has the largest green tech cluster in Germany. At the same time, full cost pricing (internalizing external environmental costs), whether as taxes or user charges is essential for inducing behaviors to be consistent with green city criteria.

5.7 Financing

Finance, particularly in times of government austerity can be a significant barrier and in some countries, national fiscal policy prevents local authorities from

Taxes	Cities need to be able to raise local taxes and service charges as they are the main revenues sources that can be used for public green city strategies
Cost recovery	Introduce user fees of municipal services to help greening these services and supporting the development of greener alternatives
Land value capturing	Financing public transport based on integrated "transport-property" development models
Micro-financing	Critical financing opportunity where micro-enterprises are involved in green city strategies, e.g. recycling developing country cities
Profit-making public companies	Cities to hold shares of profit making companies, e.g. utilities to allow for long-term green investments
Purchasing pools	Cities can also work together to purchase technology thereby bringing down the cost
Carbon credits	Clean Development Mechanisms (CDM) already pay for a range of green city projects in Bogotá, São Paulo and Dhaka

Fig. 4 Selected financing instruments

accessing the relevant funds. There are three key imperatives central to advancing on green city finance.

1. Understanding the existing financial position in terms of potential revenue, where a comparison with similar sized cities internationally is helpful.
2. City governments need to initiate a partnership with local business and community organizations, which is essential for leveraging private sector finance.
3. Horizontal and vertical networks are required especially for cross-municipal cooperation and regional and international participation in various local government policy forums.

Such examples of green financing include London and Paris, where urban bike hire schemes are paid for privately in return for prime advertising space. Figure 4 illustrates a breakdown of financing opportunities. A priority in any green urban planning is investment in cost-effective public transport infrastructure particularly over investment in road construction that further promotes private car use. Surface public transport such as bus rapid transit needs to play a central role particularly in lower income contexts. Non-motorized transport has to be recognized as basis of any transport system and requires greater shares of overall transport budgets.

6 Conclusions

Greening cities results in a wide range of social and economic benefits. As well as lowering carbon emissions, densification as a green city strategy tends to enhance productivity, promote innovation and reduce the capital cost of infrastructure. Densification can also raise congestion and the local cost of living, but green city strategies and interventions to subsidize housing costs can help to mitigate these.

In most countries cities will be important sites for the emerging green economy. Cities' basic offer of proximity, density and variety delivers productivity benefits for firms, and helps stimulate innovation and new job creation – for example in high-tech clusters, as are already emerging in urban regions like the Silicon Valley. Much of a green economy is service-based, and will tend to cluster in urban areas where consumer markets are largest.

Numerous instruments for enabling green cities are available and tested but need to be applied in a tailored, context-specific way. In contexts with strong local government it is possible to envisage a range of planning, regulatory, information and financing instruments to advance green infrastructure investments, green economic development and a multitrack approach to greater urban sustainability. City governments need to coordinate policies and decisions with other levels of government, but more importantly, they need to be equipped with strategic and integrated planning capacities, including the capacities to choose regulatory tools and economic incentives to achieve locally appropriate green city objective.

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