City Resilience Index

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(Front Cover)

Community workshop
in Surat

Executive summary

The City Resilience Framework is an initiative led by Arup with the support of the Rockefeller Foundation to provide an accessible, evidence-based articulation of city resilience. The framework will be further developed to create a City Resilience Index (CRI) to identify variables that provide a robust basis for measuring resilience at the city scale. To facilitate the development of the CRI, the Urban Measurement report has been developed to understand how indicator frameworks and variables have been developed and applied in a variety of urban contexts, and assessing the implications for the CRI.

The Urban Measurement report summarises research undertaken by Arup on practices, drivers, challenges and frameworks related to urban measurement, and assess how these approaches could inform the development of the CRI. As the CRI was initially aimed at developing an index, the report specifically explores how indices are used by different frameworks and the merits, challenges and utility of creating an index.

The report is based on a review of 11 documents on the use of indicators and 24 different indicator frameworks. There is no single framework available at the moment that enables resilience to be measured holistically and comprehensively at a city level. Most of the indicator frameworks identified addressed disaster risk management, urban resilience, climate change and sustainability. There is a strong need for a framework like the CRI to be created to enable adequate measurement of resilience at a city scale.

Indicators can serve as powerful tools for cities to understand their performance, identify weaknesses and gaps, and develop actions aimed at improvement. Given the objective of the developing the CRI framework is to influence plans, policies and investments to support resilience, rather than benchmarking the performance of one city to another, it is recommended that an indicator framework be used that does not aggregate data into an index. An index would require data from vastly different systems (transport and health for example) to be weighted and aggregated together, which means the ability to understand resilience at a system level is lost. As the users of the CRI would be the city's own departments, it would be very beneficial to be able to give access to data at a disaggregated systems level. Clustering indicators by thematic areas or sub-indices without any aggregation may help to communicate the range of issues addressed by the CRI in a clear manner.

To enable resilience improvements to be tracked over time, specific, measureable indicators would need to be established. In reality, this may be quite challenging with a topic as complex as city resilience. Some socially-focused indicators may have to be developed using qualitative indicators or these indicators may need to be measured using an ordinal scale. The CRI framework will also need to capture a mix of leading and lagging indicators. Lagging indicators will be useful for measuring the current state of performance. Leading indicators will help to ensure actions to improve resilience are being put into place, particularly for issues where there is a long time period between putting the action into

place and evaluating the effectiveness of the action. Context indicators are useful, as they provide users an understanding of how external factors may affect performance.

Given that the CRI framework will be the first time cities assess their resilience comprehensively, they may wish to seek a third party to facilitate the assessment process, while starting to build their own assessment capacity. In addition, cities may wish to undertake a materiality test to determine the most critical indicators to measure, as well as assess how their sphere of influence may affect their ability to collect and use data. It is also important that cities have a clear idea of the depth of the assessment they wish to undertake and plan accordingly.

The analysis of the 24 indicator frameworks provides good insights for structuring the CRI. Indicator frameworks can be quite comprehensive, with as many as 128 variables. Typically they aggregate at the levels of about 4 sub-indices, each which may have about 4 indicators, which in turns each may have 5 variables on average. As it is geared at influencing change, the CRI framework will need to utilise a large number of variables that can holistically and comprehensively measure resilience. However, aggregating beyond indicators into an index or sub-index level will make it difficult for users to understand and track performance.

The evidence from the analysis suggests that the assessment approach process should be led by the city, though some degree of support or facilitation may be necessary. Cities need to take ownership of resilience, and adopt the CRI as their own. Taking ownership of the CRI is essential to building a city's commitment to understanding and addressing its resilience, and capacity to carry out subsequent assessments.

In terms of visual outputs, there are numerous options available. A bullseye diagram has the benefit of being able to show a vast array of indicators and to quickly communicate performance through colours. It also enables qualitative and quantitative data to be incorporated. A digital dashboard could also be a useful tool due its multiple modes and levels of visual display which can be filtered by users.

In summary the specific implications the development of the CRI are as follows:

- Define a clear purpose and audience for the CRI- if the CRI is focused on driving performance improvement, , then the user is the city leadership
- Establish a broad universe of variables but allow flexibility in selecting the most relevant variables
- Aggregate up to indicator level only to enable greater transparency
- Include different types of variables as appropriate (leading, lagging, innovation and context variables)
- Use established variables that are already in use by government and industry where possible
- Identify systems or functions related to variables to facilitate their use within city government
- Strengthen capacity and ownership of CRI assessment, using outside facilitation to support the initial baseline assessment

Introduction

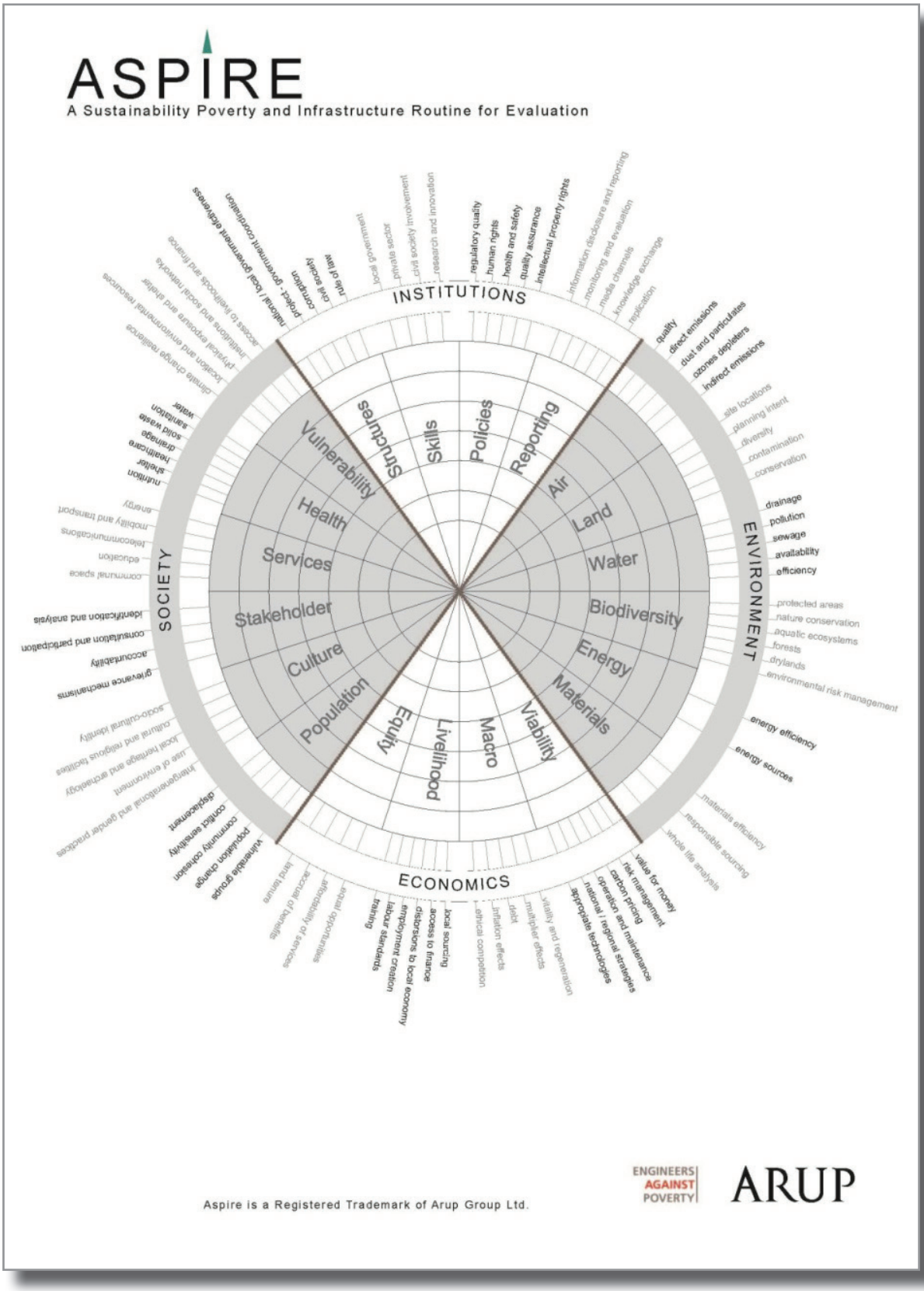
Based on the principle that you cannot manage what you don't measure, assessing city resilience is a critical step in strengthening the ability of a city to withstand, recover from, and adapt to shocks and stresses. A number of governmental and private organisations have developed frameworks and indicators to tackle the challenge of measuring resilience over the past few years. Each of these have adopted different perspectives; some emphasize the human and social capacities of communities (IFRC, 2011) while others focus on the role played by technology in enhancing the performance and preventing failure of urban infrastructure (Siemens, 2013). The frameworks that relate specifically to cities or urban areas have tended to focus on sustainability and natural hazards, particularly disasters and climate change (ACCCRN, 2012; CityNet el al., 2010; UNISDR, 2012). At present there is no single set of indicators that enables resilience to be holistically and comprehensively measured at a city scale. There is a clear need to develop a framework and indicators to reflect the factors that influence human behaviour and the performance of physical assets, as well as the perspectives and contributions of a wide range of city stakeholders (Arup, 2014).

Recognising this gap, the City Resilience Index (CRI) is being developed by Arup with support from the Rockefeller Foundation. The CRI will provide an accessible, evidence-based method for measuring resilience at the city scale. It is aimed at informing urban planning, practice, and investment patterns so as to better enable urban communities to survive and thrive following significant social, environmental, or economic stress and disruption.

The purpose of this report is to summarise research undertaken by Arup on practices, drivers, challenges and frameworks related to urban measurement, and assess how these approaches could inform the development of the CRI. As the CRI was initially aimed at developing an index, the report specifically explores how indices are used by different frameworks and the merits, challenges and utility of creating an index.

The report is structured as follows:

- **Literature Review** summarises the review of relevant academic literature and 'grey literature' on the use of indices/indicators, their selection, structure, aggregation, and challenges and limitations associated with the development and use of indicators
- **Measurement Framework Analysis** presents an analysis of 24 existing measurement frameworks in terms of their focus, structure, ownership and outputs
- **Implications for CRI** discusses the implications of these approaches for future development of the City Resilience Index.
- **Appendix A** summarises the different urban measurement case studies reviewed
- **Appendix B** summarises the frameworks reviewed by purpose, ownership, structure and product


ASPIRE
A Sustainability Poverty and Infrastructure Routine for Evaluation
INSTITUTIONS
regulatory quality
human rights
health and safety
quality assurance
intellectual property rights
information disclosure and reporting
monitoring and evaluation
media channels
knowledge exchange
replication
research and innovation
civil society involvement
private sector
local government
rule of law
civic society
corruption
national / local government coordination
policies - government alignments
ENVIRONMENT
quality
direct emissions
dust and particulates
ozones depleters
indirect emissions
site locations
planning intent
diversity
contamination
conservation
drainage
pollution
sewage
availability
efficiency
protected areas
nature conservation
aquatic ecosystems
forests
drylands
environmental risk management
energy efficiency
energy sources
materials efficiency
responsible sourcing
whole life analysis
ECONOMICS
value for money
risk management
carbon pricing
operation and maintenance
national / regional strategies
appropriate technologies
viability and regeneration
multiplier effects
debt
inflation effects
ethical competition
local sourcing
access to finance
disbursions to local economy
employment creation
labour standards
training
regular opportunities
affordability of services
access of tenants
land tenure
vulnerable groups
population change
community cohesion
conflict sensitivity
displacement
intergenerational and gender parities
use of environment
local heritage and archaeology
cultural and religious factors
socio-cultural identity
grievance mechanisms
accountability
consultation and participation
identification and analysis
SOCIETY
nutrition
shelter
healthcare
drainage
solid waste
sanitation
water
energy
mobility and transport
telecommunications
education
communal space
access to welfare and finance
institutions and social networks
access to employment and shelter
physical environmental resources
location and climate resilience
Air
Land
Water
Biodiversity
Energy
Materials
Viability
Macro
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Literature Review

The literature review was based on a review of 11 documents, comprising both peer-reviewed academic papers and 'grey' literature. Some documents focused on resilience and disaster risk management, while others were more broadly focused on the use of indicators for performance measurement, reporting and management in cities, companies and countries. They were chosen via academic research databases and related on-line searches to give an indication of current thinking regarding the creation of indices and indicators for urban measurement.

The literature review sought to address:

- What are indicators and indices?
- What is the rationale or motives behind their creation?
- How do indicator frameworks address complexity and aggregate information?
- What types of indicators or variables can be used?
- What are the key challenges when designing and implementing a framework for urban measurement?

(Opposite)

Arup's ASPIRE sustainability assessment tool for infrastructure projects

Defining Indicators and Indices

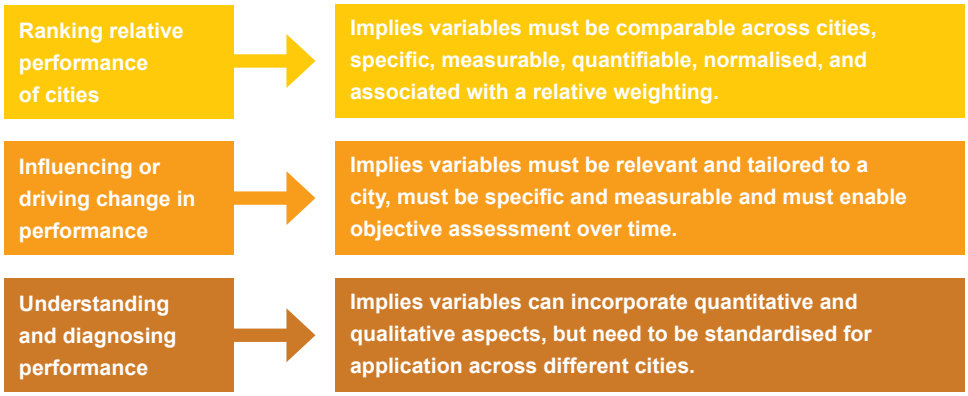
The literature review and analysis of frameworks suggests the term indicator is used to mean different things in different contexts. For the purposes of this report, the terms are defined as follows:

- An index is a composite representation of numerical measurements, manipulated in some manner to give a single value (Morse, 2004). An index is commonly referred to as an "aggregated index", as it is composed of a large quantity of aggregated information. As discussed in the measurement framework analysis section of this report, not all indicator frameworks aggregate values under an index.
- A sub-index or category is a composite representation of several indicators. These can either be aggregated into a single number (index) or presented in a category or thematic grouping (set of indices).
- An indicator is a value or a group of variables that give an indication or direction. Indicators are used to measure conditions and changes over time. If used as part of an index, they may be weighted to reflect their relative importance (Simpson, 2006). Indicators are defined by clustering, aggregating or multiplying several variables that relate to the same topic and are measured together (Cutter, Burton, & Emrish, 2010).
- Variables are information (data) to be used for analysis, reasoning, or decision-making (Simpson, 2006). They are used to represent performance of an indicator.
- Metrics define precisely how variables are measured and are quantitative in nature.

Understanding the Purpose and Audience

Understanding how indicators will be used and who is their intended audience is essential to defining appropriate indicators. Review of a wide range of indicator frameworks suggests there are three main motivations for developing indicators. Figure 1 provides a summary of how indicators differ based on the motives for their creation.

