Developing Urban Climate Adaptation Indicators

Photo credit: Patrick Benko, DC Climate Photo Contest Winner

SECTION 1: SURVEY OF THE FIELD

SECTION 2: A USER GUIDE FOR SUSTAINABILITY DIRECTORS

Section 1: Survey of the Field

Purpose

For years, USDN member cities have successfully developed and used diverse and robust indicators to measure progress in climate change mitigation. Cities face a new challenge as they must now develop similar assessment systems to establish baselines and track progress toward climate adaptation goals. To support this effort, a number of third-party adaptation frameworks and indicators are emerging. However, the community of framework developers lacks consistent, organized input from urban adaptation practitioners. USDN has an opportunity to take a leadership role to shape these frameworks to ensure results based on cities' experience, needs, and priorities.

To that end, USDN established its Climate Adaptation Indicators Group in the spring of 2015 to assess leading climate adaptation indicator frameworks, determine their relevance and feasibility from a city perspective, and identify gaps. The group has funding from the USDN Innovation Fund grant and technical support from the Institute for Sustainable Communities (ISC). The working group is led by Washington, DC. Other members of the group include Aspen, CO; Baltimore, MD; Berkeley, CA; Boston,

MA; Cleveland, OH; and Vancouver, BC. Additional input was provided by Boulder County, CO; Louisville, KY; Seattle, WA; Surrey, BC; Toronto, ON.

This document reviews seven leading adaptation frameworks out of an initial scan of 28. The analysis is intended to help city practitioners understand, assess and appropriate current approaches for measuring adaptation progress. Empowered with this information, USDN members will be better positioned to shape their own adaptation efforts and influence the development of adaptation frameworks so that they reflect the needs and priorities of actual urban practitioners.

Towards an Urban Consensus on Adaptation Indicators

Many of the frameworks investigated by the group are still under development and the creators are soliciting feedback from cities. This represents an opportunity for USDN members to influence their development so they are most useful for local adaptation efforts. It is the goal of this survey to inform USDN members about leading frameworks to determine their relevance to local efforts. The analysis considers the following questions where appropriate:

- Is the framework practical for governments of all capacity levels and budgets?
- Who is the intended audience for the framework? What are its goals? Do they conflict with the needs of urban sustainability practitioners?
- Do frameworks allow for diverse local political, geographic, economic contexts? What are the tradeoffs when using a standardized system common to multiple cities vs. "homegrown" frameworks?
- Do frameworks allow cities and their constituents to participate in defining successful resilience on their own terms?
- Do frameworks consider equity? Do they ensure that disadvantaged populations are considered and involved in adaptation planning?

Summary of Adaptation Frameworks (click links for more information)

Framework	Scope	Goal	Status
C40 Climate Risk Assessment Framework and Taxonomy (CRAFT)	Mitigation and adaptation risks and actions for cities.	Elevate the actions of cities to influence international climate policy. Also meant to standardize climate risk reporting for investors.	Released at COP21 (December 2015). Will be integrated into 2016 CDP reporting.
CDP Climate Adaptation Reporting	Mitigation and adaptation risks and actions for cities and companies.	Standardize adaptation and mitigation reporting, help cities and companies collaborate.	Under development – draft adaptation questions revised annually.

Boston Draft Climate Change Adaptation Framework	Adaptation plan for and by City of Boston.	Internal adaptation management, public transparency.	Under development – draft plan and specific indicators not yet developed.
ICLEI Preparing for Climate Change Guide and **ADAPT tool**	General guidance on adaptation planning for cities, ADAPT tool for managing planning and vulnerability assessments.	Standardize adaptation planning, empower local governments, foster peer learning.	Guide is complete, ADAPT tool under development, seeking USDN input.
US Climate Resilience Toolkit	General guidance and scientific tools for local vulnerability assessments and adaptation planning.	Empower local governments with climate adaptation tools.	Toolkit is complete, may include indicators in future.
ND-GAIN - Urban Adaptation Assessment	Tool for measuring vulnerability and readiness of countries, adapted for cities.	Standardize measurement to help businesses, cities, nonprofits make better decisions.	Under development, soliciting feedback from cities.
Rockefeller City Resilience Framework and Index	Framework guides action for 100 Resilient Cities members, Index will provide measurement system.	Standardize measurement in a nuanced, comprehensive way, "elevate the consensus" around resilience.	Framework is complete, Index is under development.

Profile of Selected Major Frameworks

C40 Climate Risk Assessment Framework and Taxonomy (CRAFT)

Developers: *C40 and Arup with funding from Bloomberg Philanthropies*

With support from Bloomberg Philanthropies, C40 and Arup are producing the Climate Risk Assessment Framework and Taxonomy (CRAFT) as the reporting tool for the Compact of Mayors, a global coalition of mayors and city officials committed to climate change mitigation and adaptation. CDP and the carbonn[®] Climate Registry (cCR) will incorporate CRAFT into a reporting framework to support the Compact of Mayors.

CRAFT builds on the City Climate Hazard Taxonomy, also developed by Arup and C40, which defined a "clear and concise lexicon" of common climate hazards faced by cities. CRAFT will combine the Taxonomy's analysis of hazards with additional resources to help cities iteratively measure their adaptation planning progress and work with other cities to collectively advocate for support from governments and the philanthropic community.

The CRAFT tool is still under development, but the Taxonomy has already been released for public comment. The hazards identified by the Taxonomy are not directly translatable to measurable indicators. For example, the sub-type hazard of "hot days" could be measured by counting the number of days above 90 degrees in a year, by measuring the average summer temperature highs, nightly lows, or by the percent change in average temperatures from a certain baseline. For this reason, the Taxonomy alone will help cities talk about climate hazards in a standardized way, but not necessarily measure them the same way.

The Taxonomy organizes climate hazards into five broad groups.

- Meteorological: Short term or small-scale weather conditions (e.g. minutes to days).
- Climatological: Long-term or large-scale atmospheric processes (e.g. intra seasonal-to multi-decadal).
- Hydrological: Mass movement of water or a change in the chemical composition of water bodies.
- Geophysical: Originating from mass movement of solid earth.
- Biological: A change in the way living organisms grow and thrive, which may lead to contamination and/or disease.

