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ABSTRACT

Over the past 100 years, urban planners have been promoting a variety of new urban forms, called *inter alia* Sustainable, Green, Low Carbon, Livable, and Eco-cities, to improve the quality of life of citizens and the local and global environment. Numerous indicator systems have been developed to evaluate the implementation of these theories. The popularity of indicator systems is increasing as local and global constituents give greater attention to mitigating and adapting to climate change, environmental damage and resource constraints. However, no two systems are alike. Each system differentially includes, categorizes and prioritizes indicators, making it difficult to define an eco-city and evaluate the status and progress of developments.

This paper evaluates the structures and component indicators of 16 international municipal-level sustainable, green and eco-city indicator systems from the last several years. While there is some consensus regarding the most important elements in determining city sustainability, there is little agreement on the method by which indicators are chosen, the weights assigned to indicators, and the best indicators themselves. Key conceptual frameworks and indicator categories are isolated and evaluated for common elements and the results are compared to other studies. The analysis of best-practices suggests that a set of standardized core indicators need to be developed first, and then enhanced with locally-relevant indicators. Ranking could be postponed until empirical data establishes causal connections between indicators and outcomes. The findings from this study will be used to further develop a low-carbon eco-city indicator system for China.

Introduction

Sustainable cities, eco-cities and similar ideas were originally conceptualized during the industrial revolution in response to poor health and living conditions in industrializing areas (Howard, E. 1898; **Error! Reference source not found.**). Since then, the core of these theories – planning and operating cities to minimize environmental, social and other negative externalities while maximizing aesthetic, health and other benefits – has evolved in the United States and Western Europe through several stages, closely following the major environmental and social issues of each era (**Error! Reference source not found.**). The result is a diversity of definitions with little specific consensus of how the city and its subsystems should be planned and perform in relation to its inhabitants and the environment (for simplicity, all such forms are called eco-cities hereafter).

The lack of clarity in the definition of these terms is in large part the result of the relative lack of physical examples (Roseland, M. 1997; **Error! Reference source not found.**; **Error! Reference source not found.**). So few examples of eco-cities exist that best practices are still being established and these limited examples lend themselves to conceptual and procedural diversity. On the one hand, diversity is likely to continue, at least in the short term, as there is evidence of more than 100 eco-cities under development around the world, from places as different as Canada and Kenya (**Error! Reference source not found.**). On the other hand the large-scale, if still nascent, embrace of eco-city and low-carbon ideals in China could produce a large number of case studies relatively soon. As of February 2011, 230 prefecture-and-above level Chinese cities have proposed to establish themselves as “eco-cities”, accounting for 80.1% of 287 such cities nationally. 133 (46%) have set targets to develop as “low-carbon cities” (China Society for Urban Studies 2011).

In recent years, programs to improve urban governance have often included the use of indicator systems to measure progress towards established policy goals. Spurred in part by the development of Agenda 21 at the United Nations Conference on Environment and Development in 1992, there has been a rush to develop systems to measure progress at a variety of political levels: national; state or province; city; neighborhood and individual site or business entity (UN 1992). This paper explores the complex issues which accompany city-level indicators and indicator systems through the examination of 16 indicator systems which evaluate environmental, economic and social aspects of large populations groups. This analysis begins with the methodology used to isolate the selected systems and a summary of their characteristics. A second section reviews critical threshold issues for indicator systems, including the use of indicator selection criteria; the aggregation of indicator performance in ranking schemes; and the use of benchmarks to define progress. The commonalities found among systems’ indicators and their importance is discussed, followed by findings and recommendations that may serve as a foundation for future adoption or development of a transparent, systemic, and methodological indicator system.

Methodology

This project responds to current efforts by China's central government to develop a national indicator system for low carbon eco-cities based in part upon international best practices. A preliminary literature review established that the concepts of eco-cities, sustainable cities, livable cities, and similar concepts cannot be clearly differentiated. Therefore a broad first order search was conducted using the terms "eco-city", "green city," "sustainable city," "low carbon city," and "livable city" to find relevant indicator systems. These search criteria turned up both indicator systems and meta-studies of such systems, which were used to expand the list of candidate systems. Many of these systems were found to be inadequate because they lacked comprehensive definitions for indicators, lacked analysis of how indicators were chosen and for other reasons that would prevent a comparative analysis. The choice of indicator systems for this study was therefore based upon their fit with the following criteria:

1. high level reference to sustainability, green cities, eco-cities, low-carbon and livability terminology;
2. measurements at the sub-national level;
3. clarity of indicator definitions;
4. clarity of indicator choice criteria and methodology; and
5. high commonality of references in the reviewed literature.