Figure 1: Motives for developing indicators



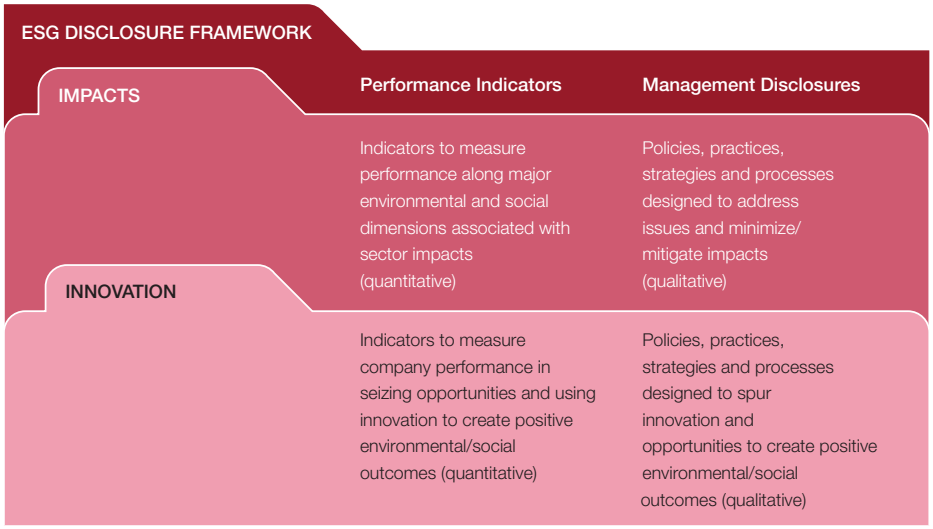
The first motive is to rank and compare performance. Indicators developed to rank and compare performance are more competitively and externally focused. They create an index to derive a single weighted score than can be used for ranking purposes. A good example of this is the World Bank Doing Business initiative, which assesses and ranks countries on a range of factors that make it easier to establish and thrive as a business.

The second motive is to influence and drive change in performance. These indicators are used to influence decision making (such as plans, policies and investments), and track performance improvement over time. There are two types of influence indicators: (1) those developed, used and reported on directly by entities; and (2) those developed by outside organisations which are trying to influence decision-making. The key distinguishing factor is that they are quantifiable, regularly tracked and aimed at influencing decision-making. For example, the city of Dublin has developed its own set of sustainability performance indicators, drawing on the Global Reporting Initiative, the Natural Step framework and stakeholder input. It is now using these indicators to track and report on its sustainability performance, as well as to understand how sustainability initiatives can support performance improvement.

Research shows disclosure of performance may provide a good incentive to improve performance. A well-known example of this is the disclosure of releases of toxic emissions in facilities and communities across the US. The publication of the Toxic Release Inventory (TRI) has driven companies to reduce their toxic emissions and commit to significant reduction targets for the future (US General Accounting Office, 1991).

Another good example of how indicators can be designed to drive performance is the use of "innovation indicators" (figure 2) that may encourage an organisation to adopt more innovative approaches and business models for the future (IRI, 2010). For example, a water utility may commit to reporting the proportion of water it recycles/reuses, even if it capacity is limited at present; it may then start developing strategies to increase water recycling to demonstrate it is progressing in this area.

Figure 2: The corporate sustainability indicator framework proposed by the IRI includes indicators that address environmental, social and governance impacts and those that focus on innovation. (IRI, 2010)



The third motive for creating indicators is to understand or diagnose performance. There are two types of indicators within this category: (1) indicators that are used as part of a quantitative or qualitative assessment by an entity and which are not regularly tracked and reported on; and (2) indicators which have been developed by an external entity purely for informational purposes. For example, the UNISDR 10 Essentials Pilot uses a self-assessment checklist that incorporates a qualitative assessment of resilience. It is meant to serve as an informative diagnostic tool, but is not designed to support regular performance monitoring and tracking. An example of indicators developed by an external organisation for information purposes is the World Bank's World Development Indicators, which covers 1200 indicators from every world economy.

Facilitating Decision-making

Indicators can serve as powerful tools to facilitate and support decision-making by policymakers. They can be used to create benchmarks and identify areas of opportunity, thereby helping to set priorities, measure progress, and aid in the decision-making progress (Cutter, Burton, & Emrish, 2010). Indicators also allow for comparison of performance across different communities (Cutter, Burton, & Emrish, 2010); as such, they can be employed to direct resources to those who need it most or to where the resources would be most effective (Global Adaptation Institute, 2012).

Local and national governments also use indicators as a mechanism to communicate performance with stakeholders and demonstrate transparency in government; this in turn may help community members to make more informed decisions about plans or policies put forward for consultation, as well as inform their decisions at the ballot box.

Managing Complexity

Cities are complex, dynamic environments made of multiple inter-related systems that are competing with other cities for investment and resources. Measurement provides a means to monitor, benchmark, and manage performance across different inter-connected systems. To enable this complexity to be better understood, frameworks that can organise data to create concise views and interrelationships are needed (Jeannette Heycox, 2007). This is particularly true for multi-dimensional concepts such as resilience which cannot be readily measured.

A framework to measure city resilience would need to use a vast number of variables that draw on a wide range of interacting systems within a city. However, having a large number of variables makes it is difficult to quickly understand the degree of resilience of a city. An indicator made up of many variables is one way to overcome this difficulty. An indicator can be used to summarise performance across related or thematic sets of information. An index goes a step further, aggregating indicators into a single measure that depicts performance. For example, the Fund for Peace annually produces the Failed States Index which combines very diverse country level data on civil conflict, human rights, state legitimacy, poverty, etc. into a single score that is then used to rank countries on their vulnerability and risk of collapse or conflict. Likewise the Human Development Index combines three different indices (a life expectancy index, an education index, and an income index) into a single value for a country.

Aggregation by Design

Both an index and indicators summarise complexity, not by accident but by design. Variables, which may relate to a diverse and complex array of information, are aggregated to produce simple and informative values that are easy to understand. Aggregation may involve transforming data into a numerical performance score and then establishing weights in order to combine data.

The advantages of using an index or indicators are that they organise and filter a mass of data, communicating it in a succinct, recognisable and approachable format that is useful to the specific audience. Aggregating data formalises and make transparent what is often done implicitly (Jollands, 2003). Proponents of indices argue that it is better to make this process explicit by creating an aggregated index rather than relying on the implicit aggregation that inevitably happens (Jollands, Lermit, & Patterson, 2003).

Caution needs to be exercised when using and communicating indices in particular. An index masks how performance has been calculated and how data has been aggregated, and hides valuable information about underlying components of the index and data sets. By summarising data into a single quantitative score, indices take on an objective authority that commands, but does not necessarily merit, respect (Morse, 2004). Nonetheless, according to Jollands et al., 'people who are removed from the measurement process have a greater willingness to accept the simplification, and potential distortion of information for the sake of obtaining an easy-to-understand, sometimes crude, picture of [a complex idea]' (Jollands, Lermit, & Patterson, 2003).

In determining if an index is appropriate, it is important to think about whom the intended audience is and how they will use the indicators. Although the disaggregated information may be provided alongside the index, some end users may not be able to understand or make sense of disaggregated data (or vice versa, an index). For example, members of the public may find an index easier to understand, while policy makers may also prefer data to be presented with some level of aggregation in order to inform decisions and compare performance across different communities. Scientists and technicians, in contrast, may prefer raw data sets free of any aggregation.

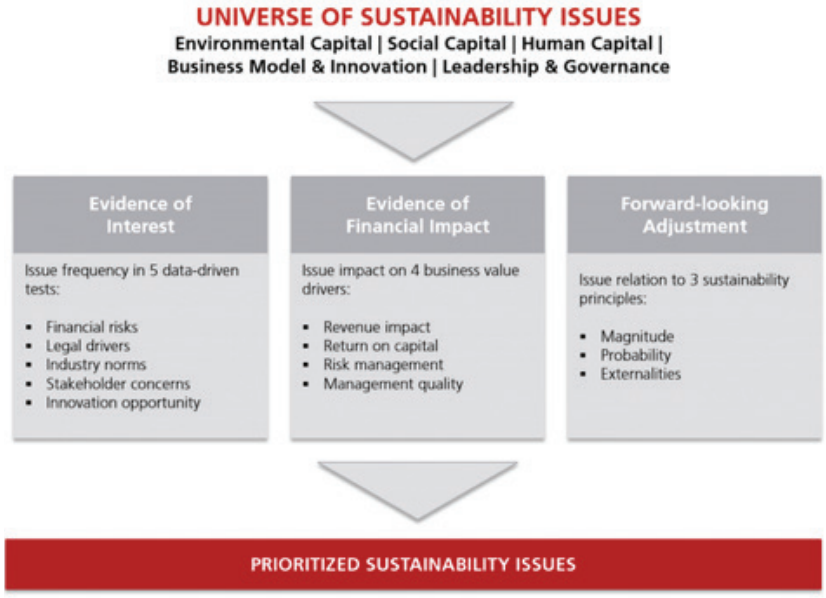
An interesting challenge occurs when multiple audiences with different interests are identified, for example, policy makers and the public. A solution might be partial aggregation to create sub-indices, or inclusion of several layers of information in the output.

Assessing Relevance or Materiality

Some indicator frameworks have been designed to have global applicability and include a broad and vast set of variables for performance measurement. Organisations are then encouraged to assess which indicators are most relevant or material to them and focus their performance measurement just on these. An example of this is the corporate sustainability reporting indicators being developed by the Sustainability Accounting Standards Board (SASB). SASB has defined a broad universe of over 40 sustainability issues addressing environmental capital, social capital, human capital, business model and innovation, leadership and governance (figure 3). It has developed a materiality framework to prioritise sustainability issues that are most relevant for specific industries (figure 4). It is then developing indicators and variables tailored to the material issues faced by a particular industry.

Figure 3: SASB's universe of sustainability issues

Figure 4: SASB's materiality framework to prioritise sustainability issues



Types of Indicators

There are different types of indicators that can be used to measure performance. Highlighted below are two which are particularly relevant to city resilience: leading/lagging indicators and context indicators.

Leading versus Lagging

Indicators and variables may be classified as being either leading or lagging. Lagging indicators provide a rear-view perspective; they reflect historical performance by measuring outcomes or impacts that have already happened. They are useful for identifying changes retrospectively and are usually easier to measure, but they are harder to directly improve or influence. Examples include the numbers of deaths resulting from a cyclone, crime rate or the unemployment rate. Leading indicators are typically input-oriented. They address actions taken to achieve a specific outcome (such as policies, practices, programmes or processes), or to the conditions that enable appropriate action to take place. They are usually more difficult to measure quantitatively, but are usually easier to directly influence. Examples of leading indicators include public education awareness campaigns to raise awareness of risks or microfinance programmes that can support creation of microenterprises. Indicator frameworks that are externally focused typically use lagging indicators, while those used to drive change within organisations may use a mix of both lagging and leading indicators.

Context Indicators

Context indicators are indirect indicators which may be useful for understanding the background situation or context related to a specific issue. For example, when discussing national level data, typical context indicators used are GDP per capita, population, literacy rate, etc. Context indicators can be used to give background information that helps a user understand how external or exogenous factors may affect performance. In addition, context indicators may help to explain different performance levels across different entities being measured. Context indicators are typically not under the direct control or influence of the entity seeking to use them.

In the context of city resilience, it is essential that cities identify what context indicators need to be assessed in order to develop effective resilience programs. Cities also need to track context indicators over time to ensure there aren't changes in exogenous factors which may call for redirection of plans or programmes. For example, a decrease in a city's precipitation levels may explain the need for water efficiency and conservation.

Challenges and Limitations

The literature review identified a number of practical challenges and risks associated with urban measurement and in particular the creation of an index or set of indices.

Qualitative versus quantitative

Ideally, indicators should use quantitative metrics to facilitate aggregation, objectivity and comparability of data over time. Quantitative metrics also enable targets for performance improvement to be established. However, some indicators may be difficult to measure quantitatively and require some form of qualitative measurement.

One way to overcome this challenge is to transform a qualitative assessment into a quantitative assessment by using an ordinal scale. For example, the UNISDR's Ten Essentials Pilot uses a quantitative score from 1 to 5 that reflects a qualitative assessment for performance. A score of 5 for example is given to denote that "comprehensive achievement has been attained, with the commitment and capacities to sustain efforts at all levels". While this approach still involves subjective analysis, it improves clarity and transparency.

Subjectivity in metric aggregation

Determining how data will be aggregated is highly subjective. In order to produce a single, one-dimensional ranking, all of the data collected for a given city needs to be consolidated into a small set of numbers or a single number (ie an index). There is no common framework that provides guidance for how aggregation should be carried out to create an index or sub-index.

Establishing a relative weight in order to combine indicators is inherently subjective, unless weights are defined through a sophisticated regression analysis. If weighting takes place at multiple levels, for instance in creating indicators and then a final index, the final result will be significantly distorted, potentially leading the reader to misinterpret the data (Jollands, Lermit, & Patterson, 2003; Simpson, 2006).

In addition, most indices are made up of information that has different units (dollars, miles, degrees, etc.) that must first be converted into an equivalent unit-less scale before weights can be applied. This leads to one of the main challenges with an index, which is that indicators become proxy measures and may not truly represent the true nature of what is being measured (Simpson, 2006).

Interpreting non-linear numbers

A further challenge related to aggregation is that as the data is unit-less, a linear interpretation of results is impossible. This is illustrated in table 1 which shows the Human Development Index (HDI) for Spain and Italy is roughly twice that of Nigeria. This suggests that the quality of life in the European countries is twice as high as that of Nigeria, but comparing GDP/capita indicates a much greater difference and is arguably more revealing of the true situation. (Morse 2004).

Table 1: Difference in scale between the Human Development Index and GDP/capita

	HDI (2002)	Real GDP/capita ($PPP) (2000)
Italy	0.913	23,626
Spain	0.913	19,472
Nigeria	0.462	896

It is important therefore to make sure there is transparency in how data in transformed into an index to ensure there is common understanding of what the final number actually represents.

Interpreting good performance

In the absence of recognised norms or benchmarks, it may be difficult for a city to interpret whether its performance in a given indicator is good or needs to be improved. For example, while it is clear that cities should strive to have the percentage of people living in poverty be as low as possible, it is less clear what average or bad performance looks like. While in Sub-Saharan Africa poverty rates range between 20 – 60%+, in East Asia poverty rates range from 10 – 40% (CIA The World Factbook, 2012).

Caution is needed in interpreting results of performance assessments and ensuring they are context-specific. Some indicator frameworks address this issue by establishing targets or benchmarks based on good practice. Others establish year 1 data as the benchmark and then try to improve performance thereafter.

Availability of data

Data availability can be a significant challenge and constraint in performance measurement. Cities may find it very time-consuming and resource intensive to collect data that isn't already being tracked. There are several options to overcome this limitation.

First, indicator metrics could be redefined to use data that currently exists and meets the intent of the indicator or is at least a proxy for the indicator. This approach may not be possible for indices that are used externally for ranking purposes, as they require consistent approaches.

The second option is for a city to carry out a baseline assessment of performance against indicators to identify gaps in data collection, and then to implement processes or software systems to start capturing relevant data for the next reporting cycle.