HAZARD GROUP	HAZARD (MAIN TYPE)	CITY CLIMATE HAZARD (TYPE)	CITY CLIMATE HAZARD (SUB TYPE)	RELATED NATURAL HAZARDS
Meteorological	Precipitation	Rain storm	Monsoon	Insects and micro-organisms
		Heavy snow	Snowstorm/blizzard	
	Wind	Severe wind	Dust storm/sandstorm	
		Tornado	Extratropical cyclone	Chemical change
		Cyclone (Hurricane/Typhoon)		Flood
		Tropical storm		Wave action
	Lightning	Electrical storm	Lightning/thunderstorm, derecho	Wild fire
	Fog	Fog		Water scarcity
	Extreme temperature - Cold	Extreme winter conditions	Ice, hail, freezing rain, debris avalanche	
		Cold wave	Cold snap, frost	Subsidence
		Extreme cold weather	Cold days	Landslide
	Extreme temperature - Hot	Heat wave		Drought
		Extreme hot weather	Hot days	
Climatological	Water scarcity	Drought	Lack of precipitation and seasonal melt (snow, glacial)	Rockfall
	Wild fire	Forest fire		Avalanche
		Land fire	Bush fire, grass fire, pasture fire, scrub fire	Subsidence, Landslide
Hydrological	Flood	Flash/surface flood	Glacial lake outburst	Subsidence
		River flood		
		Coastal flood		Insects and micro-organisms
		Groundwater flood	Waterlogging	
	Wave action	Storm surge	Seiche	Landslide
	Chemical change	Salt water intrusion		Flood
		Ocean acidification		
Geophysical	Mass movement	Landslide	Lahar, mud flow, debris flow	Chemical change
		Avalanche	Debris avalanche, snow avalanche	
		Rockfall		
		Subsidence	Sudden subsidence (sinkhole), long-lasting subsidence	Flood
Biological	Insects and micro-organisms	Water-borne disease	E.g. Cholera, Typhoid, Legionnaires' disease	Extreme temperature - hot
		Vector-borne disease	E.g. Malaria, Dengue Fever, Yellow Fever, West Nile Virus, Bubonic Plague	
		Air-borne disease	E.g. Pneumonic Plague, Influenza	Flood
		Insect infestation	E.g. Pine beetles, killer bees, termites	

Draft City Climate Hazard Taxonomy

Within each of the groups, there are one or more "main types" of hazard, which can be further divided into "types" and "sub-types." See the graphic above for a breakdown of the hazards and how they are organized. In the rightmost column of the Taxonomy are related natural hazards. These are hazards from other groups (color-coded to represent their original group) that relate to this group, meant to show the interconnected nature of many climate hazards.

CRAFT is designed for use by C40 cities to measure their own hazards and progress, rather than for external organizations to measure cities. Its goals are to improve the effectiveness of city adaptation planning and action and to help cities better share best practices, tools, and actions. The Hazard Taxonomy in particular can help cities identify others who are facing the same challenges by ensuring that they are using the same terminology. The framework is also meant to standardize climate risk in a way similar to how financial risk is disclosed to investors. This has the advantage of allowing climate-ready communities to attract investment, but could also potentially affect cities' standing in municipal bond markets.

The public comment period for the Taxonomy ended in April of 2015. The CRAFT tool is still under development by C40 and Arup. The developers are primarily seeking feedback from C40 cities, but are also open to comments from others. C40 is developing a questionnaire for member cities that would solicit information about the risks cities are identifying as well as the indicators they are using to track progress.

For more information, contact Kathryn Vines, Head, Adaptation Research, C40: kvines@c40.org

CDP Climate Adaptation Reporting

Developer: *CDP*

CDP regularly sends climate reporting questionnaires to selected cities and companies around the world, then uses this data to benchmark their climate actions. CDP has now added a "Risks and Adaptation" section to their disclosure forms that are sent to cities and companies. The section asks respondents to detail their climate hazards and risks, whether they have conducted a vulnerability assessment or taken other actions to address climate hazards, and what kind of opportunities climate change may present to them. The form also includes a question about the social and health risks posed by climate change.

CDP seeks to facilitate standardized reporting of climate adaptation and mitigation risks and actions, rather than to facilitate internal management and tracking. However, cities may find it valuable to learn how other cities and the private sector are thinking about climate change adaptation as it may spur inter-city or public-private cooperation.

CDP is considering aggregating questionnaire responses from cities and companies within the same geographies and then making it available to reporting entities. They believe that this "360°" view of risk can help cities and businesses establish a common platform to identify shared risk and collaborate on adaptation.

For more information, contact Katie Walsh, CDP Cities, Cities Manager for North America: katie.walsh@cdp.net

Draft Climate Change Adaptation Framework for the City of Boston

Developers: *Prepared by SeaPlan for the Boston Harbor Association, with contributions from the City of Boston and EcoAdapt*

This Draft Adaptation Framework is Boston's first attempt to create adaptation metrics to guide the city's planning efforts, as was called for in Boston's Climate Action Plan. The project developed a framework of six high-level indicators and a series of nested metrics, with "indicator" being a synonym for "category." Within each metric are more specific sub-metrics, which are a mix of process and output indicators, such as "Climate preparedness is considered a priority in City planning" and "Number of disease outbreaks and climate related illnesses, and prevention measures included in ongoing health programs." The indicators are described below.

- Institutional Planning, Capacity and Coordination
    - The degree to which planning, capacity and coordination to effectively prepare for and respond to climate change and extreme weather events is in place. Climate change is mainstreamed into city plans and programs. Finances and resources are available to adequately address climate change and related events. Government is able to continue operating and providing critical services during climate-related events.
- Climate Science and Information
    - The degree to which information and data are available and used to adequately address climate change and related events.
- Public/Stakeholder Engagement and Awareness
    - The degree to which the public and specific stakeholders are aware of and provide input into preparing for climate change and related events.
- Public Health and Safety
    - The degree to which Boston residents are vulnerable to climate-related health risks and have access to needed services and amenities.
- Natural Resources and Coastal Infrastructure
    - The degree to which natural ecosystems in Greater Boston are able to withstand impacts of climate change and related events. Green/gray infrastructure is expanded to address climate vulnerabilities. Protective infrastructure (e.g., ecosystem components and coastal infrastructure - dikes, levees and sea walls) exist and are adequate to protect against climate- related events and risks.

- Public/Private Buildings and Utilities
  - The degree to which public/private buildings and utilities are adequately prepared to withstand climate change and climate-related events.

Boston used the following principles to guide the development of these indicators and metrics:

- Indicators should be linked to Boston's stated adaptation goals.
- Indicators should allow for adaptive, flexible planning.
- Indicators should be linked to topics most relevant to Boston and the region.
- Indicators should complement Boston's existing mitigation goals.
- Indicators should avoid maladaptation.
- Indicators should include both process and outcome measures.

The metrics listed under each indicator category are still in draft form and will gain more specificity as they are developed further. The framework is designed as a management tool for city staff to track progress towards meeting adaptation goals. It is also designed to align with Boston's mitigation goals, and includes both process and outcome measures. The nested structure of indicators, sub-indicators, and metrics could allow for simplified reporting on overarching indicators and also more granular and technical reporting on individual metrics. These characteristics should enable the framework to support transparent public reporting and be used for detailed internal management.