When indicator systems had existed for several years, the most recent version was chosen on the assumption that the quality of these systems was improved through empirical testing. When a single organization was the author of multiple systems, only one was chosen to represent this organization, as was the case with the Economist Intelligence Unit's systems (EIU 2011). 16 systems at the local level (1 neighborhood level, 14 city level, and 1 provincial level) were chosen for evaluation.

Summary documents regarding these indicator systems were reviewed for information on indicator selection criteria, weighting, and benchmarking. Indicators were grouped into eight primary categories: energy and climate; water quality, availability, and wastewater treatment; air quality; waste production and treatment; transportation; economic development or health; land use and urban form; and demographics and social health. Indicators within each primary category were then analyzed for their commonality according to several secondary categories established by the researchers.

Characterization of the Reviewed Indicator Systems

Table 1 characterizes the indicator systems reviewed for this analysis. Out of 16 systems reviewed, 9 systems ranked comparative performance between cities (Ranking Systems), and 7 used historical performance in the same city to track progress (Non-Ranking Systems). The 9 Ranking Systems included an average of 26 indicators. The average number of indicators in the 7 Non-Ranking Systems was 45.

Table 1. Summary of Reviewed Indicator Systems

Type	Reference	Object of Analysis	Number of Indicators and categories
City Rankings	EIU 2011	22 largest and most important cities in Asia	29, in 8 categories
	PriceWaterhouse Cooper 2011	26 large cities of financial and political importance worldwide	4, in 1 category (only Sustainability category used. Total of 66 in 10 categories)
	Forum for the Future 2010	UK's 20 largest cities	11 indicators grouped in 3 categories
	ACF 2011	Australia's 20 largest cities	15 grouped in 3 categories
	Karlenzig et al. 2007	U.S.'s 50 largest cities	15 in 15 categories
	Corporate Knights 2011	Canada's 17 overall most populous cities and most populous city in each province	28 in 5 categories
	EU Green Capitals Program 2011	Applicant cities in Europe with population >200k	71* in 10 categories
	MONET 2009	17 cities in Switzerland	31* in 3 categories
Provincial Rankings	Esty et al. 2011.	All Chinese provinces	33 in 12 categories
Non-ranking City-level	GCI 2007	Core and secondary indicators of sustainability of urban areas to facilitate standardized policy practice sharing among member cities.	77, grouped in 20 themes
	ESMAP 2012	Tool to allow city leaders benchmark energy efficiency in their cities against similar cities to indicate best practice policies and strategies.	28, in 6 categories
	Heine et al. 2006	Indicators chosen to establish a framework and process to improve Victoria state citizen engagement, community planning and evidence based policy making.	21 in 1 Category (only Sustainable Built and Natural Environment category used, out of 75 in 5 categories)
	Sustainable Seattle n.d.	Indicators used to empower Seattle sustainability advocates and practitioners to take effective action independently and together.	99* in 22 categories (goals)
	Boston Indicators Project 2012.	Project aims to democratize access to information, foster informed public discourse, track progress on shared civic goals, and report on change	29* in 1 category (only Sustainability Category used here, out of a total of 185 in 10 categories)
	Hakkinen 2007	EU Environmental Program priorities regarding climate change, nature and bio-diversity, high environmental quality and health, and sustainable resources use and waste management.	45 in 5 categories
	Xiao, Xue and Woetzel, 2010	Tool to measure relative performance over time at city level in Chinese cities that have been the focus of sustainable development efforts.	18 in 5 categories

Source: authors' compilation.

* indicates that total may differ from official publications due to author's choice in three instances: when listed data represented two different indicators and publications indicated data were evaluated separately indicators were split in two; when indicators had been struck by the authors they were excluded; and when indicator boundaries were unclear, the similar indicator were left separate.

Critical Conceptual Frameworks

Before delving into the commonality of indicators between indicator systems it is useful to look into how their creators have dealt with three threshold issues: the criteria by which indicators are chosen; the use of aggregating and weighted ranking; and the use of benchmarking to establish absolute targets for indicators.