A third option is for cities to harness the power of big data. Big data refers to data that exceeds the processing capacity of conventional database systems. Cities typically generate a wealth of data on all kinds of systems—from transport to education to land use. Using powerful technology and cloud architecture, cities may be able to combine and analyse data points to extract meaningful insights. Alternatively, cities may choose to publish open data to enable residents and companies to undertake big data analysis for them.

A fourth option to overcome the lack of data is to crowdsource the information directly from the public. There are a variety of different ways to crowdsource data, from more passive techniques like online surveys to more sophisticated approaches, like smart phone applications that facilitate quick capture of data. For example, following the devastating earthquake in Christchurch, New Zealand, the Sensing City initiative has distributed 200 water quality testing kits to pupils. Students test water quality and then upload results to a server for analysis.

Capacity and ownership

Two related constraints faced by cities are their institutional capacity to carry out performance assessment and the ownership or leadership of the assessment. Cities may need support in defining or tailoring indicators to be analysed and in undertaking the assessment of their performance. Some may turn to partners or consultants to facilitate the performance measurement process. These third parties may take a role in leading the whole assessment, undertaking data collection in particular areas/sectors, or in undertaking a quality control review or validation of data.

Enlisting third parties may improve the integrity and reliability of the data collection process. However, it also means the ownership of the process may lie with the third party partner. It is important for cities to assess their ability to define and assess indicators and determine if and how bringing in a third party could improve the quality of this process.

Boundaries and sphere of influence

City performance indicators may need to draw on data for systems that are not under the sphere of influence of city leaders or not within the administrative boundaries of the city. This creates challenges in terms of data collection and compilation. For example, a water-stressed city may wish to track its water consumption, but the utility responsible for water supply may be managed by a regional/national public operator or a private operator. In such cases, cities may need to rely on or extrapolate from whatever data is publicly accessible, even if such data may reflect a different geographic boundary (such as water use per capita for the region rather than for the city). Any such manipulation of data needs to be transparent to ensure consistent approaches are applied to calculations in each reporting cycle. Alternatively, cities could also lobby public or private operators to provide data needed by the city for its annual reporting.

The greater challenge with respect to boundaries is that cities will be limited in their ability to improve their performance if they have limited control or influence over key systems. The C40 has undertaken a comprehensive review of the powers of nearly 60 cities over key assets and functions related to climate change (C40, 2013). It has classified Mayoral powers according to the degree a city controls or influences: the ownership/operation of assets, policymaking and enforcing, budgetary control and the vision for municipal assets or services. The analysis shows cities have strongest power over water and buildings and least control over energy supply and ICT (C40, 2013). Crucially, the C40 research also shows that even where their control is limited, Mayors have been able to take action on climate change using their influence and ability to drive the vision for a sector.

Data verification

Assuring the quality of data can be challenging and expensive, in particular if a manual data collection process is used. In the corporate world, financial and non-financial data appearing in annual reports has been audited by reputable accounting firms and signed off by both accountants and chief executives. Seeking third party verification can be very costly and may add limited value. For cities, data validation remains an important, but elusive issue. As cities become more sophisticated in using systems to automate data capture, validation of data on city resilience could become a reality.

Depth of assessment

The depth of a performance assessment is a key consideration and constraint for cities. Undertaking a large scale, in depth assessment of performance may yield highly valuable information, but also consumes a significant amount of time and resources. Cities need to weigh the benefits and costs of a comprehensive assessment versus a quick diagnostic review. Using a materiality filter could help cities to identify what indicators are the most important to assess, track and report.

Conclusions

Indicators can serve as powerful tools for cities to understand their performance, identify weaknesses and gaps, and develop actions aimed at improvement. Given the objective of the developing the CRI framework is to influence plans, policies and investments to support resilience, rather than benchmarking the performance of one city to another, it is recommended that an indicator framework be used that does not aggregate data into an index. An index would require data from vastly different systems (transport and health for example) to be weighted and aggregated together, which means the ability to understand resilience at a system level is lost. As the users of the CRI would be the city's own departments, it would be very beneficial to be able to give access to data at a disaggregated systems level. Clustering indicators by thematic areas or sub-indices without any aggregation may help to communicate the range of issues addressed by the CRI in a clear manner.

To enable resilience improvements to be tracked over time, specific, measureable indicators would need to be established. In reality, this may be quite challenging with a topic as complex as city resilience. Some socially-focused indicators may have to be developed using qualitative indicators or these indicators may need to be measured using an ordinal scale. The CRI framework will also need to capture a mix of leading and lagging indicators. Lagging indicators will be useful for measuring the current state of performance. Leading indicators will help to ensure actions to improve resilience are being put into place, particularly for issues where there is a long time period between putting the action into place and evaluating the effectiveness of the action. Context indicators are useful, as they provide users an understanding of how external factors may affect performance.

Given that the CRI framework will be the first time cities assess their resilience comprehensively, they may wish to seek a third party to facilitate the assessment process, while starting to build their own assessment capacity. In addition, cities may wish to undertake a materiality test to determine the most critical indicators to measure, as well as assess how their sphere of influence may affect their ability to collect and use data. It is also important that cities have a clear idea of the depth of the assessment they wish to undertake and plan accordingly.

Table 2: Summary of Measurement Frameworks

	- City Scale	- Other Scales
Resilience	- UN-HABITAT (2012). City Resilience Profiling Programmed Disaster resilience - UNISDR (2012) City Resilience 10 Essentials CityNet/Kyoto University/ TDLC/SEEDS/ UNISDR (2010) Climate and Disaster Resilience Initiative (Capacity building Program) - CityNet/Kyoto University/ TDLC/SEEDS/ UNISDR (2009) City Profiles	- Cutter, S (2010) Disaster Resilience Index - Berkeley (2011). Resilience Capacity Index - IFRC (2011). Characteristics of a Safe and Resilient Community - ACCCRN (2012). ACCCRN City projects
Related focus	- EIU (2010). Liveable Cities Index - EIU (2012). Global City Competitiveness Index - McKinsey & Urban China Initiative (2011). Urban Sustainability Index - LSE Cities (2012). Global Metro Monitor - AT Kearney (2012). Global Cities Index - AT Kearny (2012). Global Cities Outlook - Siemens (2012). Green Cities Index - PWC (2012). Cities of Opportunity Index - C40 Cities climate action group (2011). C40 cities report Climate Action in MegaCities - UN HABITAT (2002). Global Urban Indicators Database	- Global Adaptation Institute. (1995-2012). GAIN Index. - Wheeler, D (2011). Climate Change Vulnerability Index - DARA + Climate Vulnerable Forum. (2012). Climate Vulnerability Monitor 2nd ed. - USAID (2011). Provincial Competitiveness Index - OECD (2001) Environmental Indicators - Arup (2008) ASPIRE

Measurement Framework Analysis

A detailed analysis was carried out on 24 existing measurement frameworks. The search for resilience frameworks revealed only four that measure resilience at a city or urban scale. The analysis has included a number of other frameworks that are aimed at assessing performance in relation to a variety of inter-related aspects (including sustainability, environmental management, climate change, urban economics, competitiveness, liveability, smart cities), and at a variety of scales (project, city, region, and state). Excluded from the analysis were sector-focused indicator frameworks (eg, International Benchmarking Network for Water and Sanitation Utilities) and frameworks developed for specific cities (eg, San Francisco Sustainable Communities Index).

The analysis was targeted at understanding three aspects of current approaches:

- Purpose: what are the motivations for measurement? Who is the target audience?
- Process: how is the assessment conducted? How many indicators (or variables) form the basis for assessment? Who carries out the assessment? What data is used? Who owns or has access to the information?
- Product: what are the outputs? How effectively do they communicate the outcomes?

The measurement frameworks selected for the analysis are mapped by scale and topic focus in table 2.

Purpose

As previously mentioned, indicators frameworks are aimed at one of three things: ranking/comparing performance, influencing/driving change in performance, and understanding/diagnosing performance. The 24 measurement frameworks were analysed to determine their primary purpose by reviewing the purpose statements from each. The analysis revealed that 10 measurement frameworks aimed to rank and compare performance, 5 focused on driving change in performance, and 9 were aimed at understanding key issues and weaknesses. The reason for the low number of frameworks focused on driving change in performance is that most of the frameworks identified in this report are global frameworks applied to a wide number of entities; frameworks aimed at influencing change are typically developed by the entity themselves and tailor-made to their needs.

Of the 10 measurement frameworks that aimed at ranking/ comparing performance, 7 focused specifically on economic topics such as competitiveness, opportunity, economic recovery, and global influence. Two of the frameworks attempted to measure sustainability and resilience, but in doing so used an economic lens when conducting the analysis. All 10 frameworks were developed by, carried out and/or funded by private entities for commercial purposes and were aimed at external, global audiences.

The measurement frameworks that aimed at influencing and diagnosing performance tackled more complex topics, including climate change, development, sustainability, and resilience. These measurement frameworks were developed or carried out by a mix of organisations, such as academic institutions, NGOs, INGOs, and the private sector, which were working on behalf of city governments.

Aggregation

Aggregation was very common across all the indicator frameworks. About 65% of the measurement frameworks aggregated data into an index. Aggregation was also very common at the variable level: 96% of the studies aggregated variables into indicators.

Of the 10 measurement frameworks aimed at ranking performance, 9 aggregated their variables and indicators to produce a final index. The one exception was A. T. Kearny's Emerging Cities Outlook, which organises cities based on their strengths and vulnerabilities (A. T. Kearney, 2012). All of the comparison measurement frameworks identified indicators used, but few provided the full set of disaggregated data.

Only half of the measurement frameworks aimed at influencing change or diagnosing performance aggregated the information into an index. These frameworks had a stronger focus on enabling performance data to be disaggregated and viewed at a detailed level.

Process

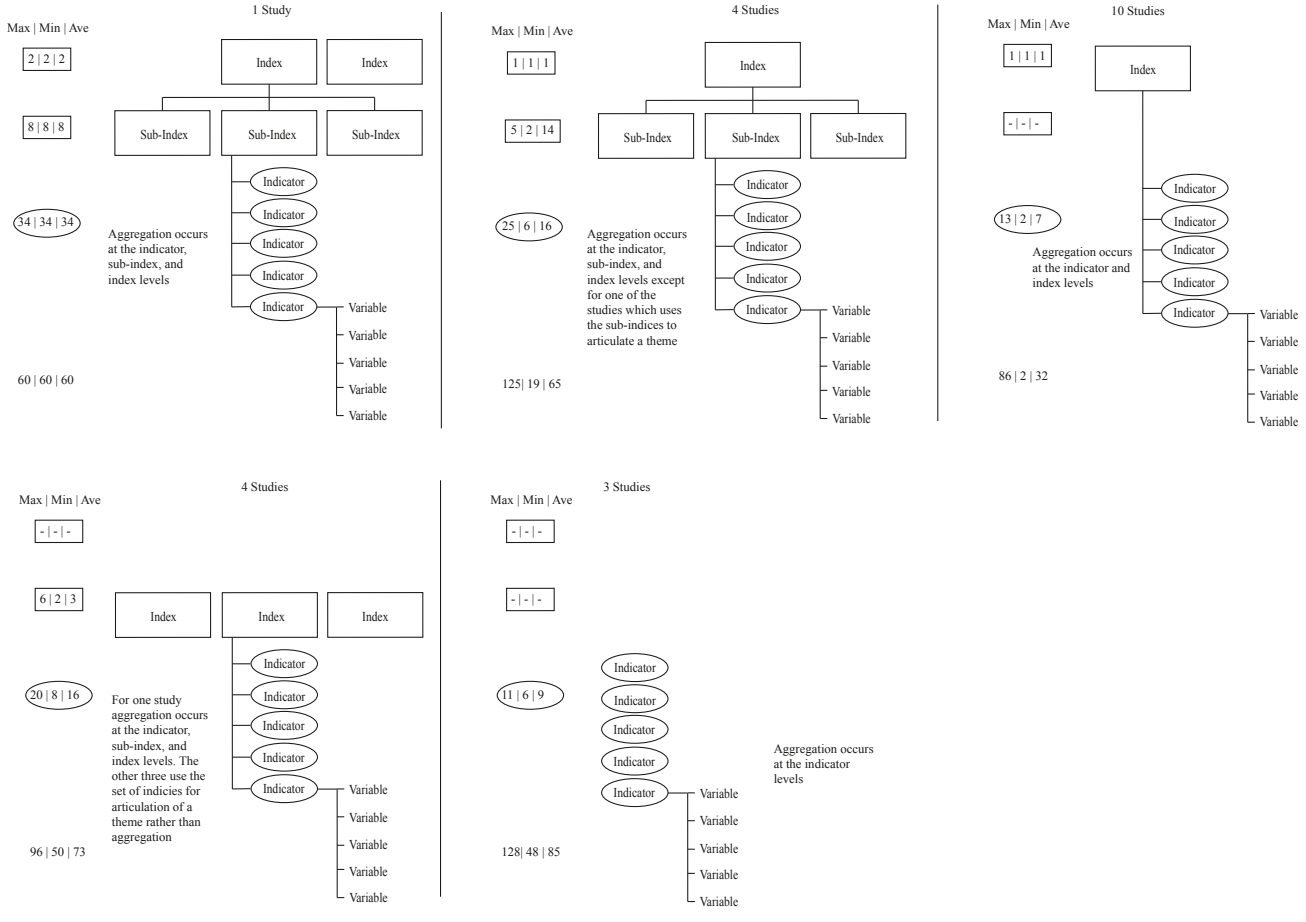
The indicator frameworks were reviewed to assess their structure, the approach to aggregation and the quantity of data aggregated within indices, as well as the owner or facilitator responsible for the performance assessment.

Aggregation structures

The analysis examined the variety of aggregation structures, and identified five different ones used by the 24 measurement frameworks. Figure x displays the five aggregation structures, the number of studies associated with that structure, and the number of variables, indicators, etc. at each aggregation layer. One study had a unique aggregation structure (DARA 2012). The fact that five different aggregation methods were identified indicates that there are many options for aggregating variables and that there is no common method.

Approximately 50 percent of the measurement frameworks used the typical variable, indicator, index aggregation method. Seven out of the ten measurement frameworks aimed to rank and compare used this method, while the three remaining frameworks each used different aggregation structures. There was no preferred aggregation structure for frameworks that aimed at influencing or understanding performance.

Figure 5: Indicator aggregation structures



Quantity of aggregated data

The measurement frameworks that aim to rank performance have been used to analyse and compare a significant number of entities, on average 119. The authors have used a small number of variables and indicators to create an index (33 and 7 on average respectively). Using fewer variables makes comparison easier, as the data is more likely to be available across all of the entities measured. For example, the Global Metro Monitor only used two variables/indicators (Gross Value Added per capita and Employment Rate) to create its final index (LSE Cities, 2012). Fewer variables also means there is less room for distortion when diverse data is aggregated. The frameworks which aimed at influencing and diagnosis used a much larger number of variables and indicators. This gives users greater flexibility and there is opportunity to apply materiality filters.

Table 3 provides a summary of the minimum, maximum and average number of indices, sub-indices, indicators and variables within the different measurement frameworks reviewed. Frameworks aimed at influencing and diagnosis typically have between 0 to 8 sub-indices, which each relate to between 5 and 34 indicators, and between 36 and 128 variables. The average across all types of purposes is 1 index, 2 sub-indices, 12 indicators and 55 variables. However, these values are distorted by frameworks which do not have indices or sub-indices. For those frameworks that do use a single index or sub-indices, the averages are 1 index, 4 sub-indices, 12 indicators and 77 variables.