For more information, contact Carl Spector, Director of Climate and Environmental Planning, City of Boston: carl.spector@cityofboston.gov

Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments

Developers: The Climate Impact Group at the University of Washington and King County, Washington, in association with ICLEI - Local Governments for Sustainability

ICLEI's Guidebook was written in 2007 by the University of Washington's Climate Impacts Group and King County, Washington. Its goal is to provide a consistent and relatively standardized process by which local governments can better understand their risks, create plans to mitigate risks, and monitor progress over time. This kind of standardized adaptation process can facilitate peer exchange between governments.

The Guidebook divides the adaptation planning process into five milestones: initiating your climate resiliency effort, conducting a climate resiliency study, setting preparedness goals and developing your preparedness plan, implementing your preparedness plan, and measuring progress and updating the plan.

The vulnerability assessment chapter walks cities through the process of creating a nuanced picture of the threats posed to their communities. First, planners identify how sensitive parts of their community are to various threats, with sensitivity defined as, "the degree to which a built, natural or human system is directly or indirectly affected by changes in climate conditions or specific climate change impacts." Next, planners assess the adaptive capacity of these systems, defined in the guide as "the ability of…systems associated with a given planning area to accommodate changes in climate with minimum disruption or minimum additional cost." Then the guide explains how to combine sensitivity and adaptive capacity into vulnerability, which is defined as "the susceptibility of a system to harm from climate change impacts."

ICLEI's guide is populated with real examples and tools used by cities in order to help planners implement its guidance. It contains links to external resources and groups that can be of assistance to planners. It also frames its guidance with considerations of the resource and capacity constraints that cities face, allowing them to tailor their level of action to their means.

The final section, on measurement, does not provide specific indicators, but instead offers guidance on how to develop them (termed "measures of resilience") in a way that relates to a city's stated resilience goals and that takes into account the reporting burden that new indicators create.

ICLEI is in the process of developing indicators for their ADAPT tool. The ADAPT tool is a cloud-based software application for managing local climate preparedness planning and vulnerability assessments, based on the framework in the above guide. ADAPT is available for free to ICLEI members.

ICLEI's advisory committee has expressed interest in USDN providing input on how the ADAPT tool could be improved in future versions. ICLEI is also working with C40 on the City Climate Hazard Taxonomy and are considering using the Carbonn tool to support a more robust focus on indicators.

For more information, contact Brian Holland, Program Director, ICLEI, brian.holland@iclei.org

US Climate Resilience Toolkit

Developers: *The White House Council on Environmental Quality and the National Oceanographic and Atmospheric Administration (NOAA)*

The web-based US Climate Resilience Toolkit is designed to present scientific tools to aid in local vulnerability assessments and adaptation planning. It lays out a stepwise process for identifying climate vulnerabilities and evaluating options for addressing them, with each step being accompanied by a suite of tools.

The Toolkit is not specifically designed for cities and includes guidance for adaptation planning at other scales and by other actors, but many of its resources will be relevant to cities. While the step-wise

guidance lacks the meticulous detail of, for example, ICLEI's Guidebook, the site is an excellent clearinghouse of a large number of tools and science-based resources, including Climate Explorer, a "visualization tool that offers maps of climate stressors and impacts as well as interactive graphs showing daily observations and long-term averages from thousands of weather stations." The Toolkit also includes links to a variety of funding sources for climate planning and action.

The toolkit currently does not have indicators and includes only cursory guidance on developing indicators. However, its developers are evaluating how to include them. They are currently exploring two sets of indicators. One set would be based on the findings of the National Climate Assessment. These would likely be limited to hazard or vulnerability indicators, rather than process or outcome indicators. The second set would be focused on coastal communities and is being developed in partnership with the Eastern Research Group.

For more information, contact David Herring, Director of Communication & Education, NOAA Climate Program Office: david.herring@noaa.gov

Notre Dame Global Adaptation Index (ND-GAIN) - Urban Adaptation Assessment DRAFT

Developers: *University of Notre Dame Global Adaptation Index, with funding from the Kresge Foundation*

ND-GAIN prepared an Index that shows which countries are best prepared to deal with global changes brought about by overcrowding, resource-constraints and climate disruption. The Index is unique in its focus on not only country vulnerability, but also country readiness to accept adaptation investment. The Urban Adaptation Assessment is an effort to build an urban-scale assessment and pilot it in five cities to inform influencers so that government, corporations and people are motivated to build social, physical, and natural systems that are resilient to the impacts of climate change.

The Urban Adaptation Assessment will become a standard measurement framework that can be applied to any city. This will necessitate a universal set of indicators, which are currently under development. This process is being informed by an advisory committee of over 35 adaptation professionals, which met in advance of the May 11, 2015 National Adaptation Forum to discuss strategic questions and solicit advice on the selection of pilot cities. ISC's Michael Crowley is an advisory committee member.

The Assessment will be organized into a framework with the following categories:

- **Vulnerability of lives and livelihoods**: The degree to which an urban area is unable to cope with the impacts of four primary climate hazards (extreme cold, drought, flooding, and heat) on its human population. Vulnerability of lives and livelihoods is a function of *exposure* and *sensitivity* to the climate hazards, as well as *adaptive capacity*.

- o **Exposure**: The potential occurrence of a biophysical event, trend, or impact caused by climate change.
    - ▪ **Extreme cold hazard**
    - ▪ **Drought hazard**
    - ▪ **Flooding hazard**
    - ▪ **Heat hazard**
- o **Sensitivity:** The extent to which an urban area will be affected by, or responsive to, climate exposure. Sensitivity indicators measure the features of an urban area that amplify the exposure to the climate hazard, such as the proportion of buildings at risk of flooding.
- o **Adaptive capacity**: The ability of an urban area to prepare for or cope with the exposed and sensitive stresses or minimize the impacts of a climate hazard.
- • **Readiness:** The general features of urban areas that will enable policy change and action implementation to reduce vulnerability to climate stresses. Readiness is a function of *economic, governance,* and *social capacities.*
- • **Adaptation plan:** The plans made by city government to proactively or reactively respond to the impact of climate stresses. The Urban Adaptation Assessment will qualitatively assess adaptation plans for their ability to reduce sensitivity or improve adaptive capacity in light of that city's vulnerability.