Indicator Selection

Number of indicators. As noted above, the number of indictors used by these systems varies greatly. Ranking System indicators, which are applied to a large number of cities, have fewer indicators. Systems developed by individual cities or those used to guide, rather than rank, cities have more indicators. This is supported by the Global City Indicators Facility finding that the 8 surveyed cities collected more than 100 indicators on average (GCI 2008). Indeed, many Ranking Systems reviewed here stated that keeping indicators to a minimum was an explicit goal so as to reduce the cost of data collection and analysis and to ensure that priority issues were appropriately emphasized.

Indicator Selection Criteria. The studies showed great differences in how indicators were selected, as shown in Table 2. Out of the 16 indicator systems, 12 discussed the criteria used to select indicators. Relevance was the only criteria used by more than half of these 12 systems. "Data availability" and "comparability" were also more common.

Table 2. Indicator Selection Criteria Used

Indicator Selection Criteria	Commonality of Use
Relevance	6
Data availability	5
Comparability	5
Easily to understand/accessible	4
Able to be influenced by actions of municipal authorities	3
Measures progress towards established policy goals	3
Data quality	2
Up-to-date	2
Used in other index systems	2
Fits on-the-ground circumstances	2
Others (18 different criteria)	1

Source: Authors' compilation

This finding of diverse selection criteria supports Tanguay's finding that 68 different selection criteria were used by 17 indicator systems reviewed there, 6 of which were most common: credibility, universality, data availability, comprehensibility, links with management, and spatial and temporal scales of applicability (**Error! Reference source not found.**). Selection criteria diversity may be due to the differing purposes of these systems. For example, the issue of ranking appears to have an impact: Ranking Systems all noted relevance was a central priority, all but one emphasized comparability, and all but two emphasized data availability. Non-ranking Systems were much more diverse in their indicator selection criteria.

Weighting and Aggregating

Weighting entails attributing relative values to one indicator relative to another, allowing performance on one or more indicators to have greater impact in determining overall ranking. In the 9 Ranking Systems, 3 overtly weigh some indicators more than others, 5 implicitly give more weight to some indicators, and 1 equally weighs all indicators. (PriceWaterhouseCooper 2011). A good example of an explicit weighting scheme is that used by the SustainLane study indicators (Karlenzig et al. 2007). It gives equal weights to 11 of the 15 indicators, and assigns a weight of 1.5 to the Commute to Work indicator due to "the direct and indirect impacts on numerous other categories" of personal automobile travel, and a weight of 0.5 to the Congestion, Affordability, and Natural Disaster Risk indicators (Karlenzig et al. 2007).

The implicit weighting scheme, which was the most common, aggregates a total score after initially grouping indicators into categories. The category-based scoring system found in the Asia Green Cities Index is an example of the implicit scheme (EIU 2011). The total score is an aggregate of subtotals of the 8 equally-weighted category scores. Indicators within each category are weighted the same against other indicators in the same category. For example, for a category with three indicators, each indicator is given a weight of 1/3 of the subtotaled category score. However, categories contain different numbers of indicators, and therefore in the agglomerated score some indicators receive more weight than others.

There are two main arguments against indicator weighting: it reduces the replicability of the indicator system and weighting can diminish construct validity. The first argument assumes that no two groups of professionals working within the same policy context would arrive at the same weighting system, if they were to act truly independently. The second argument regarding construct validity may only hold in extreme circumstances. At the heart of the argument is the question: how is one to know whether the weight assigned to any one factor is even approximately proportionate to the effect of that indicator on the desired outcome? Proving a weight is scientifically justified is not a simple task because cities are complex systems and can behave in counterintuitive and confounding ways. The policy and infrastructure adaptations which might be made in response to one relatively heavy factor may work to limit the long term sustainability of the city. One can imagine such a result occurring if, for example, air pollution emissions were so heavily weighted that egregious emitters instead decided to filter emissions through water, which they then might dump into local water bodies or underground aquifers whose quality is less of a policy priority, but nevertheless crucial to city health.