Table 3: Number of indices, indicators and variables used in different frameworks

Purpose	**Index** (max|min|avg)	**Sub-index** (max|min|avg)	**Indicator** (max|min|avg)	**Variable** (max|min|avg)
Ranking (10)	1 | 0 | 1	4 | 0 | 1	13 | 0 | 7	86 | 2 | 33
Driving change (5)	2 | 0 | 1	8 | 0 | 3	34 | 9 | 18	128 | 50 | 91
Diagnosis (9)	1 | 0 | 0	6 | 0 | 2	25 | 5 | 13	125 | 36 | 65
Average across all	1	2	12	55
Average, excluding zeros	1	4	12	77

The frameworks which were aimed at influencing or driving change in performance had been used to assess 131 entities on average with a maximum number of 255, while those which were aimed at diagnosis were applied to an average of 151 entities with a maximum number of 736. This shows the frameworks used to understand and diagnose performance are more broadly applied than those aimed at influencing performance. Finally, the largest number of indicators used in any one framework was 34.

Aggregation process

The frameworks were analysed to understand the aggregation process used to create an index, specifically, to determine at what point a number of variables or indicators is aggregated or clustered into the next level. Table 4 below indicates that the frameworks typically aggregate via a pattern of four or five units into the next level (excluding those which do not aggregate). However, there is a large spread as the maximum number identified was 13 while the minimum was one. This analysis demonstrates that it is therefore likely that the number of variables can have a significant impact on the number of aggregation stages.

Table 4: Aggregation structure

Number of:	Maximum	Minimum	Average
Indices in a framework	2	1	1
If sub-indices used: Sub-indices in an index	5	2	4
If no sub-indices used: Indicators in an index	13	2	7
Indicators in a sub-index	5	3	4
Variables in an indicator	6	1	5

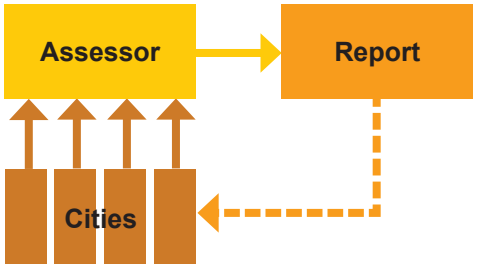
Ownership of the Measurement Process

Analysis was undertaken to understand how different players are involved in the measurement process. The review looked at who wanted the assessment completed, who undertook the assessment using the different indicator frameworks, how they engaged with the city, and who owned the final product. Four different measurement processes were identified. Figure 6 provides a summary of these structures and groups them into two main categories – those where an external party owns the collected information and those where the cities own their information.

About half of the measurement frameworks reviewed involved an external party owning the assessment. Most of the measurement frameworks conducted and owned by external parties focused on creating an index to rank and compare. These frameworks were less transparent and less focused on the assessment process itself. As the audience for many of these frameworks is the business community, there is little need to provide full disclosure. In addition, external parties may obfuscate their methods as they may be seeking to promote the market for their products and services; some in fact use proprietary methodology. Without a clear understanding of how the measurement frameworks were created and applied, it is difficult for the cities to use the results to make policy changes or investment decisions.

Figure 6: Ownership of the Performance Assessment

Assessment owned by external actor

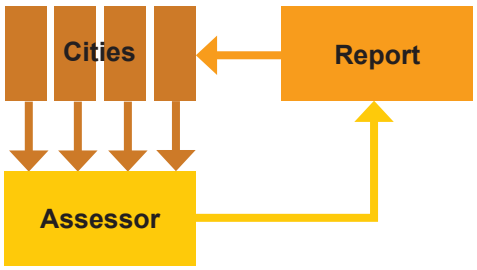


Externally Driven: An external party leads the development of the performance assessment, either for its own purposes or on behalf of another organisation. Data used is typically what is publicly available. The assessment usually applies to a significant number of cities.

Examples:

- PWC's Cities of Opportunity Index which draws on data from other indices and city information
- The Global Metro Monitor prepared by the Brookings Institution, LSE Cities and Deutsche Bank Research and funded by the Alfred Herrhausen Society
- The Green Cities Index which was developed by the Economist Intelligence Unit for Siemens

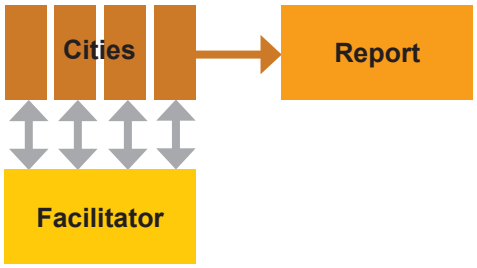
Assessment owned by cities



City-network driven: A city, group of cities or an organisation representing cities commissions a study that is undertaken by an external party, but owned by the cities or their representative organisation.

Examples:

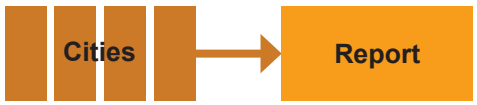
- The C40 Cities Climate Action in MegaCities where the C40 group commissioned Arup to carry out the assessment.



Facilitator-aided-assessment: An organisation develops a framework and provides it to cities for self-assessment, but also serves as facilitator to help the city with its assessment.

Examples:

- The CityNet et al worked closely with the urban stakeholders as part of the Climate and Disaster Resilience Initiative to measure their urban systems. This process was ultimately aimed at capacity building.



Self-assessment: Cities use a predefined measurement framework to conduct a self-assessment without external facilitation.

Examples:

- The UNISDR 10 Essentials uses this method. UNISDR created a list of 41 questions for cities to assess their resilience to natural disasters.

The assessments that remain owned by the city typically were not aimed at ranking, but instead sought to drive change or diagnose performance. Some assessments were commissioned by organisations that represent cities (such as the C40), some used external parties to facilitate the assessment process and some used a self-assessment process. These assessments are more transparent and include indicator, and in some cases variable data. The data remains owned by the city or its representative. Easy access to this data means cities can use the information in their strategic planning, policy making, and investment decision making.

A key advantage of a city-owned assessment is that it creates greater commitment and sense of responsibility for participating cities. Cities must be actively engaged in the measurement framework for the assessment to be successfully carried out. In cases where capacity may be weak, a facilitated process may be beneficial. Using a facilitator could help build local capacity and enable a larger and more complex measurement framework to be used. It is essential if the purpose of the assessment is to drive change in performance through regular assessments. Facilitation may only be needed for the first round to baseline or help analyse performance. It may be of particular value for cities that are assessing a complex issue like their resilience performance.

Products

The product of a measurement framework refers to the visual format or representation of the performance measurement data. It is a means of communicating results with the target audience and enhancing the transparency of the measurement framework. The different types of products developed to communicate measurement results are summarised below.

Lists / Bar Charts

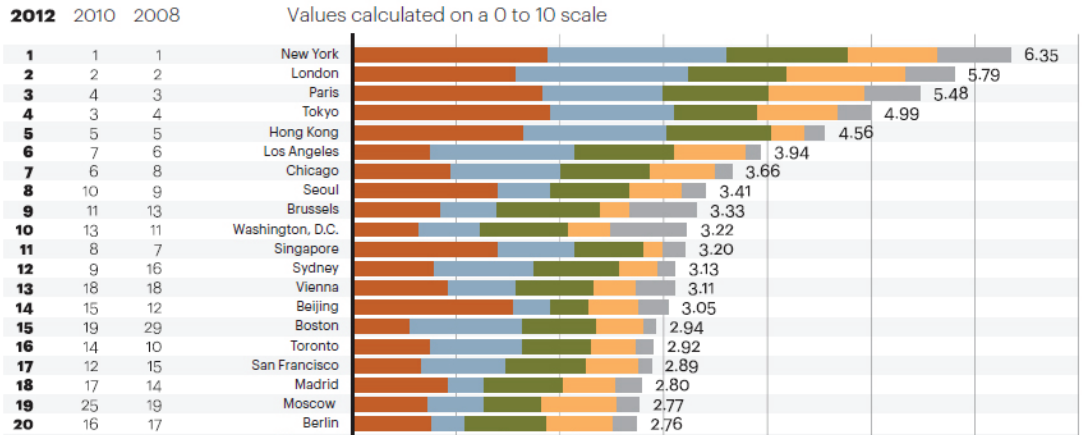
Most of the case studies which aimed to rank and compare used lists and/or bar charts. The use of a list allows the audience to understand the ranking and comparison made by the measurement process (figure 7). Alternatively, a bar chart can be used to create a ranking list, but is able to include the value of the indicators which comprise the final index (figure 8).

Figure 7: : Global City Competitiveness Index and Indicator Summaries (EIU, 2012)

Rankings by category (Top 60 cities; for full rankings see appendix)
Scores 0-100 where 100=best

Overall score			Economic strength			Physical capital			Financial Maturity			Institutional effectiveness		
1	New York	71.4	1	Tianjin	56.6	=1	Vancouver	100.0	=1	Zurich	100.0	=1	Zurich	96.0
2	London	70.4	2	Shenzhen	55.4	=1	Tokyo	100.0	=1	Toronto	100.0	=1	Geneva	96.0
3	Singapore	70.0	3	Dalian	55.0	=1	Stockholm	100.0	=1	Tokyo	100.0	3	Auckland	95.9
=4	Paris	69.3	4	New York	54.0	=1	Singapore	100.0	=1	Singapore	100.0	4	Sydney	94.8
=4	Hong Kong	69.3	5	Doha	53.7	=1	Melbourne	100.0	=1	New York	100.0	5	Melbourne	94.7
6	Tokyo	68.0	6	Guangzhou	53.6	=1	Hong Kong	100.0	=1	London	100.0	6	Singapore	87.8
7	Zurich	66.8	7	Shanghai	51.8	=1	Hamburg	100.0	=1	Hong Kong	100.0	=7	Vancouver	87.1
8	Washington	66.1	8	Tokyo	50.5	=1	Amsterdam	100.0	=1	Frankfurt	100.0	=7	Toronto	87.1
9	Chicago	65.9	9	Chongqing	49.9	=9	Zurich	98.2	=1	Chicago	100.0	=7	Montréal	87.1
10	Boston	64.5	10	Beijing	49.8	=9	Vienna	98.2	=10	Washington	83.3	=10	Washington	85.8
11	Frankfurt	64.1	11	Qingdao	49.4	=9	Sydney	98.2	=10	Vancouver	83.3	=10	Seattle	85.8
12	Toronto	63.9	12	Chengdu	49.2	=9	Oslo	98.2	=10	Sydney	83.3	=10	San Francisco	85.8
=13	San Francisco	63.3	13	Suzhou (Jiangsu)	48.1	=9	Geneva	98.2	=10	Shanghai	83.3	=10	Philadelphia	85.8
=13	Geneva	63.3	14	Hangzhou	47.6	=9	Frankfurt	98.2	=10	Seoul	83.3	=10	New York	85.8
15	Sydney	63.1	15	Singapore	46.0	=9	Copenhagen	98.2	=10	San Francisco	83.3	=10	Miami	85.8
16	Melbourne	62.7	16	Bangalore	45.9	=9	Barcelona	98.2	=10	Paris	83.3	=10	Los Angeles	85.8
17	Amsterdam	62.4	17	Los Angeles	45.7	=17	Osaka	94.6	=10	Melbourne	83.3	=10	Houston	85.8
18	Vancouver	61.8	18	Houston	45.6	=17	Madrid	94.6	=10	Kuala Lumpur	83.3	=10	Dallas	85.8
19	Los Angeles	61.5	19	Ahmedabad	45.3	=17	Boston	94.6	=10	Geneva	83.3	=10	Chicago	85.8
=20	Stockholm	60.5	=20	Hong Kong	43.8	=20	Washington	93.8	=10	Dublin	83.3	=10	Boston	85.8
=20	Seoul	60.5	=20	Hanoi	43.8	=20	Paris	93.8	=10	Dubai	83.3	=10	Atlanta	85.8
22	Montréal	60.3	22	Paris	43.6	=20	Berlin	93.8	=10	Boston	83.3	22	Hong Kong	85.3
=23	Houston	59.9	=23	Washington	43.4	23	Rome	92.9	=10	Beijing	83.3	23	Stockholm	84.2
=23	Copenhagen	59.9	=23	Dallas	43.4	=24	New York	92.0	=10	Amsterdam	83.3	=24	London	83.8
=25	Vienna	59.8	25	Abu Dhabi	42.5	=24	Brussels	92.0	=25	Shenzhen	66.7	=24	Birmingham	83.8

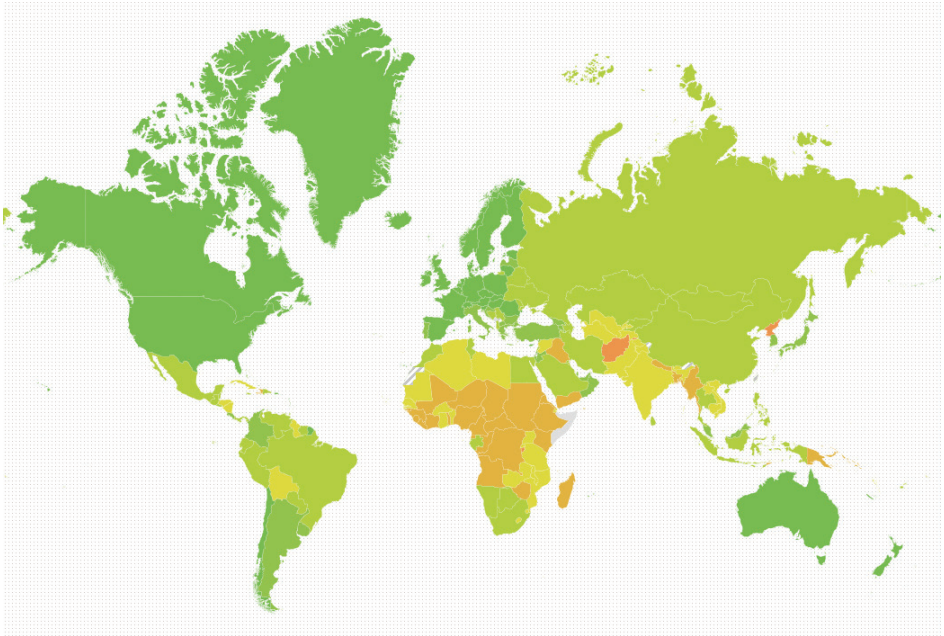
Figure 8: : Global Cities Index (A. T. Kearney, 2012)



Maps

Frameworks which are focused on comparison of regional or national data tend to use maps. For example, the GAIN Index compares countries based on their climate change vulnerability on a colour coded world map (figure 9). A map is less useful for cities unless it is used to summarise and compare districts within a city.