The following graphic shows how the various categories of assessment relate to each other.
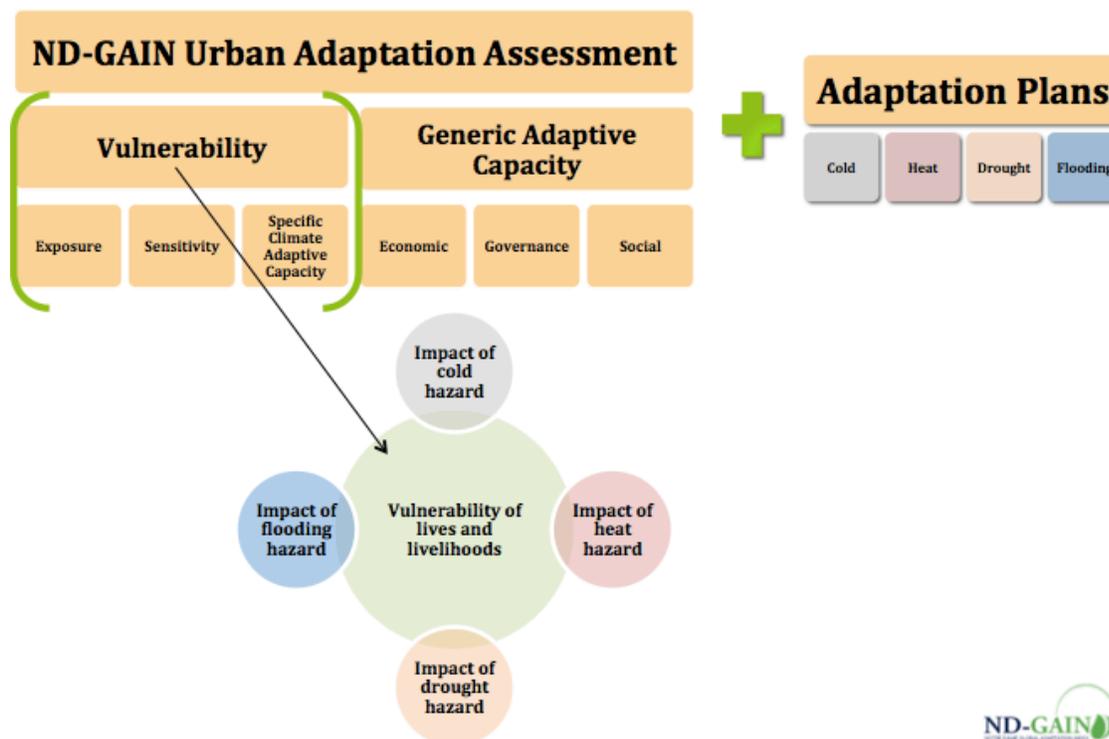
ND-GAIN's Urban Adaptation Assessment is still in draft form. The five assessed cities were chosen by the advisory committee to represent a diversity of size, location, economic strength, and climate hazards faced: Baltimore, Maryland; Davenport, Iowa; Los Angeles, California; Memphis, Tennessee; and Seattle, Washington.

For more information, contact Joyce Coffee, Managing Director, Notre Dame Global Adaptation Index: jcoffee@nd.edu and visit the Adaptation Collaboratory where the project collects publicly accessible resources.

City Resilience Framework and Index

Developers*: Rockefeller Foundation and Arup*

The Rockefeller/Arup City Resilience Framework is used by members of 100 Resilient Cities to define a standardized approach to resilience in cities. Arup is currently developing an index as a companion to the framework, intended to help measure and monitor progress. The index will measure three broad aspects of resilience: condition (the existing baseline), potential (opportunities to build resilience through specific initiatives), and value (cost-benefit of resilience actions).

The index in its current form is fairly detailed and multi-layered, with nested categories, indicators, sub-indicators, variables, and qualities. The index is based on desk research and fieldwork in six cities that have "recently experienced a major shock or are suffering chronic stresses." The index is organized according to seven qualities of resilient systems: reflective, robust, redundant, flexible, resourceful, inclusive and integrated. These are meant to "distinguish a resilience city from on that is simply livable, sustainable, or prosperous."

The developers then identified 12 "indicators" divided into four categories as shown below:

- Leadership and Strategy
    - Effective leadership and management
    - Empowered stakeholders
    - Integrated development planning
- Health and Wellbeing
    - Minimal human vulnerability
    - Livelihoods and employment
    - Safeguards to human life and health
- Economy and Society
    - Finance including contingency funds
    - Social stability and security
    - Collective identity and mutual support
- Infrastructure and Environment
    - Reliable mobility and communications

- o Continuity of critical services
- o Reduced physical exposure

Yet to be developed are the 48-54 sub-indicators under each indicator and the 130-150 "variables" (what we have referred to as "indicators" elsewhere in this document) that would fall under each sub-indicator. Each sub-indicator contributes to one or more of the seven qualities, as shown in the graphic below.

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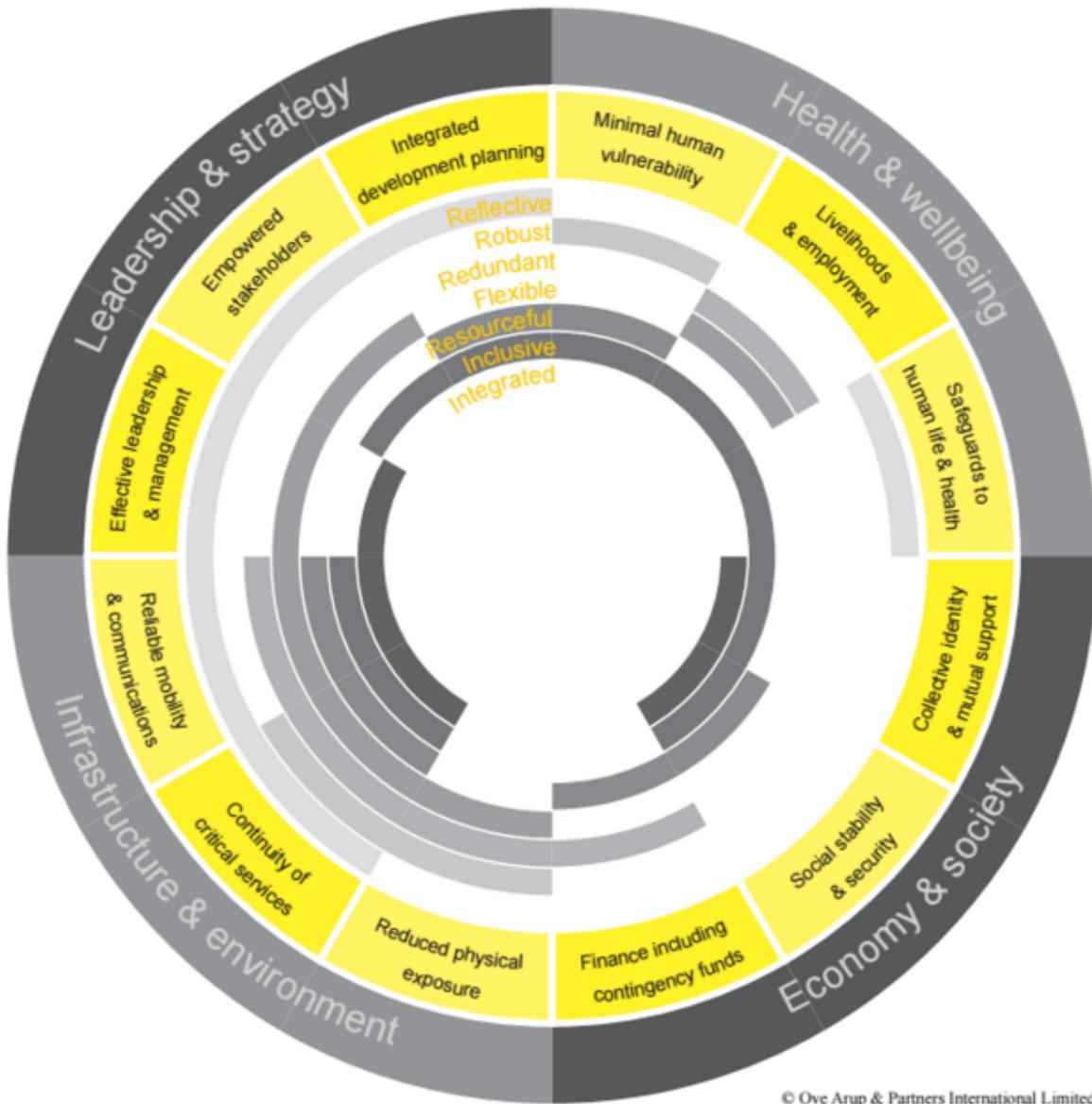
The Rockefeller/Arup Framework and Index will allow participating cities to understand and describe resilience in a nuanced and comprehensive manner, which Rockefeller hopes will "elevate the consensus" around resilience. As exhibited by the above indicators, the index incorporates both tangible and intangible aspects of resilience, such as collective identity and effective leadership. Rockefeller and