The Use of Benchmark Criteria

Tanguay introduces a choice between performance evaluations based upon threshold values, critical values, target values, and relative performance for benchmarking indicators (Tanguay et al. 2009). Threshold, critical and target values are all endogenously-set goals for indicator performance, whereas relative values rely upon comparisons to past performance or the performance of other cities. The choice of which benchmark criteria to use is determined by whether policymakers feel there are objective performance standards which hold across all cities in the indicator system, or whether relative performance is sufficient. Relative values are the most commonly used benchmarking method for the systems reviewed here. The indicator systems analyzed here rarely use benchmark values to evaluate city performance and those that do only refer to benchmarks for some indicators (generally regarding water and air quality). A good example of the use of benchmark criteria is the China Environmental Performance Index (Esty et al. 2011). This study evaluates Chinese provincial performance based upon both Chinese policy goals, international standards from the World Health Organization, and expert judgment. Esty's system is an example of the difficulty of using benchmarks, as 11 of the 24 indicators do not have benchmarks.

Common Categories and Indicators

In addition to selection criteria and the use of benchmarks, indicator system creators express priorities in three other ways: the selection of primary categories of policy importance; the selection of secondary categories to refine primary categories; and the selection of indicators.

This research has identified 8 primary categories common to all systems, and 65 secondary categories, as shown in Table 3. A secondary category refers to a more specific means of measuring or evaluating the state of the primary category issue, but is not an indicator itself as it lacks measurement units. For instance, energy use intensity as well as total energy use are both secondary categories. The secondary category of energy use intensity might be expressed by several different specific indicators: total primary energy use per GDP, household final energy use per capita, and the like. Illustrative examples of the indicators used in these secondary categories are given but do not represent equally-common measurement methods.

Table 3. Commonality of Primary and Secondary Indicator Categories

Primary Category	Commonality %	Secondary Category	Example units of measurement	Commonality %
Energy and Climate	100%	Carbon Intensity	CO_2e/ unit GDP	63%
		Energy Intensity	Primary energy consumption/unit GDP	50%
		Building Energy Use/Carbon	Number of green rated buildings per person (number per capita)	50%
		Renewable and Clean Energy	Proportion of primary energy from renewable sources (%)	45%
		Transport Energy/Carbon	Energy consumption per vehicle mile traveled (J/VMT)	38%
		Energy and Climate Change Policy	The existence of carbon emissions reduction targets (yes/no)	38%
		Split of Total Energy/Carbon Within All Sectors; Energy Security; Industry Energy/Carbon	Proportion of energy use in sectors (%); Percentage of population with authorized electricity service (%)	<30%
Water Quality, Avail-ability, and Treatment	88%	Water Consumption Intensity	L/capita/day	56%
		Water Quality	Proportion of water bodies over water quality limits (%)	44%
		Waste water Treatment Connection and Rates	Proportion of homes connected to sanitary facilities (%)	44%
		Water Availability by Carrying Capacity	Proportion of ground water extraction rate to refilling resources rate (%)	25%
		Access to Water	Proportion of households with improved water source (%)	25%
		Other; Water Policy Achievements	Marine trophic index (change in mean trophic level of fisheries landings); measure of a city's efforts to reduce pollution associated with inadequate sanitation (qualitative evaluation)	<30%
Air Quality	88%	PM10 Concentrations	Annual daily PM10 concentrations in ug/m^2	44%
		NOx Concentrations and Total Emissions	Annual daily NOx concentrations in ug/m^2	31%
		Other Types of Emissions; Index of Multiple Air Pollutant Concentrations; Exceedance of Air Quality Benchmarks; SO2 Concentrations and Emissions; O3 Concentrations and Emissions; Other	Toxicity equivalent tons released by nearby industrial firms (toxicity equivalents); Ambient concentration of air pollutants in urban areas (ozone, Pm10, Pm2.5, SO_2, NO_2, and Pb, CO, NO, VOCs); Number of days when pollution concentration exceeds guideline; Pop. Weighted SO_2 concentrations (ug/m^3)	<30%