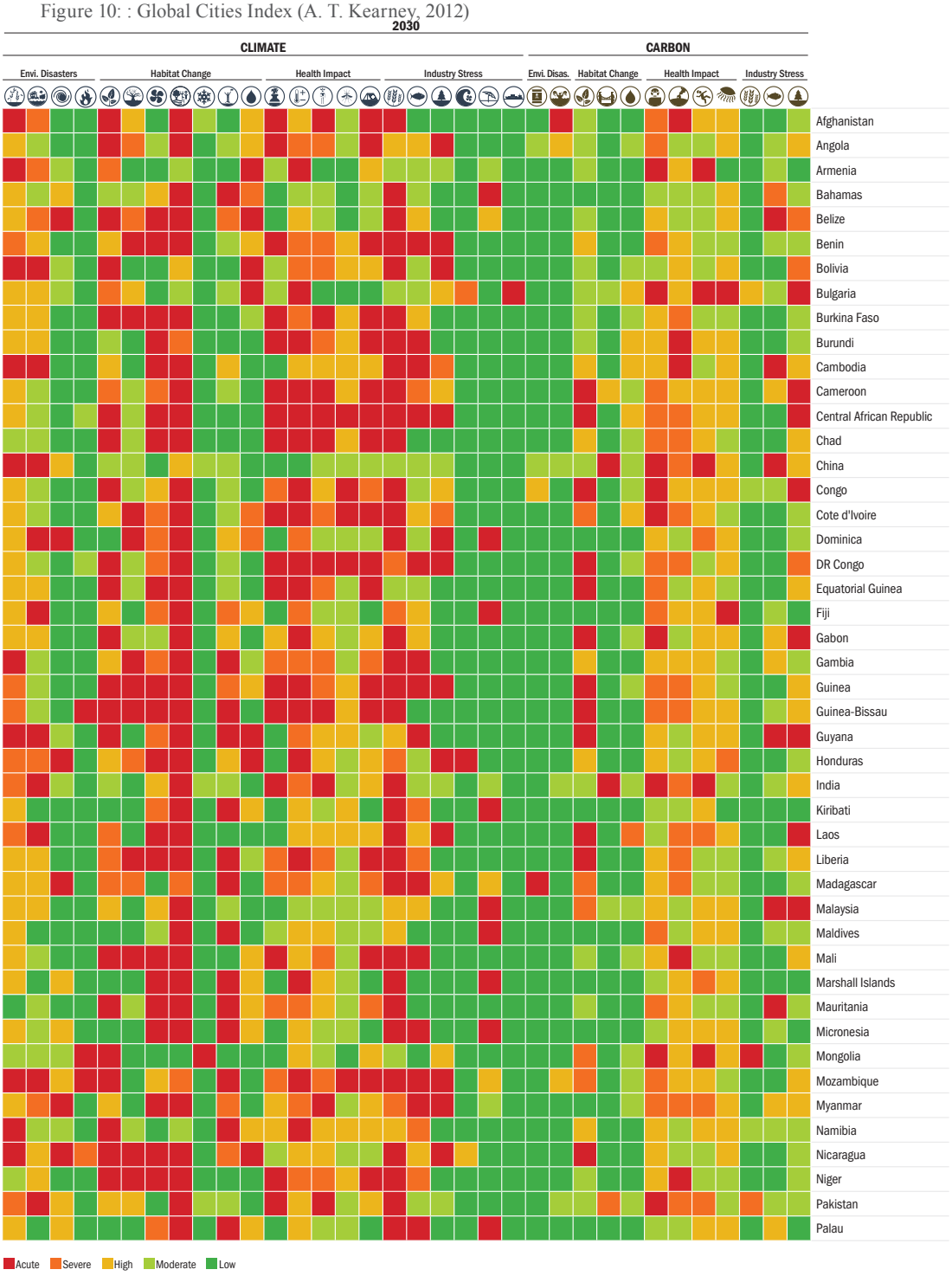
Figure 9: : GAIN Index Map (Global Adaptation Institute, 2012)



Colour Scales

Many of the studies use coloured scales or codes in preference to numbers. Colour scales allow the performance measures to fall on a spectrum rather than on a specific number (Figure 10). Colour codes, such as traffic lights, also allow the audience to ascertain performance at a glance without having to know the values behind the numbers.

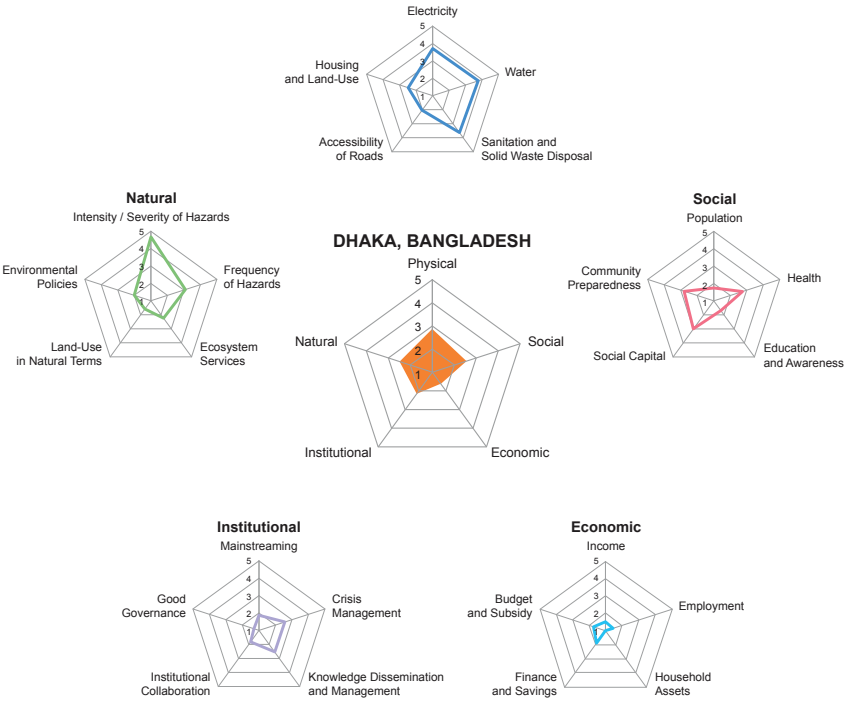
Figure 10: : Global Cities Index (A. T. Kearney, 2012)



Spider web / radar diagrams

Several of the case studies use spider web or radar diagrams as the final product. The benefit of such diagrams is they can show quality improvements of an on-going programme as iterative outputs can be layered on top of one another (Figure 11). This kind of visualisation tool can also be used to easily identify outliers. The weakness of these diagrams, however, is that it is difficult to identify linkages between different indicators or to compare performance of different entities. These diagrams may also be more difficult for the general public to understand.

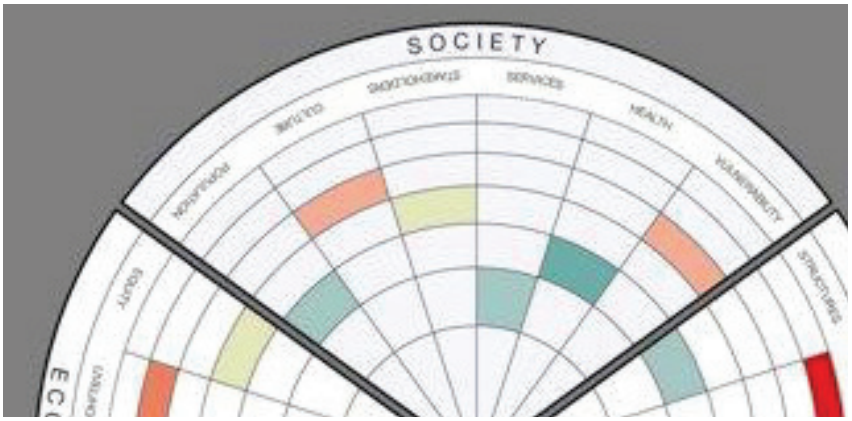
Figure 11: : CityNet Indicator Summary (CityNet et al., 2009)



Bullseye diagrams

To reduce the need to aggregate data, some organisations prefer to use a bullseye diagram whereby indicators are individually summarised on the outside edge. Using colour coding, areas where performance is weak can be quickly identified. (figure 12)

Figure 12: : Arup's ASPIRE sustainability assessment tool for infrastructure projects

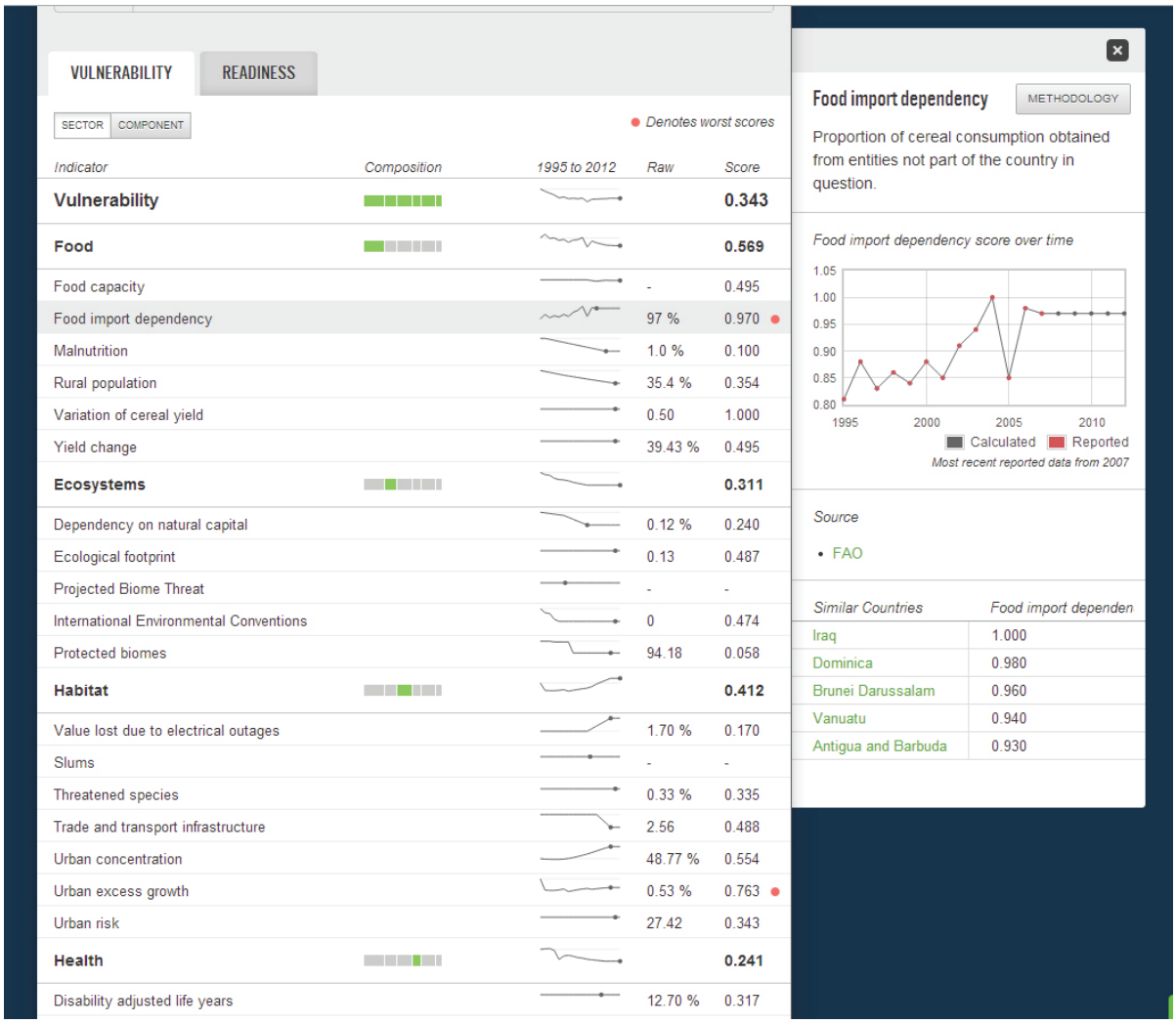


Dashboards

Only one of the case studies (The GAIN Index) uses a web-based digital dashboard for audience engagement and communication. A digital dashboard allows the user to visualise the information in several different forms, not simply those which appear in a published report. It also allows audiences to interact with the information at a level that is interesting and useful to them. In addition, this method can store historical data and present it alongside current or even real time data so that trends can easily be identified (figure 13).

Dashboards can be particularly useful if the audience includes different types of stakeholders. Its multiple modes of visual display ensure that data can be used as both a tool to influence and educate policy makers and as a tool for communicating with the general public.

Figure 13: : Global Adaptation Institute, 2012



Conclusions

The analysis of the 24 framework structures provides good insights for the CRI. Indicator frameworks can be quite comprehensive, with as many as 128 variables. Typically they aggregate at the levels of about 4 sub-indices, each which may have about 4 indicators, which in turns each may have 5 variables on average. As it is geared at influencing change, the CRI framework will need to utilise a large number of variables that can holistically and comprehensively measure resilience. However, aggregating beyond indicators into an index or sub-index level will make it difficult for users to understand and track performance.

The evidence from the analysis suggests that the assessment approach process should be led by the city, though some degree of support or facilitation may be necessary. Cities need to take ownership of resilience, and adopt the CRI as their own. Taking ownership of the CRI is essential to building a city's commitment to understanding and addressing its resilience, and capacity to carry out subsequent assessments.

In terms of visual outputs, there are numerous options available. A bullseye diagram has the benefit of being able to show a vast array of indicators and to quickly communicate performance through colours. It also enables qualitative and quantitative data to be incorporated. A digital dashboard could also be a useful tool due its multiple modes and levels of visual display which can be filtered by users.

(Image Opposite)

Global City Competitiveness Index and Indicator Summaries (EIU, 2012)

Summary of Implications for the CRI

This report has sought to review literature and indicator frameworks to ascertain what are the current practices, challenges, limitations, structures and outputs that need to be taken into consideration in developing an indicator framework. The implications of these findings on the development of the CRI are summarised as follows:

1. Define a clear purpose and audience: Developing an appropriate indicator framework for the CRI requires the purpose of the assessment and the audience to be clear. If the CRI is focused on understanding a city's current resilience performance and influencing or driving change to improve performance in the future, then the user of the CRI is the city leadership; they have the greatest ability to control and influence the resilience of a city. This does not mean stakeholders do not have a role in city resilience; civil society and the public can provide feedback on performance and take the lead on actions at a community level.

2. Establish a broad universe of variables but allow flexibility: As the CRI measurement framework is likely to be applied to a wide range of cities, it is recommended that a large number of variables be developed that define the "universe of resilience", recognising that a city may want to focus on only the most relevant or material variables. Identifying quantitative variables is preferred, although this may be more challenging with some of the more social aspects of resilience. Using a relevance or materiality test could help cities in identifying which indicators are most important given their own situation, particularly if resources aren't available to undertake a full in-depth analysis.