Arup intend for the variables is to be based on existing data where possible and aligned with variables already in use by cities for other purposes in order to minimize the reporting burden. This index will be reviewed and refined in consultation with experts and cities, including the 100RC Network and the Asian Cities Climate Change Resilience Network.

For information, contact Jo da-Silva, Director, Arup International Development: Jo.da-Silva@arup.com

ISO 37121: Indicators for Sustainable Development and Resilience in Cities

Developer*: International Organization for Standardization (ISO)*

ISO, the international body made up of representatives from national standards organizations around the world, is currently developing a set of indicators for use by cities to measure both sustainability and resilience. The standard will be closely related to ISO 37120: Sustainable Development of Communities, Indicators for City Services and Quality of Life, a collection of 100 indicators across 17 themes that was developed by the World Council on City Data, a network of cities from around the world.

ISO 37121, like other ISO standards, is both a set of indicators and a certification, allowing certified cities to demonstrate their sustainability and resilience in a standardized way to citizens, governments, and investors. The standard would cover 14 thematic areas:

- Smart Cities
- Emergency Preparedness
- Changes in rainfall and storm surges
- Protection of biodiversity
- Alternative energy
- Risk assessment
- Resilience infrastructure
- Smart grid
- Economic resilience
- Political resilience
- Walkability and accessibility
- Transit and mobility
- Water and waste management
- Green buildings

Section 2: A User Guide for Sustainability Directors

Introduction

An increasing number of sustainability directors across North America are leading efforts to address significant climate vulnerabilities and impacts including sea-level rise, heat waves, and extreme weather events. The scale, complexity, and interconnectedness of the challenges presented by climate change are by definition unprecedented. To meet a growing demand for guidance, many indicator frameworks have been developed to help cities measure their impact as they work to address climate change, but products that rely on universal indicators cannot address the great diversity of contexts in which cities are operating. Each community is unique not only in its specific vulnerabilities, but also in how it defines successful adaptation. This guide is designed to help practitioners develop customized indicators that are appropriate for their communities and address their specific adaptation goals, while helping them avoid some of the common pitfalls encountered in measurement.

Climate Adaptation Indicators and the Planning Process

Choice of climate adaptation indicators should be done in concert with an overall planning process. While there are many planning frameworks (see Section 1), most follow a continuous improvement process that outlines practical steps for climate adaptation planning.

Table 1 outlines a framework for adaptation planning that aligns key planning goals (identifying vulnerabilities, tracking progress, and measuring success) with planning steps (adapted from the US Climate Resilience Toolkit) and indicator types. The framework is intended to provide a planning context to develop and choose adaptation indicators, as described in the next section.

Table 1. Adaptation Indicators and the Planning Process

Planning Goals	Planning Steps[1]	Indicator Types
1. Develop a Vision of Resilience and Identify Vulnerabilities All communities have unique assets, social and economic stressors and shocks, and climate change drivers that influence the adaptation planning process. Vulnerability assessments help identify specific populations and assets at risk to inform a vision of what preferred adaptive future would look like. Success can take on many forms, ranging from being prepared for the next disaster to new, climate-sensitive economic development strategies.	**Step 1: Identify the Problem** Focus on climate stressors that threaten people, buildings, natural resources, or the economy in your area. A starting point for identifying stressors is the US Climate Risk Assessment. **Step 2: Determine Vulnerabilities** Identify specific populations, locations, and infrastructure that may be impacted by the climate problem you identified. See http://bit.ly/vulnerability_toolkit for a vulnerability assessment tool developed by ISC and Adaptation International.	**Exposure**. Indicators that describe how exposed a community is to climate impacts, rather than describing the results of a community's adaptation actions. For example, the number of people living in a floodplain would be a measure of exposure. **Sensitivity**. Sensitivity describes the degree to which a population or asset is affected by a climate impact. Two neighborhoods might have the same level of exposure to heat waves, but if one neighborhood has a greater percentage of homes equipped with air conditioners, then it would have a lower level of sensitivity.
2. Prioritize Actions Once a vision is established and vulnerabilities are understood, adaptation actions need to be developed and prioritized.	**Step 3: Investigate Options** Compile a list of potential solutions, drawing on the experiences of others who have addressed similar problems. **Step 4: Evaluate Risks and Costs** Consider risks and values to analyze the costs and benefits of favored options. Select the best solution for your situation and make a plan.	**Process**. These include the critical steps needed to produce outcomes, including number and type of stakeholders consulted, dollars spent, etc. Process indicators are only meaningful if they show direct progress toward outcomes. For example, process indicators may measure whether key changes have been made to the zoning code or how many people attend public meetings on adaptation.
3. Measure Success These include measures that prove physical adaptation goals were reached, such as acres of wetlands conserved that act as natural storm buffers. Outcome indicators typically have longer timescales and are measured only after predicted climate scenarios	**Step 5: Take Action** Implement your plan and monitor your progress. As necessary, adjust your plan to move toward your desired outcomes. Be prepared to iterate, if needed.	**Adaptive capacity (flexibility)**. The ability of a community to learn from experiences and proactively adjust responses according to changing conditions, while maintaining standard operations. Or, the ability of a community to