Primary Category	Commonality %	Secondary Category	Example units of measurement	Commonality %
Waste	88%	Waste Generation Intensity	Total waste generated (kg/cap)	69%
		Waste Treatment – Recycling	Proportion of solid waste that is recycled (%)	56%
		Waste Treatment – Diversion from Landfill; All Treatment of Total by Proportion; Waste Treatment – Landfill Disposal; Waste Capture Rates; Other Treatment; Other Waste Indicators	Percentage of municipal solid waste diverted from the waste stream to be recycled (%); Share of waste collected in the city and adequately disposed either in sanitary landfills, incineration sites or in regulated recycling facilities (%).	<30%
Trans-portation	88%	Transportation Facilities and Infrastructure	Cars per capita	69%
		Modal Use	Proportion of commutes by non-automobile means (%)	69%
		Accessibility of Transport Options	Proportion of people living near public transit (%)	38%
		Policies; Other; Air Transport.	Measure of a city's efforts to create a viable mass transport system as an alternative to private vehicles (qualitative); energy consumption by transport mode (% of total transport energy); commercial air connectivity (# of flights)	<30%
Economic Health	75%	Employment	Unemployment rate (%)	50%
		Green or Innovative Sectors	Number of farmers markets per capita;	44%
		Cost of Living	Proportion of income spent on housing (%)	44%
		Other	Local score on competitive index	38%
		GDP and Income	GDP per capita	31%
		Debt, Savings, and Investment Levels; Government Financing; Businesses with Environmental Management Systems; Resource Productivity.	Average savings rate (% of income); Debt service ratio (debt service expenditures as a percent of a municipality's own-source revenue); % of organizations with registered environmental management system; resource productivity (GDP/annual quantity of raw materials extracted from the domestic territory of the focal economy, plus all physical imports minus exports)	<30%
Land Use and Urban Form	88%	Public Green Space	Proportion of city as dedicate green spaces	63%
		Population Density	Number of people per m^2	56%
		Biodiversity	Number of bird specific present versus potential in region	38%

Primary Category	Commonality %	Secondary Category	Example units of measurement	Commonality %
		Other; Protected Lands; Built Up Area Forestry; Policies; Smart Growth Index; Ecological Footprint; Agricultural lands.	% of lands under legal conservation; Soil sealing (m^2)/cap; Proportion of county acreage in forest and farmland (%); does the city have a comprehensive urban biodiversity monitoring program?; Acres of farmland in production by product in Agricultural Production Districts (total)	<30%
Demo-graphics and Social Health	81%	Health	Average life expectancy (years)	50%
		Education	% of adults with a high school degree or equivalent (%)	50%
		Public, NGO, and Academic Participation	Voter participation rate (% of eligible)	44%
		Aesthetics	Adults who say they are satisfied with city environment (%)	38%
		City Leadership in Collaborative Efforts	Existence of efforts by city to monitor environmental performance (qualitatively evaluated)	31%
		Risks and Crime; Equity; Other; Noise.	Number of homicides per 100,000 population; Proportion of urban population living in slums (%); Awareness raising and training to encourage the development and take-up of environmentally friendly technologies, particularly through training in industrial and business settings (qualitatively evaluated); share of population exposed to noise values of L (day) above 55 dB(A) (%)	<30%

Source: Authors' compilation

Table 3 illustrate that while there is consensus on primary categories, the types of indicators in each primary category vary significantly. These results are comparable to research by the University of Pennsylvania's PennDesign Institute that looked at 22 national, regional, city, neighborhood and site indicator systems mostly in Western countries. Majority consensus was found for a few environmental categories ("reducing air pollution", "environmental responsibility", "water quality", "energy conservation", "waste reduction", and "reduced VMT"), whereas less consensus was found for social and economic goals (Andreason et al. 2011). Environmental issues also predominate in the current study, with economic and social goals less commonly used.

The secondary category findings are particularly valuable in showing policy priorities because there is significantly less agreement in the use of specific indicators. Within the 16 indicator systems analyzed here, only 10 indicators were common to more than 2 systems. The two most common indicators, "total water consumption in liters/capita/day" and "CO_2 emissions in tonnes/capita/day" were found in 7 systems. Two indicators were found in 5 systems, 1 was found in 4 systems, and 5 indicators were found in 3 systems. This lack of commonality in the use of specific indicators is not surprising given the results of other city indicator meta-studies and strongly indicates that even if indicator systems agree upon priority issues, they rarely agree on the best means by which to measure progress. This is comparable to Tanguay's study of 17 municipal level indicator systems that found that 72% of indicators were used by only one system, and none were used by a majority of the systems (Tanguay et al. 2009). Research undertaken by the Global City Indicators Facility found that within eight examined cities over 1,000 indicators were being collected with only three indicators common to all cities.