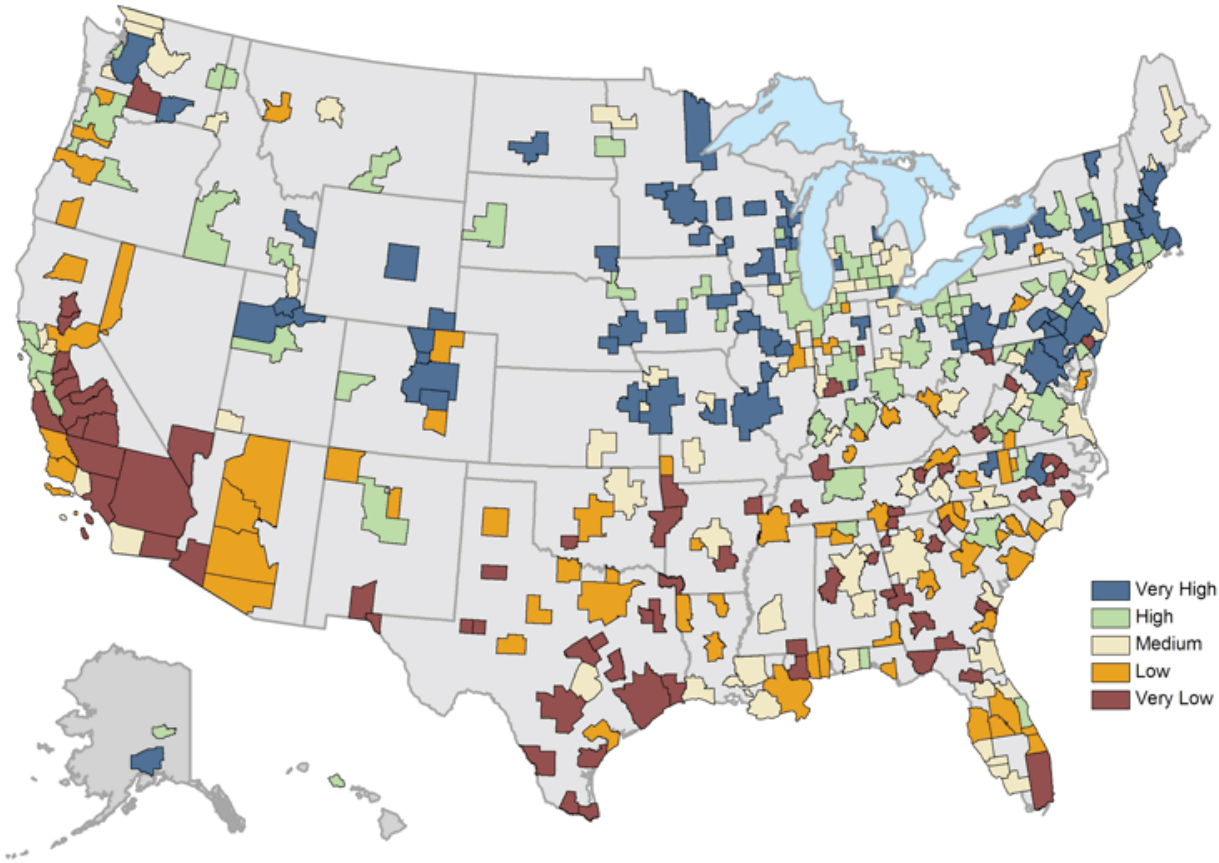
3. Aggregate up to indicator level: Using an index with fully aggregated data will have limited value, as resilience is a complex, multi-faceted topic which demands greater transparency. It is recommended that the CRI framework aggregate only up to the indicator level. These indicators could be clustered around related thematic areas or sub-indices. The CRI should be organised to have about 4-5 sub-indices or thematic areas, each which has about 4-5 indicators, each with a maximum of 5-6 variables. This suggests a total of no more than 150 variables.

4. Include different types of variables: The CRI will need to include some lagging variables in order to give an indication of current performance and some leading variables to give an indication of progress on inputs or outputs that will shape performance outcomes. While quantitative, variables are preferable, some qualitative indicators may need to be included. Variables should also be used to encourage more innovative solutions to improving resilience. The CRI may also need to include variables that address what context may help a user understand how the external environment affects performance levels within a given city.

5. Use established variables where possible: There are a range of variables and metrics already being used by cities, national government, international organisations and industry to measure performance in a number of different issues and systems related to resilience. This includes sector-based indicators, such as water indicators used by the International Water and Sanitation Benchmarking Network. Where possible, the CRI variables and metrics should align with those already being used.

6. Identify systems or functions related to variables: As the CRI will incorporate a broad range of variables, it is advisable that the system or city function applicable to each variable be identified (eg, housing, education) to facilitate the assessment within the city and enable city departments to take greater responsibility in monitoring and improving their performance.

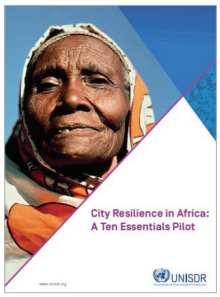
7. Strengthen capacity and ownership of CRI assessment: Ensuring cities have the capacity and resources to undertake a comprehensive, in-depth resilience assessment is going to be challenging. Cities, particularly those that are newer to the concept of resilience, will likely need facilitation support to carry out their initial baseline assessment. By using a workshop format, cities could obtain feedback from stakeholders on performance, while also reducing the cost of undertaking the assessment. Ultimately, it is critical that cities take ownership of the CRI Framework and integrate performance measurement throughout the whole organisation. Once cities start to undertake on-going performance monitoring, they will be in a strong to report on their progress and set targets for in improving city resilience in the future.



(Image above)

Resilience Capacity Index (Berkeley and the Buffalo Regional Institute, 2011)

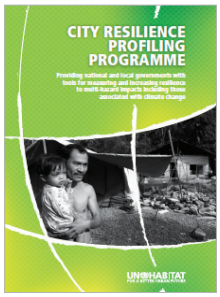
Appendix A: Measurement Frameworks



UNISDR – City Resilience in Africa: Ten Essentials Pilot

The ten essentials of resilience was designed by the United National International Strategy for Disaster Reduction (UNISDR) primarily for local government leaders and policy makers to support public policy, decision making and organisation as they implement disaster risk reduction and resilience activities.

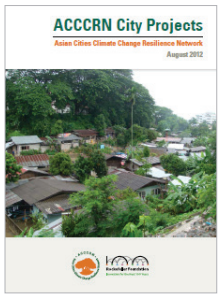
The tool is to be used by city leaders to conduct a self-assessment and identify areas of weakness. It is comprised of 41 questions (variables) which have been grouped into the 10 Essentials (indicators). For each question the participant is asked to give a value between 1 and 5. Further work is being done by AECOM & IBM to turn the information presented into an actual aggregated indicator tool. There are no visual outputs.



UN-HABITAT – City Resilience Profiling Programme

The City Resilience Profiling Programme is being designed to provide national and local governments with tools for measuring and increasing resilience to multi-hazard impacts including those associated with climate change.

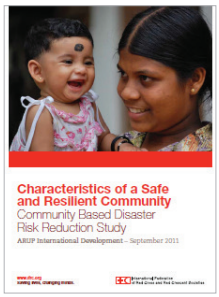
UN-HABITAT is partnering with 10 worldwide cities, and aims to produce the following 5 outputs: (1) An urban systems model, (2) a set of indicators, (3) City resilience profiles and tools, (4) a set of Global standards, and (5) a monitoring framework. When research was being completed for this report the programme was in phase 1: research and development.



ACCCRN - ACCCRN City Projects

The study aims to catalyse attention, funding, and action of cities to strengthen their resilience to climate change impacts.

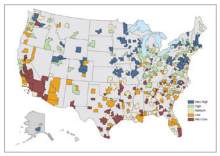
The study is a catalogue overview of 22 projects across the Asian Cities Climate Change Resilience Network (ACCCRN) cities displaying the results of five indicators of resilience: Resourcefulness, Learning, Safe Failure, Redundancy and Modularity, Flexibility and Diversity, Responsiveness. ACCCRN representatives helped the cities to review their projects as part of a capacity building programme. An illustration was produced to show the different areas of project resilience.



IFRC – Characteristics of a Safe and Resilient Community

Arup ID worked with the International Federation of the Red Cross and Red Crescent (IFRC) to define the characteristics of resilient communities as part of the wider Community Based Disaster Risk Reduction (CBDRR) programmes. The characteristics from this research are used in the design, monitoring and evaluation of future IFRC programmes.

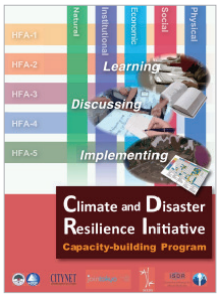
Workshops were held in 30 communities in Sri Lanka, Indonesia, Thailand, and the Maldives to identify factors of resilience (in addition to a desk study) and the final result was a list of six characteristics of resilient communities. An illustration was produced to convey the concept of the six characteristics.



Buffalo Regional Institute – Resilience Capacity Index

The Resilience Capacity Index was developed by the Buffalo Regional Institute as a member of the 'Building Resilient Regions' academic network. The mission of the study was to create something to allow regional leaders to compare their region's capacity profile (business lens) to that of other metropolitan areas. Data was obtained from previous studies and information databases.

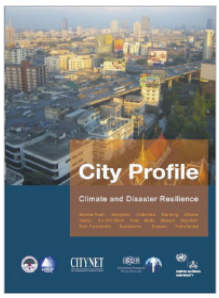
An index was created to compare 361 metropolitan areas using 12 variables and 3 indicators. The index for each metro area is displayed on a map.



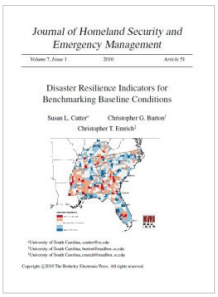
CityNet/Kyoto Univeristy/TDLC/SEEDS/UNISDR – Climate and Resilience

The work from CityNet et al. focuses almost exclusively on the disaster risk resilience (DRR) of cities. The methodology takes an assets based approach and uses extreme events as the entry point, rather than considering the resilience of the city – or communities within the city – to a wide range of shocks and stresses.

The first study created a measurement framework comprised of 125 variables, 25 indicators, 5 sub-indices, and an index as part of a three month capacity building programme in eight Asian cities. This study is meant to be a diagnostic.



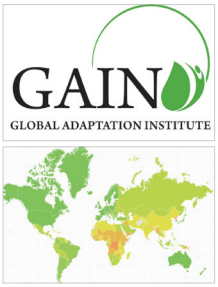
The second study uses a similar framework but applies it to 15 Asian cities. The results are based on a survey filled out by city leaders and is meant to influence and drive change. Outputs for both studies were on web diagrams and bar charts.



Cutter et al. – Disaster Resilience Indicators

Professor Susan Cutter led a group of researchers from the University of South Carolina to create a methodology and a set of indicators to measure the present conditions influencing disaster resilience within communities. The motivation for the study was to inform methodological practice for DRR measurement for policy makers and other academics.

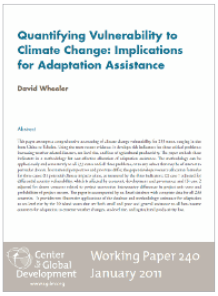
The study develops a theoretical framework for variable selection, weighting, and aggregation. Five core indicators were produced from 36 variables. The study covers 736 counties in the south eastern United States. The output from the study was a series of maps.



Global Adaptation Institute – GAIN Index

The Global Adaptation Index (GaIn) was developed as a navigation tool to help prioritize and measure progress in adapting to climate change and other global forces. The index is aimed at national governments and the private sector with the intention of leveraging investment in adaptation measures by diagnosing the key issues. The creators are now looking at increasing the granularity of the index to assess adaptation on a sub-national scale.

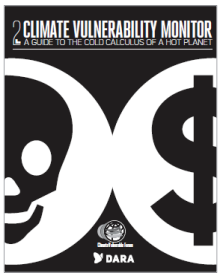
The GAIN index project profiles the 'vulnerability' and 'readiness' of countries using a set of thematic indicators. Each country is scored, and the results are both mapped and used in a ranking system. The information is also available on a digital dashboard format. The data behind the GAIN index is open-source, and users are encouraged to download, use and republish findings. A range of sources are used; the 'World Development Indicators' from the World Bank are used for many of the indicators. The index is composed of 50 indicators, nine indicators, and two sub-indices.



Wheeler, D - Center for Global Development – Climate Change Vulnerability Index

The objective of the study is to create comprehensive information on climate change vulnerability for donor institutions (MDBs, bilateral aid agencies, NGOs) that seek to provide financial assistance for adaptation to climate change on a national level.

The study covers 233 states / regions by looking at 11 variables/ indicators. One of the outputs of the work was a list of the impacts of climate change; specifically at the effects of Extreme Weather, Sea Level Rise, Agricultural Productivity Loss and Overall impact.



DARA + Climate Vulnerability Forum – Climate Vulnerability Monitor (2nd Edition)

The Monitor was first assembled to contribute to a fuller understanding of the global climate crisis and to support communities facing serious challenges as a result of this emerging concern. It aims to inform the public and policymakers and help shape more effective climate change policies.

The assessment uses 60 variables, 34 indicators, 8 categories, and 2 indices to appraise the impacts of both climate change and carbon (separately to climate change). The monitor also systematically assesses the impacts of environmental disasters, habitat change, health impacts and industry stress against common metrics. Most of the variables assess the monetary or death impacts of climate change and carbon increase. The output is a set of symbols to represent the various indicators; the indicator value for each country is also displayed by use of a 'traffic light' colour-scheme to easily demonstrate city performance. Variable level information is also provided for each country.

Economist Intelligence Unit (EIU) – Liveable Cities Index

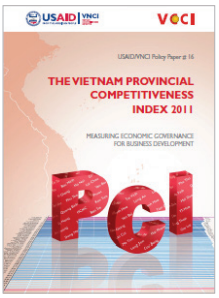
The survey sent out by the EIU originated as a means of testing whether Human Resource Departments needed to assign a hardship allowance as part of expatriate relocation packages. While this function is still a central potential use of the survey, it has also evolved as a broad means of benchmarking cities.

Each city is rated against 30 variables within five indicators. Additional information is not available as the study was not purchased for this report.

Economist Intelligence Unit (EIU) – Global City Competitiveness Index

The Economist Intelligence Unit (EIU) was commissioned by Citigroup to develop a "Global City Competitiveness Index" to rank cities according to their demonstrated ability to attract capital, businesses, talent and visitors. The report's findings are mainly for business leaders.

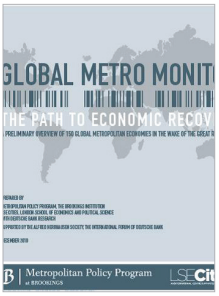
Cities are ranked against eight distinct indicators of competitiveness; their economic strength, physical capital, financial maturity, institutional effectiveness, social and cultural character, human capital, environment and natural hazards and global appeal. 31 variables are used across these categories (21 qualitative and 10 quantitative) and weightings are applied. The output is a series of lists for each indicator and the final index. Variable information is not provided.



USAID / VCCI – Provincial Competitiveness Index

The PCI was created by the Vietnam Chamber of Commerce and Industry (VCCI) with the help of the US Agency for International Development (USAID). The PCI provides insights to government leaders at the central and provincial levels on economic governance performance and how to improve the business environment to foster domestic and foreign investment, job creation, and economic development. The PCI also provides investors and businesses considering investment or expansion of existing investments in Vietnam with a picture of the business climate in each province as perceived by their private sector peers.

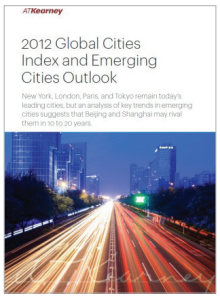
The PCI is a tool for measuring the standards of economic governance and administrative reform across Vietnam's 63 provinces by using 86 variables, and 13 indicators within an index. The data was collected via surveys to each government; however, the information is not shared. The outputs are a series of lists and graphs.