[1] Adapted from US Climate Resilience Toolkit

|		
occurred. For example, an outcome indicator that would measure the effectiveness of a stormwater management program might be the number of combined sewer overflows in a given period, compared to a baseline year.		minimize exposure to risk and buffer against climate-related shocks and stressors while continuing business-as-usual. A key element of adaptive capacity is being aware of changing conditions, and being able to respond to them. For example, the degree to which a community can measure the effectiveness of an erosion control plan as precipitation patterns change and adjust course if needed. **Transformative capacity (change)**. The degree to which fundamentally new governance, economic, and social systems are created to adapt to conditions. For example, the ability of a community to equitably and justly relocate populations deemed too at risk due to climate impacts.

Framework for Developing Indicators

The Resilient America Roundtable of the National Academy of Sciences convened the workshop *Measures of Community Resilienc*e in September of 2014. Dr. Susan Cutter, director the Hazards and Vulnerability Research Institute at the University of South Carolina offered a simple framework for developing indicators organized by target sectors (see Figure 1-1 & 1-2).

Each target category represents a key sector, or impact area. The Resilient America Roundtable identified four target areas for resilience:
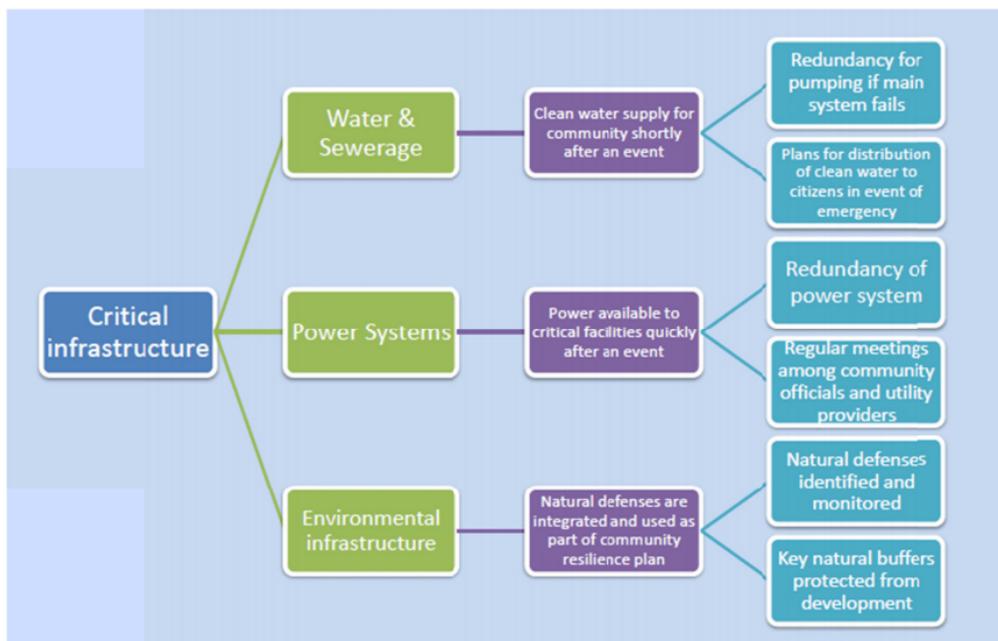
1. Critical infrastructure
2. Social factors
3. Buildings and structures
4. Vulnerable populations

Components for each target area are then defined. For example, under critical infrastructure, three components can include water & sewerage, power systems, and environmental infrastructure. Adaptation objectives for each component are then identified, with appropriate measures for each.

This framework can be incorporated into a city's adaptation planning process to ensure that indicators are incorporated early in the process.
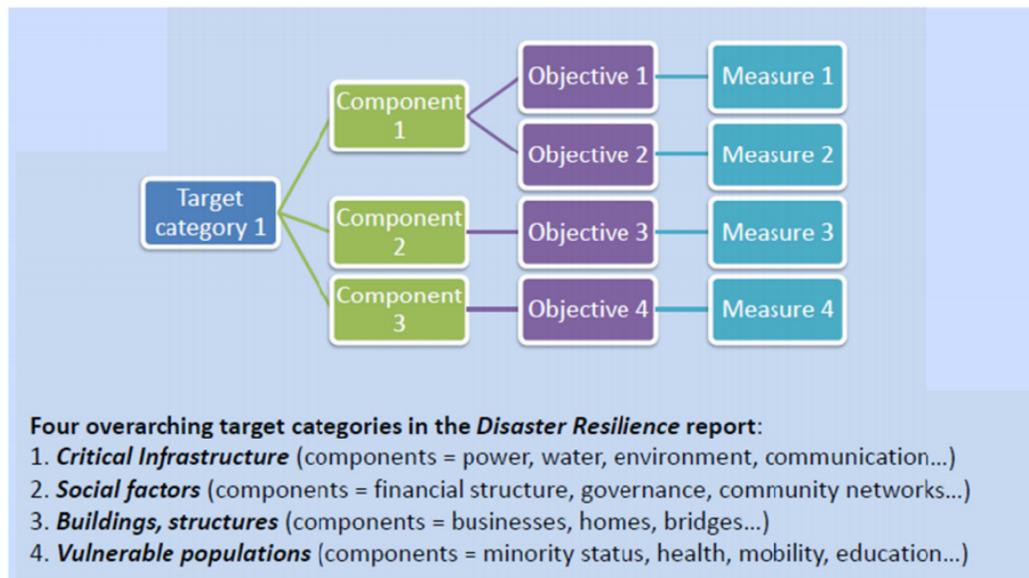
FIGURE 1-1 Four overarching target categories, components, objectives, and measures used in identifying elements for community resilience. SOURCE: Dr. Susan Cutter, presentation, September 5, 2014, Washington, D.C.

FIGURE 1-2 An example of components, objectives, and measures identified using the critical infrastructure target category. SOURCE: Dr. Susan Cutter, presentation, September 5, 2014, Washington D.C.