Findings and Recommendations

The trend in indicator choice criteria is clearly towards data availability and the more loosely defined "relevance" and "comparability"; however this is more strongly seen in ranking systems conducted by non-government organizations and corporations. The types of parties undertaking this research are usually resource-constrained in developing new data, however a few non-governmental organizations have worked to increase data availability regarding social and economic indicators with custom-built surveys. Cities often rely upon data gathered by high-level (for example, county, province, and state-level data), but the relevance of this data to city managers is questionable. Few systems examined an empirical connection between indicator values and final outcomes with regards to the achievement of policy priorities. Empirical research tying indicators to outcomes would increase transparency and reduce uncertainty in selection criteria. While this data develops, evaluating cities based upon relative improvements over time may enhance administrative incentives and public transparency.

Many systems reviewed here acknowledged a need to keep indicator systems small to reduce compilation costs and lower access barriers. The right balance between comprehensiveness and practicality of compilation and use is still undetermined and requires more research.

Whether cities can or should be ranked according to over-all indicator performance remains controversial. The use of universal threshold benchmarks is uncommon and there is little explicit agreement on how indicators or indicator categories should be weighed. New, large-scale indicator system construction efforts being undertaken by ICLEI, the U.S. government and other organizations may work to improve inter-comparability and consensus on indicators of importance and their weights (Geyer 2012, GAO 2011, ICLEI USA 2011, Eco-city Builders 2010). However, the multiple iterations undertaken by the multi-year indicator systems evaluated here is an indication that these systems might also continue to develop over time. Further, data directly linking indicator performance to desired outcomes would more greatly support standardized weighting than expert consensus.

There is a certain degree of high level consensus on the types of phenomena which should be measured by indicator systems applied to sustainable, green, eco-, and similarly labeled cities. All eight primary categories were included in the strong majority of systems, however social and economic issues were least commonly and most diversely measured. Evaluations at the secondary level indicates that the majority of indicator systems include carbon intensity, energy intensity and building energy use, water consumption intensity, waste generation, waste recycling, measures of the extent of transportation infrastructure, transportation modal use, employment; public green space, population density, health and education as key eco-city issues. This analysis can help narrow the scope of future projects.

The diversity of these systems strongly supports the finding that the structures and indicators used in these systems explicitly or implicitly reflect policy priorities of their developers. Although several ongoing efforts are attempting to build globally-applicable urban indicator systems, the resulting indicator systems will undoubtedly differ from national policy priorities. Furthermore, few indicator systems discuss the methodological challenges of comparing cities with very different physical and social circumstances, even within the same nation. The value of chronological comparisons found in single city systems is instructive –annual improvements may be a more important indicator of the city's status than comparisons between dissimilar entities and can better inform city-level policy makers of their successes. However, allowing cities to form their own indicators limits comparability and the sharing of best-practices. Working towards a nationally-applicable indicator system which combines both nationally-relevant indicators applicable to all cities and a number of indicators specific only to certain kinds of cities (for instance, industrial cities rather than services cities) may be an appropriate middle ground. Further research is needed to determine how cities should be grouped to determine best non-core indicators by city type

Conclusion

Governments at all levels and other stakeholders are increasingly using indicator systems to give a transparent, systematic, and methodical evaluation of city policy achievements. The use of city-level indicators is nearing ubiquity in developed economies and is quickly spreading to less-developed economies. Although there is wide-spread consensus on high level issue areas, little agreement exists regarding specific indicators. Wide variance in indicator systems and their structural choices shows that international consensus on the best indicators may not be possible. Developing a set of very few core indicators, supported by city-specific non-core indicators, present a practical solution to the issue of comparability and standardized evaluation. This study has resulted in a preliminary set of secondary categories to be used as core indicators. Potential indicators within these categories will be evaluated based upon their relevance to China's national policy goals, data availability, and comparability, and other appropriate selection criteria. Non-core indicators may be developed to isolate regional or city-specific issues. After further evaluation of the issue of weighting, a software tool will be created to aggregate city-scores into a final performance ranking.

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References

[ACF] Australia Conservation Foundation. 2011. *Sustainable Cities Index: Ranking Australia's 20 Largest Cities in 2010* Melbourne, Victoria, Aus.: Australia Conservation Foundation.

Andreason, S. 2011. "Developing a Sustainability Indicator System." Presentation given at the Community Indicators Consortium Conference, Philadelphia, Penn. April 12.

Basiago, A.D. 1996. "The search for the sustainable city in 20th century urban planning." *The Environmentalist,* 16(2): 135–155.

Boston Indicators Project. 2012. "Sustainable Development" http://www.bostonindicators.org/ Indicators2008/SectorCrosscuts/Default.aspx?id=10474. Boston, Mass.: Boston Indicators Project.