LSE Cities – Global Metro Monitor

The Global Metro Monitor was produced by the Metropolitan Policy Program, the Brookings Institution and the LSE Cities, London School of Economics and Political Science with Deutsche Bank Research. The overall aim of the study is to benchmark each economy (150 metro areas) with respect to their state of recovery, although the study concludes that most metropolitan areas are in a state of 'mixed decline/recovery'

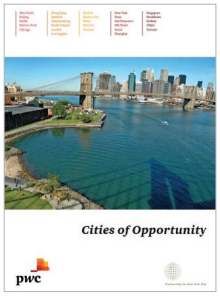
The publication ranks the performance of these metropolitan economies and compares their position relative to three time periods including their 'pre-recession' state. The index is created by aggregating the two variables Gross Value added and the rate of employment.



A.T. Kearney – Global Cities Index and Emerging Cities Outlook

The report by management consultants A.T. Kearney comes in two parts: Global Cities Index and Emerging Cities Outlook. The Global Cities Index measures global 'engagement' of cites by attempting to track the way cities manoeuvre as their populations grow and the world continues to shrink (business activity, human capital, information exchange, cultural experience, political engagement). The Emerging Cites Outlook, measures the strengths and vulnerabilities of cities in developing countries to suggest cities in which to invest.

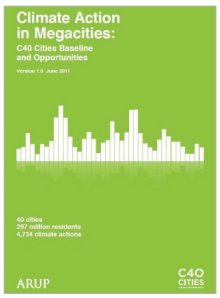
The Global Cities Index ranks metropolitan areas according to 25 variables across 5 indicators while the Emerging Cities Outlook utilises eight variables in two indicators. The Global Cities Index displays the index as a bar chart of the indicators while the Emerging Cities Outlook uses as SWOT type chart to visualise the two sub-indices (strengths and vulnerabilities) which are comprised of eight indicators.



PWC – Cities of Opportunity

The Cities of Opportunity report by Price Waterhouse Coopers (PWC) is a continually evolving project created for 27 cities, their leaders, businesses, and citizens seeking to improve their economies and quality of life. The audiences are: "officials and policy makers setting the course, businesses invested in city well-being and citizens who build their lives in thousands of city neighbourhoods."

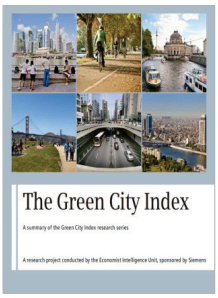
Cities are ranked across 60 variables within 10 indicators. The report also provides projections of population, employment and production. Several 'what-if?' scenarios are considered. A series of graphs are used to visualise the indicators.



C40 Cities & Arup – C40 Cities Report on Climate Action in Megacities

The report was commissioned by the C40 Climate Action Group, and the assessment was carried out by Arup to be a "proof of action: the first-ever comprehensive analysis of actions underway in the world's megacities to address climate change". The report is used to identify successful policies to increase awareness to the public on the actions of the cities within the C40.

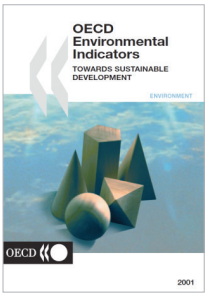
The assessment utilises a common framework to report on action to address climate change rather than attempting to measure mitigation or adaptation in absolute terms. This report nevertheless provides a baseline against which cities are able to benchmark their own activities, if not their performance. There are 128 variables used in the creation of 11 indicators. The data and indicators are available in tables and charts.



Siemens – Green Cities Index

The report was commissioned by Siemens and carried out by the Economists Intelligence Unit. The report seeks to focus attention on the critical issue of urban environmental sustainability by creating a unique tool that helps cities benchmark their performance and share best practices. The report is intended to help "city stakeholders to better understand their specific challenges, provide insights into effective policies and best practices and support their decision making.

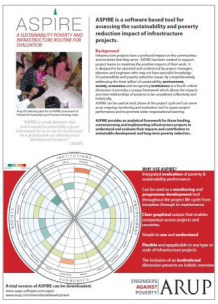
This index assesses over 120 cities worldwide using 30 variables within eight indicators. The output from the report is a list of city ranking for each global region.



OECD – Environmental Indicators

The Organization for Economic Co-operation and Development (OECD) developed the environmental indicators for three main purposes: (1) Keeping track of environmental progress; (2) Bringing environmental concerns to the forefront of policy debate; and (3) Ensuring integration of environmental concerns into economic policies. The primary audience is policy makers while the secondary audience is the public to demonstrate progress made by the states.

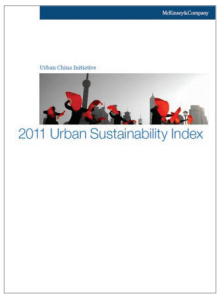
The study used 50 variables within 15 indicators to create two indices.



Arup ID – ASPIRE

ASPIRE was created by Arup International Development (Arup ID) to support project teams to maximise the positive impacts of their work. The tool is designed to be operated and understood by project managers, planners, and engineers who may not have specialist knowledge of sustainability and poverty reduction issues.

The tool is comprised of 96 variables within 20 indicators which are articulated across four sub-indices. A visual illustration of the indicators within the four sub-indices is produced.



Urban China Initiative / McKinsey & Co. – Urban Sustainability Index

The Urban China Initiative commissioned McKinsey to create an index to develop insights into the relative sustainability of China's rapidly growing cities (with a business lens), as well as to highlight case studies of successful policies and outcomes. The insights on 112 rapidly growing Chinese cities are to be used by policy makers, business leaders, and academics.

The tool is designed to measure relative performance of Chinese cities over time and encompasses: basic needs; resource efficiency; environmental health; built environment; commitment to policy. The six indicators are comprised of 17 variables. The six indicators are articulated across four sub-indices. A series of lists are used to rank the cities.

UN-HABITAT – Global Urban Indicators Database

UN HABITAT first launched the Global Urban Indicators Database (GUID1) following the Habitat II conference in 1996. By 1998 GUID2 was produced with information on 232 cities. The database aimed at "assessing and evaluating urban conditions and trends between 1993 and 1998" to address the urgent global need to improve the baseline of urban knowledge as part of the UN-HABITAT human settlements programme.

The database is a collection of information from the Demographic and Health Survey (DHS), Multiple Indicators Cluster Survey (MICS), and national household surveys. The information collected in the database has been used by third parties to produce the City Development Index.

Appendix B: Analysis Tables

Purpose Tables

Background						Purpose		
Title	**Author**	**Topic**	**Scale**	**Year Completed**	**Number of Subjects Studied**	**Mission Statement of Project**	**Motivation Type**	**Intended Audience**
Global City Competitiveness Index	Citigroup	Competitiveness	City	2012	120	The Economist Intelligence Unit (EIU) was commissioned by Citigroup to develop a "Global City Competitiveness Index" to rank cities according to their demonstrated ability to attract capital, businesses, talent and visitors.	Compare	Business managers General public
Economist Liveable Cities Index	Economist Intelligence Unit (EIU)	Liveability	City	2008	140	The survey originated as a means of testing whether Human Resource Departments needed to assign a hardship allowance as part of expatriate relocation packages. While this function is still a central potential use of the survey, it has also evolved as a broad means of benchmarking cities.	Compare	Businenss managers
Global Cities Index	A. T. Kearney	Global Influence	City	2012	29	It is designed to track the way cities maneuver as their populations grow and the world continues to shrink.	Compare	Businesses
Emerging Cities Outlook	A. T. Kearney	Global Influence	City	2012	66	It is designed to track the way cities maneuver as their populations grow and the world continues to shrink.	Compare	Businesses
Global Metro Monitor	LSE cities, et. Al	Economic Recovery	City	2010	150	The overall aim of the study is to benchmark each economy with respect to their state of recovery, although the study concludes that most metropolitan areas are in a state of 'mixed decline/recovery'.	Compare	Business managers
Urban Sustainability Index - China	McKinsey & Company, Columbia University and Tsinghua University	Sustainability	City	2011	112	The Index strives to develop insights into the relative sustainability of China's rapidly growing cities, as well as to highlight case studies of successful policies and outcomes. *Though it states that it is to influence, only a couple of policies are given in the report - the main emphasis is on ranking and comparing	Compare	Business managers National and local policy makers
Resilience capacity index	Buffalo Regional Institute	Resilience	Metro Area	2011	361	Allow regional leaders to compare their region's capacity profile to that of other metropolitan areas * Focus is economic and industry focused	Compare	Business managers Policy makers
Climate and Disaster Resilience Initiative (Capacity building Program)	CityNet/Kyoto University/ TDLC/SEEDS/UNISDR- Climate and Resilience	Resilience	City	2010	8	Report on the capacity building programme to help government officials become more aware of potential future risks which their city faces.	Diagnose	Policy makers
Climate Change Vulnerability Index	Center for Global Development	Vulnerability	Country	2011	233	Comprehensive information for donor institutions – MDBs, bilateral aid agencies, NGO's – that seek to provide financial assistance for adaptation to climate change.	Diagnose	Donor institutions – MDBs, bilateral aid agencies, NGO's – that seek to provide financial assistance for adaptation to climate change
Global Urban Indicators Database	UN-HABITAT	Urban Development	City	1998	237	To address the urgent global need to improve the base of urban knowledge by helping countries and cities design, collect and apply policy-oriented indicators data.	Diagnose	Policy makers
City Resilience Profiling Programme	UN-HABITAT	Resilience	City	2012	10	To provide national and local governments with tools for measuring and increasing resilience to multi-hazard impacts including those associated with climate change	Diagnose	Policy makers
GAIN Index	Global Adaptation Institute.	Climate change vulnerability and readyness to improve Resilience	Country	2011	176	The Global Adaptation Index ("GaIn") was developed as a navigation tool to help prioritize and measure progress in adapting to climate change and other global forces.	Diagnose	Policy makers NGOs International institutions Private sector.
OECD Environmental Indicators	OECD	Environmental Sustainability	Country	2001	29	The OECD programme on environmental indicators has three major purposes: ♦ keeping track of environmental progress; ♦ ensuring that environmental concerns are taken into account when policies are formulated and implemented for various sectors, such as transport, energy and agriculture; ♦ ensuring similar integration of environmental concerns into economic policies, mainly through environmental accounting.	Diagnose	Policy Makers General public

Purpose Tables

Background						Purpose		
Title	Author	Topic	Scale	Year Completed	Number of Subjects Studied	Mission Statement of Project	Motivation Type	Intended Audience
ASPIRE	Arup ID	Sustainability	Projects	2008	Variable	ASPIRE has been created to support project teams to maximise the positive impacts of their work.	Diagnose	Project managers Planners Engineers
10 Essentials of City Resilience	UNISDR	Resilience	City	2012	10	Designed primarily for local government leaders and policy makers to support public policy, decision making and organization as they implement disaster risk reduction and resilience activities	Diagnose	Local policy makers and government leaders
Climate Vulnerability Monitor 2nd ed.	DARA + Climate Vulnerable Forum	Vulnerability	Country	2012	196	The Monitor was first assembled to contribute to a fuller understanding of the global climate crisis and to support communities facing serious challenges as a result of this emerging concern. It aims to inform the public and policymakers and help shape more effective climate change	Diagnose	Policy makers General public
Disaster Resilience Indicators	University of South Carolina	Resilience	County	2010	736	To provide a methodology and a set of indicators to measure the present conditions influencing disaster resilience within communities.	Diagnose	Academics Policy makers
City Profile- Climate and Disaster Resilience	CityNet/Kyoto University/ TDLC/SEEDS/UNISDR- Climate and Resilience	Resilience	City	2009	15	To help government officials become more aware and able to communicate more easily on the current and potential future risks which their city faces.	Influence	Policy makers
Cities of Opportunity	Price Waterhouse Cooper & Partnership for New York City	Urban Opportunity	City	2012	27	Cities of Opportunity is a continually evolving project created for cities, their leaders, businesses, and citizens seeking to improve their economies and quality of life.	Influence	Policy makers Business managers General public
C40 Cities Report Climate Action in MegaCities	C40 Cities climate action group	Climate Action	City	2011	36	Proof of action: the first-ever comprehensive analysis of actions underway in the world's megacities to address climate change.	Influence	Primarily the C40 cities themselves to monitor and improve their own performance. Also
ACCCRN City projects	Rockefeller Foundation	Resilience	Projects	2012	22 Projects in 10 Cities	The study aims to catalyse attention, funding and action by cities to strengthen their resilience to climate change impacts by: - Improving the capacity of cities for planning, financing, coordinating, and implementing climate change resilience strategies - Strengthening the awareness, engagement, and demand for building urban climate change resilience among ACCCRN cities and other stakeholders - Build urban climate change resilience in ACCCRN and new cities are deepened and scaled up through additional support (finance, policy, technical).	Influence	Policy makers Project managers
Green Cities Index	Siemens	Environmental Sustainability	City	2012	120	It seeks to focus attention on the critical issue of urban environmental sustainability by creating a unique tool that helps cities benchmark their performance and share best practices.	Influence	"City Stakeholders" - Authorities, Policy Makers, and Citizens
Characteristics of a Safe and Resilient Community	IFRC	Resilience	Community	2011	30	It is intended that the characteristics arising from this research will be used in the design, monitoring and evaluation of future programmes	Influence	Policy makers Project managers
Provincial Competitiveness Index	USAID/VNCI	Economic Competitiveness	Provincial	2011	63	The PCI provides insights to government leaders at the central and provincial levels on economic governance performance and how to improve the business environment to foster domestic and foreign investment, job creation, and economic development. The PCI also provides investors and businesses considering investment or expansion of existing investments in Vietnam with a picture of the business climate in each province as perceived by their private sector peers.	Influence	Policy makers Investors Businesses managers

Structure Tables

Background						Structure			
Title	**Author**	**Topic**	**Scale**	**Year Completed**	**Number of Subjects Studied**	**Index**	**Sub-indices**	**Indicators**	**Variables**
Global City Competitiveness Index	Citigroup	Competitiveness	City	2012	120	1	-	8	32
Economist Liveable Cities Index	Economist Intelligence Unit (EIU)	Liveability	City	2008	140	1	-	5	30
Global Cities Index	A. T. Kearney	Global Influence	City	2012	29	1	-	5	25
Emerging Cities Outlook	A. T. Kearney	Global Influence	City	2012	66	-	2	8	?
Global Metro Monitor	LSE cities, et. Al	Economic Recovery	City	2010	150	1	-	2	2
Urban Sustainability Index - China	McKinsey & Company, Columbia University and Tsinghua University	Sustainability	City	2011	112	1	4	6	19
Resilience capacity index	Buffalo Regional Institute	Resilience	Metro Area	2011	361	1	-	3	12
Climate and Disaster Resilience Initiative (Capacity building Program)	CityNet/Kyoto University/ TDLC/SEEDS/UNISDR- Climate and Resilience	Resilience	City	2010	8	1	5	25	125
Climate Change Vulnerability Index	Center for Global Development	Vulnerability	Country	2011	233	1	-	-	11
Global Urban Indicators Database	UN-HABITAT	Urban Development	City	1998	237	-	6	20	43
City Resilience Profiling Programme	UN-HABITAT	Resilience	City	2012	10	To be completed	To be completed	To be completed	To be completed
GAIN Index	Global Adaptation Institute.	Climate change vulnerability and readyness to improve Resilience	Country	2011	176	1	2	9	50
OECD Environmental Indicators	OECD	Environmental Sustainability	Country	2001	29	-	2	15	50