Challenges to Developing Adaptation Indicators

Measuring success for climate adaptation is not as easy as climate mitigation: there is no single metric (like greenhouse gas emissions) or unifying method for baselines (like GHG inventory scopes), and the impacts are predicted, but generally unknown. This presents several challenges to developing adaptation indicators that should be considered at the outset of the adaptation planning process.[2] While these challenges in many ways define the difficulties in adaptation planning, if they are properly understood and communicated they may also serve to make the process more transparent and practical. Further, if indicators are developed using good principles (discussed in the next section), then many of these challenges can be avoided or minimized.

- **Defining success**. There is lack of agreement on what constitutes "successful adaptation," and the definition of success usually depends on local context. There is some debate over whether adaptation is an outcome that can be achieved, or a set of processes.[3] On the one hand, considering adaptation to be a discrete outcome can make success easy to measure, and therefore easier to achieve. However, this approach can blind practitioners to the value of building adaptive or transformational capacity – qualities that can make communities more resilient as climate conditions continue to change.
- **Long time-horizons and shifting baselines.** The final impact of adaptation efforts may not be measurable for a long time. For example, planning for sea level rise may have time horizons of 30–50 years. Long time-horizons also mean that underlying conditions affecting adaptation change over time - meaning that baselines from which to measure progress shift. This makes it difficult to isolate the impact of individual adaptation measures.
- **Counterfactuals.** Successful adaptation often means preventing certain impacts from occurring – a phenomenon known as a counterfactual. Establishing success then means comparing reality against hypothetical scenarios, such as avoided impacts from flooding. To address this, potential flood damage in your own community can be compared against similar communities who did not take certain adaptive measures but who experience similar rainfall.
- **Potential for maladaptation**. Due to the complexity of systems (social, economic, political, climatic) in which adaptation measures operate, it can be challenging to tell when adaptation measures have unintended negative effects, like increasing GHG emissions, limiting future adaptation choices, or disproportionately burdening certain populations.
- **Invalid measures**. Indicators do not always measure true goals. For example, measuring the amount of funds spent on an intervention might not reflect whether the intervention was "economically beneficial, economically helpful, and socially acceptable."[4]
- **Unfunded measures**. There is a temptation to create a long list of indicators that address all known vulnerabilities. Yet, tracking indicators can be expensive, and if the list of indicators is too long, communities risk losing the ability to track and act on them effectively.

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[2] Source: Good Practice Study on Principles for Indicator Development, Selection, and Use in Climate Change Adaptation Monitoring and Evaluation produced by Climate-Eval, 2015

[3] Villanueva, Paula Silva. 2011. "Learning To ADAPT: Monitoring and Evaluation Approaches in Climate Change Adaptation and Disaster Risk Reduction – Challenges, Gaps and Ways Forward." SCR Discussion Paper 9. Strengthening Climate Resilience (SCR) Consortium. Brighton, United Kingdom: Institute of Development Studies (IDS).

[4] Moser, Susanne. "Why we need to do better on adaptation indicators." Sci Dev Net

Principles for Developing Good Indicators

When developing indicators there are certain overarching principles that every community should consider. These principles, collected from interviews with practitioners and from adaptation literature, fall into three categories:

1. Focus on Purpose
2. Think in Systems
3. Deliver Impact

It is recommended that these principles be used to develop proper adaptation goals and good indicators to measure progress toward those goals.

Focus on Purpose

Adaptation indicators must be tied to a specific adaptation goal to be useful and relevant.

- **Match Indicators to Adaptation Vision and Goals**. A good adaptation planning process begins with a vision for a healthy community amidst climate impacts, and matches indicators directly to goals and impact areas. Within this process, a range of adaptation outcomes could be appropriate, depending on how ambitious or specific the adaptation goal is. For example, success outcomes could range from simply being prepared for the next disaster to moving or fortifying critical assets, protecting specific populations, or reducing business investment risk.

> *Example from the field:* The City of Vancouver's Adaptation Strategy defines its vision as follows: "To ensure that Vancouver remains a livable and resilient city, maintaining its values, character and charm in the face of climate change." Accompanying this fairly brief vision statement is a list of "principles" which refer to the values the city holds that will guide its adaptation strategy. These include concerns for inclusivity ("establish and maintain strong networks with First Nations") and efficiency ("Give priority to adaptation strategies that build on existing programs or policies and provide co-benefits with mitigation and sustainability goals").

- **Target to Stakeholder(s)**. Indicators must be relevant to those who will use them. In some cases, indicators will be used to inform the public about how adaptation may affect their daily lives. In other cases they will be used communicate climate risk to the businesses community. Alternatively, indicators might be designed as internal management tools, meant primarily for local government staff and elected leadership. Citywide indicators can provide useful overall information, but can mask crucial differences in how climate impacts may threaten specific populations or assets. Be sure to consider indicators that reflect the differences in risk experienced by vulnerable population groups.
- **Assign Responsibility**. Assigning responsibility for individual indicators to specific government agencies can provide accountability and make use of indicators more likely.

- **Create Decision-Relevance**. Indicators must be used to make adaptive management and policy decisions related to adaptation. Climate adaptation researcher Susanne Moser, PhD argues that the best indicators "hit a nerve" with influential decision-makers. For example, if adaptation interventions increase local tax base, elected officials will take notice.[5]
- **Translate for a Lay Audience**. By necessity, some indicators may not be readily understood by the general public. However, to keep the public involved and informed, some indicators will need to be translated for a lay audience or incorporated into a communications strategy.

Example from the field: The City of Chicago has designed their Climate Action Plan, which covers both mitigation and adaptation, to be very accessible to the general public. To this end, they produce an easy-to-understand dashboard so that the public can track the city's progress on various goals.

Think in Systems

Good adaptation planning takes into account the larger systems that affect adaptation outcomes. For example, indicators that focus on drought need to look beyond isolated water-saving measures and address the dynamics of an entire watershed.

- **Determine Scale and Integration.** Indicators should match the scale of the intervention (e.g., neighborhood, city, metro-region, watershed, coastal zone, etc.) to its level of integration with other sectors. For example, if an indicator is measuring the resilience of a watershed to local flooding, it should draw clear boundaries around the relevant inputs to the causes of flooding, such amount of impervious surface, integrity of riparian zones, and capacity of stormwater systems. Since each input likely involves different stakeholders, the larger the boundary the more parties you may need to include.
- **Create Bundles**. Adaptation success is holistic in nature and therefore single indicators are less likely to tell the whole story. Creating indicator bundles that balance short-term and long-term, scientific and subjective, small and large scale, can help create a more realistic picture.
- **Choose achievable over comprehensive**. It is tempting to create a comprehensive list of indicators that cover all known vulnerabilities. Yet this is often unachievable. Instead, it is better to concentrate on a few, "keystone" indicators that are scaled to inform a larger story. Consider the workload required to collect information on each indicator.