China Society for Urban Studies, Ed. 2011. *The Progress Report on China's Low-Carbon Eco-city Development.* Beijing, China: Building Industry Press.

Corporate Knights of Canada. 2011. The 2011 Most Sustainable Cities in Canada. Corporate Knights Magazine 34.

Ecocity Builders. 2010. *International Ecocity Framework and Standards.* Oakland, Calif.: Ecocity Builders.

[EIU] Economist Intelligence Unit. 2011. *Asian Green City Index: Assessing the Environmental Performance of Asia's Major Cities*. Munich, Germany: Siemens AG

[ESMAP] Energy Sector Management Assistance Project. 2011. *Tool for Rapid Assessment of City Energy (TRACE): Helping Cities Use Energy Efficiently* Washington, D.C.: World Bank.

Esty, D., M. Levy, J.Wang, and H. Chan. 2011. *Towards a China Environmental Performance Index*. NewHaven, Conn: Yale Center for Environmental Law and Policy.

EU Green Capitals Program. 2011. *Application form for the European Green Capital Award 2014*.

Forum for the Future. 2010. *The Sustainable Cities Index 2010: ranking the 20 largest British cities*. London, UK: Overseas House.

Geyer, Josh (U.S. Department of Housing and Urban Development). 2012. Personal Communication. February 1.

[GCI] Global City Indicators Facility. 2007 "Themes", available at http://www.cityindicators.org/themes.aspx. Toronto, Ontario: University of Toronto.

___. 2008. “Global City Indicators Preliminary Report.” Toronto, Ontario: University of Toronto.

Hakkinen, T. (ed.). 2007. “Trends and Indicators for Monitoring the EU Thematic Strategy on Sustainable Development of Urban Environment: Final Report Summary and Recommendations”, Finland: VTT Technical Research Center of Finland.

Heine, W., A. Langworthy, N. McLean, J. Pyke, H. Raysmith, and M. Salvaris. 2006. *Measuring Wellbeing, Engaging Communities: Developing a Community Indicators Framework for Victoria: The final report of the Victoria Indicaotrs Project.* Melbourne, Victoria: Institute of Community Engagement and Policy Alternatives (ICEPA), Victoria University,

Howard, E. 1898. *Garden Cities of To-morrow*, London: S. Sonnenschein & Co., Ltd. 1898.

ICLEI USA. 2011. “STAR Community Index Update, October 2011.” http://www.icleiusa.org/news/star-community-index-update-october-2011. Oakland Calif: ICLEI USA.

Jenks, M., and Jones, C. 2010. “Issues and Concepts,” in *Dimensions of the Sustainable City,* eds. M. Jenks and C. Jones. London, U.K.: Springer.

Joss, S. 2010. “Eco-cities – a global survey 2009.” *WIT Transactions on Ecology and The Environment* 129: 239–250.

Karlenzig, W., F. Marquardt, P. White, R. Yaseen, and R. Young. 2007. *The SustainLane U.S. City Ranking: How Green is your City?* Gabriola Island, B.C.: New Society Publishers.

MONET, 2009. *Cercle Indicateurs: Vue d'ensemble des indicateurs centraux - Relevé 2009*. Switzerland Federal Office of Statistics: Geneva, Switzerland.

PriceWaterhouseCooper, 2011. “Cities of Opportunity.” New York, N.Y.: PriceWaterhouseCooper.

Roseland, M. 1997. “Dimensions of the eco-city.” *Cities* 14(4), August: 197–202.

Sustainable Seattle. N.d. “All Indicators” http://www.b-sustainable.org/indicator_index. Seattle, Wash.: Sustainable Seattle.

Tanguay, G.A.; J. Rajaonson, J. Lefebre, and P. Lanoie. 2009. “Measuring the Sustainability of cities: an analysis of the use of local indicators”. *Ecological Indicators,* 10, 407–418.

[UN] United Nations. 1992. *Earth Summit: Agenda 21: the United Nations Programme of Action from Rio.* New York: United Nations.

Wheeler, S.M., and T. Beatley. 2004. *The Sustainable Urban Development Reader*. New York, N.Y.: Routledge.

Xiao, G., L. Xue, and J. Woetzel, 2010. *The Urban Sustainability Index: a new tool for measuring China's cities*. New York, N.Y.: The Urban China Initiative.