Structure Tables

Background						Structure			
Title	Author	Topic	Scale	Year Completed	Number of Subjects Studied	Index	Sub-indices	Indicators	Variables
ASPIRE	Arup ID	Sustainability	Projects	2008	Variable	-	4	20	96
10 Essentials of City Resilience	UNISDR	Resilience	City	2012	10	-	-	10	41
Climate Vulnerability Monitor 2nd ed.	DARA + Climate Vulnerable Forum	Vulnerability	Country	2012	196	2	8	34	60
Disaster Resilience Indicators	University of South Carolina	Resilience	County	2010	736	1	-	5	36
City Profile- Climate and Disaster Resilience	CityNet/Kyoto University/ TDLC/SEEDS/UNISDR- Climate and Resilience	Resilience	City	2009	15	1	5	24+	?
Cities of Opportunity	Price Waterhouse Cooper & Partnership for New York City	Urban Opportunity	City	2012	27	1	-	10	60
C40 Cities Report Climate Action in MegaCities	C40 Cities climate action group	Climate Action	City	2011	36	-	-	11	128
ACCCRN City projects	Rockefeller Foundation	Resilience	Projects	2012	22 Projects in 10 Cities	-	-	6	-
Green Cities Index	Siemens	Environmental Sustainability	City	2012	120	1	-	8	30
Characteristics of a Safe and Resilient Community	IFRC	Resilience	Community	2011	30	-	-	-	-
Provincial Competitiveness Index	USAID/VNCI	Economic Competitiveness	Provincial	2011	63	1	-	13	86

Ownership Tables

Background						Ownership				
Title	Author	Topic	Scale	Year Completed	Number of Subjects Studied	Assessment Structure	Data Ownership	Sponsor	Assessor	TYPE OF ASSESSOR
Global City Competitiveness Index	Citigroup	Competitiveness	City	2012	120	Sponsor Driven	External	Citigroup	Economist Intelligence Unit	PRIVATE
Economist Liveable Cities Index	Economist Intelligence Unit (EIU)	Liveability	City	2008	140	Sponsor Driven	External	Economist Intelligence Unit (EIU)	Economist Intelligence Unit (EIU)	PRIVATE
Global Cities Index	A. T. Kearney	Global Influence	City	2012	29	Sponsor Driven	External	A. T. Kearney	A. T. Kearney	PRIVATE
Emerging Cities Outlook	A. T. Kearney	Global Influence	City	2012	66	Sponsor Driven	External	A. T. Kearney	A. T. Kearney	PRIVATE
Global Metro Monitor	LSE cities, et. Al	Economic Recovery	City	2010	150	Sponsor Driven	External	The Alfred Herrhausen Society, The International Forum of Deutsche Bank	LSE cities, et. Al	ACADEMIC
Urban Sustainability Index - China	McKinsey & Company, Columbia University and Tsinghua University	Sustainability	City	2011	112	Sponsor Driven	External	Urban China Initiative	McKinsey & Company, Columbia University and Tsinghua University	TASKFORCE
Resilience capacity index	Buffalo Regional Institute	Resilience	Metro Area	2011	361	Sponsor Driven	External but available	MacArthur Foundation	Buffalo Regional Institute	ACADEMIC
Climate and Disaster Resilience Initiative (Capacity building Program)	CityNet/Kyoto University/ TDLC/SEEDS/UNISDR- Climate and Resilience	Resilience	City	2010	8	City Driven	Internal	CityNet/Kyoto University/ TDLC/SEEDS/UNISDR- Climate and Resilience	CityNet/Kyoto University/ TDLC/SEEDS/UNISDR- Climate and Resilience	TASKFORCE
Climate Change Vulnerability Index	Center for Global Development	Vulnerability	Country	2011	233	Assessor Driven	External but available	Center for Global Development	Center for Global Development	ACADEMIC
Global Urban Indicators Database	UN-HABITAT	Urban Development	City	1998	237	City Driven	Internal	UN-HABITAT	UN-HABITAT	AGENCY
City Resilience Profiling Programme	UN-HABITAT	Resilience	City	2012	10	City Driven	Unknown	UN-HABITAT	UN-HABITAT	AGENCY
GAIN Index	Global Adaptation Institute.	Climate change vulnerability and readyness to improve Resilience	Country	2011	176	City Driven	Internal	Global Adaptation Institute.		TASKFORCE
OECD Environmental Indicators	OECD	Environmental Sustainability	Country	2001	29	City Driven	Internal	OECD	OECD	TASKFORCE

Ownership Tables

Background						Ownership				
Title	Author	Topic	Scale	Year Completed	Number of Subjects Studied	Assessment Structure	Data Ownership	Sponsor	Assessor	TYPE OF ASSESSOR
ASPIRE	Arup ID	Sustainability	Projects	2008	Variable	Self-Assessment	Internal	Variable	Arup ID	PRIVATE
10 Essentials of City Resilience	UNISDR	Resilience	City	2012	10	Self-Assessment	Internal	UNISDR	UNISDR	TASKFORCE
Climate Vulnerability Monitor 2nd ed.	DARA + Climate Vulnerable Forum	Vulnerability	Country	2012	196	Self-Assessment	Internal	DARA + Climate Vulnerable Forum		TASKFORCE
Disaster Resilience Indicators	University of South Carolina	Resilience	County	2010	736	Sponsor Driven	External but available	University of South Carolina	University of South Carolina	ACADEMIC
City Profile- Climate and Disaster Resilience	CityNet/Kyoto University/ TDLC/SEEDS/UNISDR- Climate and Resilience	Resilience	City	2009	15	City Driven	Internal	CityNet/Kyoto University/ TDLC/SEEDS/UNISDR- Climate and Resilience	CityNet/Kyoto University/ TDLC/SEEDS/UNISDR- Climate and Resilience	TASKFORCE
Cities of Opportunity	Price Waterhouse Cooper & Partnership for New York City	Urban Opportunity	City	2012	27	Assessor Driven	External	Price Waterhouse Cooper & Partnership for New York City	Price Waterhouse Cooper & Partnership for New York City	PRIVATE
C40 Cities Report Climate Action in MegaCities	C40 Cities climate action group	Climate Action	City	2011	36	City Driven	Internal	C40 Cities climate action group	Arup	PRIVATE
ACCCRN City projects	Rockefeller Foundation	Resilience	Projects	2012	22 Projects in 10 Cities	Self-Assessment	Internal	Rockefeller Foundation	Asian Cities Climate Change Resilience Network City	TASKFORCE
Green Cities Index	Siemens	Environmental Sustainability	City	2012	120	Sponsor Driven	External	Siemens	Economist Intelligence Unit	PRIVATE
Characteristics of a Safe and Resilient Community	IFRC	Resilience	Community	2011	30	City Driven	Internal	International Federation of the Red Cross and Red Crescent	Arup ID	PRIVATE
Provincial Competitiveness Index	USAID/VNCI	Economic Competitiveness	Provincial	2011	63	Sponsor Driven	External	USAID/VNCI	Vietnam Chamber of Commerce and Industry	TASKFORCE

Output Tables

Background						Outputs		
Title	**Author**	**Topic**	**Scale**	**Year Completed**	**Number of Subjects Studied**	**Numerical**	**Visual**	**Interactive**
Global City Competitiveness Index	Citigroup	Competitiveness	City	2012	120	Index (number) and indicator levels (no number)	-	-
Economist Liveable Cities Index	Economist Intelligence Unit (EIU)	Liveability	City	2008	140	Unknown - Study not purchased	Unknown - Study not purchased	Unknown - Study not purchased
Global Cities Index	A. T. Kearney	Global Influence	City	2012	29	Index (numbers) and indicator levels - no variable info	*	-
Emerging Cities Outlook	A. T. Kearney	Global Influence	City	2012	66	*	*	-
Global Metro Monitor	LSE cities, et. Al	Economic Recovery	City	2010	150	*	*	-
Urban Sustainability Index - China	McKinsey & Company, Columbia University and Tsinghua University	Sustainability	City	2011	112	* ranking only	-	-
Resilience capacity index	Buffalo Regional Institute	Resilience	Metro Area	2011	361	*	*	-
Climate and Disaster Resilience Initiative (Capacity building Program)	CityNet/Kyoto University/ TDLC/SEEDS/UNISDR- Climate and Resilience	Resilience	City	2010	8	Displayed on webdiagrams (subindices with indicators) - no data	*	-
Climate Change Vulnerability Index	Center for Global Development	Vulnerability	Country	2011	233	*	-	-
Global Urban Indicators Database	UN-HABITAT	Urban Development	City	1998	237	*	-	-
City Resilience Profiling Programme	UN-HABITAT	Resilience	City	2012	10	Unknown - Study not completed	Unknown - Study not completed	Unknown - Study not completed
GAIN Index	Global Adaptation Institute.	Climate change vulnerability and readyness to improve Resilience	Country	2011	176	*	*	*
OECD Environmental Indicators	OECD	Environmental Sustainability	Country	2001	29	*	*	-

Output Tables

Background						Outputs		
Title	**Author**	**Topic**	**Scale**	**Year Completed**	**Number of Subjects Studied**	**Numerical**	**Visual**	**Interactive**
ASPIRE	Arup ID	Sustainability	Projects	2008	Variable	*	*	-
10 Essentials of City Resilience	UNISDR	Resilience	City	2012	10	*	-	-
Climate Vulnerability Monitor 2nd ed.	DARA + Climate Vulnerable Forum	Vulnerability	Country	2012	196	*	*	-
Disaster Resilience Indicators	University of South Carolina	Resilience	County	2010	736	*	*	-
City Profile- Climate and Disaster Resilience	CityNet/Kyoto University/ TDLC/SEEDS/UNISDR- Climate and Resilience	Resilience	City	2009	15	Displayed on webdiagrams (subindices with indicators) - no data	*	-
Cities of Opportunity	Price Waterhouse Cooper & Partnership for New York City	Urban Opportunity	City	2012	27	*	*	-
C40 Cities Report Climate Action in MegaCities	C40 Cities climate action group	Climate Action	City	2011	36	*	*	-
ACCCRN City projects	Rockefeller Foundation	Resilience	Projects	2012	22 Projects in 10 Cities	-	*	-
Green Cities Index	Siemens	Environmental Sustainability	City	2012	120	*	-	-
Characteristics of a Safe and Resilient Community	IFRC	Resilience	Community	2011	30	-	-	-
Provincial Competitiveness Index	USAID/VNCI	Economic Competitiveness	Provincial	2011	63	*	*	-

Appendix C: References

A. T. Kearney. (2012). Global Cities Index and Emerging Cities Outlook.

ACCCRN. (2012). ACCCRN City projects. Asian Cities Climate Change Resilience Network.

Aguna, C. G., & Kovacevic, M. (2010). Uncertainty and Sensitivity Analysis of the Human Development Index. United Nations Development Programme.

Arup. (2008). San Franscisco Public Utilities Commission Sustainability Plan.

Arup. (2011). C40 Cities Report Climate Action in MegaCities. Arup and C40 Cities climate action group.

Arup. (2014, January 10). City Resilience Presentation. New York City.

Berkeley and the Buffalo Regional Institute. (2011). Resilience capacity index.

Center for Global Development- Wheeler. D. (Climate Change Vulnerability Index). 2011.

CityNet el al. (2010). Climate and Disaster Resilience Initiative (Capacity building Program). CityNet/Kyoto University/ TDLC/SEEDS/UNISDR.

CityNet et al. (2009). City Profile- Climate and Disaster resilience. CityNet/Kyoto University/ TDLC/SEEDS/UNISDR.

Cutter, S., Burton, C., & Emrish, C. (2010). Disaster Resilience Indicators for Benchmarking Baseline Conditions. Journal of Homeland Security and Emergency Management.

da Silva, J., Kernaghan, S., & Luque, A. (2012). A systems approach to meeting the challenges of urban climate change. International Journal of Urban Sustainable Development, 125-145.

DARA. (2012). Climate Vulnerability Monitor 2nd ed. DARA and the Climate Vulnerable Forum.

EIU. (2010). Economist Liveable Cities Index. Economist Intelligence Unit.

EIU. (2012). Global City Competitiveness Index. Economist Intelligence Unit.

Federation of Canadian Municipalities. (2012). The Quality of Life Reporting System.

Global Adaptation Institute. (2012). GAIN Index.

Heycox, J. (2007). Integrating data for sustainable development: introducing the distribution of resources framework. Chichester, UK: John Wiley & Sons, Ltd.

IBM. (2010). Smarter Cities Challenge.

IFRC. (2011). Characteristics of a Safe and Resilient Community.

IRI. (2010). From Transparency to Performance: Industry-Based Sustainability Reporting on Key Issues. Cambridge, Massachusetts, USA.

Jollands, N., Lermit, J., & Patterson, M. (2003, March 26). The usefulness of aggregate indicators in policy making and evaluation: a discussion with application to eco-efficiency indicators in New Zealand. Retrieved 03 27, 2013, from International Society for Ecological Economics: http://isecoeco.org/pdf/jollands.pdf

Lam, D. (2012, 10 05). Sustaibable Cities: A city by any other ranking. Retrieved 03 26, 2013, from World bank blog: http://blogs.worldbank.org/sustainablecities/a-city-by-any-other-ranking

McKinsey et al. (2011). Urban Sustainability Index. Urban China Initiative.

Meadows, D. (1998). Indicators and information for sustainable development. USA: The Sustainability Institute.

Metropolitan Policy Program, the Brookings Institution, LSE Cities, London School of Economics and Political Science with Deutsche Bank Research. (2012). Global Metro Monitor.

Morse, S. (2004). Indices and indicators in development: An unhealthy obesession with numbers. London: Earthscan.

National Preparedness Leadership Initiative. (Ongoing). Harvard's MetaLeadership program.

OECD. (2001). OECD Environmental Indicators: Towards Sustainable Development. Organization for Economic Cooperation and Development.

PWC. (2012). Cities of Opportunity. Price Waterhouse Coopers.

Rockefeller Foundation. (2013). Resilience Inception Workshop Report.

Saisana, M., Saltelli, A., & Tarantola, S. (2005). Uncertainty and sensitivity analysis techniques as tools for the quality assessment of composite indicators. Journal of the Royal Statistical Society, 307-323.

Siemens. (2012). Green Cities Index. Economist Intelligence Unit and Siemens.

Siemens. (2013). Resilient Cities Toolkit.

Simpson, D. (2006). Indicator Issues and Proposed Framework for a Disaster Preparedness Index. Louisville, USA: Center for Hazards Research and Policy Development.

UN HABITAT. (2002). Global Urban Indicators Database.

UN-HABITAT. (2013). City Resilience Profiling Programme.

UNISDR. (2012). City Resilience in Africa: 10 Essentials Pilot.

United Nations Environment Programme- Green Economy Initiative. (2011). Green Economy.

US General Accounting Office. (1991). Toxic Chemicals: EPA's Toxic Release Inventory is useful but can be improved.

USAID. (2011). Provincial Competitiveness Index.

Vienna University of Technology, University of Ljubljana, Delft University of Technology. (2007). Smart cities Ranking of European medium-sized cities.

World Bank. (2011). Guidelines for Monitoring and Evaluating World Bank Projects Aimed at Improving Reproductive Health Outcomes. Retrieved 03 26, 2013, from worldbank.org: http://siteresources.worldbank.org/INTPRH/Resources/376374-1278599377733/ReproductiveHealthMEFinalMarch22011.pdf

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