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[5] Moser, Susanne. "Why we need to do better on adaptation indicators." Sci Dev Net

- **Consider Primary, Secondary, and Cascading Impacts**. When designing an adaptation plan and accompanying metrics it is important to consider various impact levels. Primary impacts include the most direct consequence of climate change, such as flood levels, heat indices, or storm surges. Secondary impacts include system-level consequences such as economic productivity loss associated with a storm. Cascading impacts include consequences that are amplified through a system, such as an electrical grid failure that limits emergency operations, which lead to further disasters.

Be Evidence-Based

Indicators must enable measurement and verification of stated adaptation goals and objectives. This can only be done with evidence-based measures based on sound science.

- **Ensure Validity.** Indicators must fulfill some basic validity requirements. Fortunately there are several validity models to choose from, including SMART principles (Specific, Measurable, Attainable, Relevant, Time-bound), and CREAM principles (Clear, Relevant, Economic, Adequate, Monitorable). The UNFCCC's Adaptation Fund also provides a checklist for selecting proper indicators, including valid, precise, practical, affordable, simple, reliable, sensitive, clear, useful and owned.
- **Account for Inequities and Geographies**. Indicators that do not account for inequalities may actually serve to make inequality worse. For example, "number of houses with air conditioners," if not segmented by income, does not help decision-makers identify who is most at risk during heat waves. Many climate impacts are localized, such as riverine flooding, and so city- or population-wide indicators may obscure important nuances. Similarly, some populations have lower tolerance or higher sensitivity for some climate impacts than others. For example, elderly residents may be at higher risk of heat-related health problems.
- **Base on Performance and Consequence**. Indicators must address specific adaptation performance goals and answer the question "resilience to what?" For example, "number of trees planted" as an outcome indicator is not connected to a climate impact, and does not measure equitable canopy cover. A better indicator would be "temperature reduced from tree canopy over during a heat event," segmented by key demographics (who benefits) and geographies (how well is the benefit distributed). An indicator based on consequences goes a step further and focuses on impacts. For example, "number of heat-related illnesses as a consequence of a heat wave" may reveal the impact of heat island adaptation strategies, including temperature reduced from tree canopies.

- **Account for Uncertainties**. Since adaptation planning is scenario-based, it will inevitably fail to predict all climate impacts. Where possible, design metrics that consider the probability of different impacts. For example, metrics for adaptive capacity will look different for 10 year, 100 year and 1,000 year floods.

Companion Resources

Example Adaptation Indicators and Objective-Indicator Framework
These tools are designed to show sustainability directors the range of actual adaptation indicators that have been proposed by various municipal governments and climate adaptation guides in the United States, Canada, and the UK. The first tab of the spreadsheet contains a categorized list of over 200 example climate adaptation indicators. The second tab depicts a simplified framework for how different types of indicators can be linked to broader adaptation goals. These tools are intended for sustainability directors to use in conjunction with the principles in this guide to create their own indicators. Many of the source documents from which example indicators were taken are in draft form. Therefore, the actual indicators adopted by the various source organizations are subject to change.

Additional Resources

A number of guides and frameworks have been produced to help governments develop their own adaptation plans. Additionally, many cities already have adaptation plans in place. These guides, plans, and their architects can serve as valuable resources for those just beginning the planning process for their own communities.

Guides and Research:

Developing Indicators of Climate Change Adaptation for Scotland: A summary of the ClimateXChange Adaptation Indicator Framework – *University of Dundee and ClimateXChange.* This brief summary describes the ClimateXChange (CXC) adaptation indicator framework, which is designed to guide the development of climate change adaptation indicators for Scotland.

Measuring Performance of Adaptation Initiatives – *Institute for Sustainable Communities.* This October 2012 report by ISC identifies emerging issues, challenges, and innovations encountered by cities seeking to measure their adaptation progress with a focus on New York City's PlaNYC, the City of Chicago, and the City and County of Denver.

Guidance note 2: Selecting indicators for climate change adaptation programming – *Sea Change and the United Kingdom Climate Impacts Program.* This report is part of Sea Change and UKCIP's guidance for M&E of climate change interventions. It examines various approaches to measuring climate change adaptation and offers guidance on selecting indicators, including the value of process and outcome indicators.

[Good Practice Study on Principles for Indicator Development, Selection, and Use in Climate Change Adaptation Monitoring and Evaluation](#) – *Climate-eval*. This study identifies and addresses key challenges concerning M&E for climate change adaptation. It does so by documenting good practices and good practice principles on the development, selection, and use of indicators used in the M&E of adaptation interventions. The study also looks at the steps and contexts M&E personnel should consider when formulating, selecting, adjusting, and/or using indicators.

[Climate Change Adaptation-Related Indicators](#) – *Sniffer*. This July 2012 report from the Scotland-based think tank Sniffer was written to inform the development of national adaptation indicators in the United Kingdom. It includes a review of adaptation work being done in other contexts within and outside of the UK.

Cities:

[Boston, MA](#) – The City of Boston is a leader in climate mitigation and adaptation planning. Its 2011 Climate Action Plan Update included an insightful and candid discussion of the City's efforts to measure progress. Boston annually updates its inventory of greenhouse gas emissions and includes climate progress indicators in its publicly-available *Boston About Results Performance Management System*. However, the City has described some indicators as "problematic, because they are difficult to measure, difficult to define, or difficult to tie directly to GHG reductions." For this reason, the City of Boston has been involved in efforts to improve climate action indicators, including the Star Community Index.

[Chicago, IL](#) – The City of Chicago became a leader in climate planning among US cities with the 2008 release of its climate action plan, which listed adaptation as one of its major priority areas. In 2010, the City produced a progress report on its first two years, which details the progress on a number of adaptation-related indicators, such as new tree canopy cover, increases in permeable surfaces, and green roofs installed.

[Durban, South Africa](#) – Durban, a major cargo port and tourist destination on the east coast of South Africa, developed their Municipal Climate Protection Programme in 2004. The city's environmental planning department has taken a unique approach to measuring progress. The city scores each of its 48 climate interventions on a suite of metrics, such as how much the intervention reduces risk, how much it reduces carbon emissions, whether it produces ancillary benefits, or its cost relative to its benefits. Each of these scores is combined to produce a composite ranking index for each intervention, ensuring that the most effective and efficient interventions are prioritized.

[Rotterdam, Netherlands](#) – The City of Rotterdam's climate adaptation efforts have garnered significant media attention due to their often unconventional and creative solutions, such as the [floating residential pavilions](#) pilot project. The document linked above describes the Rotterdam Programme on Sustainability and Climate Change and lists indicators that track progress on 89 different climate initiatives. The report also includes a table (page 77) that details the estimated cost of achieving each goal, how that cost burden would fall on various stakeholders, and the projected carbon reductions resulting from each goal.