

CLIMATE CHANGE ADAPTATION
A FRAMEWORK FOR THE CITY OF PHILADELPHIA

M.S. SUSTAINABILITY MANAGEMENT PROGRAM

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EXECUTIVE SUMMARY

Climate change presents a threat to Philadelphia's residents and its infrastructure. Climate hazards such as extreme precipitation, heat waves, and drought are predicted to become more frequent and intense in the US Northeast.¹ The damage caused by Hurricane Irene in September 2011 is the most recent indicator that reducing greenhouse gas (GHG) emissions alone is not enough. The City must prepare for more frequent weather and climate related events, and start adapting to a changing climate. Adaptation is needed to lessen the city's vulnerability to anticipated climate disruption, and should be part of a comprehensive climate action plan. While Philadelphia has already put in place a comprehensive plan to reduce GHG emissions, the city now turns to climate resilience.

Other US cities that have sought to plan for climate change have faced a set of common obstacles: access to climate risk information; dealing with the uncertainty of climate change forecasts; addressing skepticism about climate change; achieving collaborative decision-making across sectors and jurisdictions; and funding both the planning and implementation stages of adaptation strategies.

Philadelphia can look to other successful adaptation plans to begin tackling these obstacles. This report aims to outline the steps that Philadelphia can take to make the city more resilient. The student authors are master's-level candidates in Columbia University's Sustainability Management program, and are advised by George Sarrinikolaou. This team has worked with the Mayor's Office of Sustainability on project direction.

The Problem

Mitigation strategies implemented in Philadelphia have succeeded in lowering GHG emissions and are imperative, as adaptation beyond a certain level of CO₂ in the atmosphere is impossible. However, this strategy alone is not enough. Climate models predict that even if global GHG emissions were halted now, that the earth's climate, slow to respond, would continue to exhibit escalating signs of global warming for decades². Climate change is already here.

The New Solution

Climate change adaptation planning inherently requires collaboration across city departments. Typically mitigation plans outline specific actions that each department must take to meet an emissions target. However, the effects of climate change do not adhere to geographic or jurisdictional constraints. For example, the effects of a severe heat wave would require the input

¹ New York City Panel on Climate Change. (17, February, 2009) *Climate Risk Information*. Retrieved on October 1, 2011 from www.nyc.gov/html/om/pdf/2009/NPCC_CRI.pdf

² Nakicenovic, N and Rob S. (2000). Emissions Scenarios. Intergovernmental Panel on Climate Change. Accessed on November 10, 2011 from ipcc.ch.

of multiple city agencies working together to form a response. Similarly, collaboration is necessary in the planning stage of preparing for possible climate events.

Adaptation planning depends on the analysis of climate model data. Uncertainty within these models and the dynamic nature of their predictions requires that cities are able to plan and make decisions under uncertainty. The wide-ranging effects of climate change will require an interconnected framework and organization. A planning structure must also have built-in flexibility in order to adapt to new climate data when it becomes available. This report provides best practices in this new approach based on practitioner expertise and published sources on adaptation planning.

The Mayor's Office of Sustainability has identified four main areas of concern: the climate change effects of flooding, heat waves, and drought. It has also recognized the need to focus on energy efficiency as it relates to adaptation, due to its close ties is preparing for extreme temperatures. Developing a comprehensive adaptation plan to address these concerns requires strategies in data acquisition and risk assessment, funding, communication and messaging techniques, successful organizational structure needed to carry out adaptation planning, and integration within municipal departments. These strategies are interconnected elements that when taken together, form a comprehensive city plan for boosting climate resilience.

SECTION OVERVIEW

Climate Resilient Philadelphia: The Link Between Mitigation and Innovative Adaptation Strategies

Philadelphia has already reduced its GHG emissions through its Greenworks mitigation plan. The next step is building adaptation measures into Greenworks to create a comprehensive climate action plan. Philadelphia has an advantage: many of the Greenworks programs mitigate emissions and enable Philadelphia to reduce its vulnerability and adapt to climate change. This section assesses Philadelphia's mitigation actions that link to adaptation and offers additional ideas to help the City pursue climate resilience.

Key findings:

A number of Philadelphia's mitigation strategies already begin to address issues of adaptation:

- Green City, Clean Waters plan – watershed and stormwater management strategies will increase the city's resilience to drought and flooding events
- Green 2015 - the plan to increase the amount of green space in Philadelphia will help reduce heat island effect and increase resilience to flooding

Setting the Foundation: Gathering and Using Climate Data

Obtaining and analyzing climate change data is fundamental to adaptation planning. Only some climactic changes will affect Philadelphia, but it is not possible to arrive at solutions without understanding what will happen, when it will occur, and how much might change. Obtaining and analyzing this data is an initial challenge. Only after this challenge has been addressed can a city begin to understand long-term implications, and identify and prioritize risks. Global and regional climate modeling information is available through different agencies and can be studied at different levels of granularity. This section examines the steps that leading practitioners and cities have taken to obtain this data and understand its implications over multiple time horizons.

Key findings:

- Engage local scientists early in the planning process, because they can:
 - Provide climate projections
 - Make climate science understandable to the planning team and to stakeholders
 - Provide recommendations on how to interpret climate projections
 - Keep Philadelphia up to speed with the latest climate science findings

- City-specific climate models provide high resolution which can sharpen the focus of adaptation planning, but they do come at a higher cost and still cannot eliminate uncertainty
- Establish early which set of climate data models will be used, to ensure that decisions across departments are made based on a common set of projections. State, regional, national, and global models may not have the resolution required for planning purposes but may be available free or at low cost.
- Plan adaptation efforts according to a range of climate scenarios
- Combining projected data with geospatial mapping tools can help assess vulnerabilities.

Risk Assessment

Risk assessment is a process by which the City of Philadelphia could prioritize the climate risks that it faces by gauging the likelihood, magnitude, and timing of projected climate change effects. Climate scientists predict that the number of 100+ degree days could increase to between 9 and 28 by the year 2070 depending on emission scenarios³, but it is difficult to plan based on that information without an understanding of the likelihood that this change will manifest or the related consequences. Risk assessment addresses these dimensions of risk by asking planners to consider the effects of climate disruption on criteria such as human health and safety, the economy, infrastructure, budgets, and on communities. This section analyzes the risk assessment methods used by leading practitioners and cities in prioritizing their adaptation strategies.

Key findings:

- Conduct a risk assessment based on the likelihood of a climate change, degree of confidence in climate projection, magnitude of the consequence, and timing of the event.
- Risk matrices can illustrate priorities:
 - High likelihood x high consequence = high priority
 - Low likelihood x low consequence = low priority
- Benefit and cost analyses can be useful when prioritizing risk
- Broadly group sectors for risk assessment by category: human, infrastructure, and environmental subsectors can be created according to the organizational structure of the city

Accounting for Vulnerable Populations

Some segments of Philadelphia's population, including the poor and non-English speakers, may be at disproportionately high risk to the effects of climate change. Identifying these groups and

³ Union of Concerned Scientists, *Climate Change in Pennsylvania: Impacts and Solutions for the Keystone State*. October 2008. Available at: http://www.northeastclimateimpacts.org/assets/climate-change-in-pennsylvania_impacts-and-solutions.pdf

assessing their vulnerability is a challenge of adaptation planning. Cities that lead in climate adaptation planning often include vulnerable populations in their adaptation risk assessment process, and often identify specific strategies for those most susceptible to climate change risks. This section examines vulnerability factors and techniques used to identify the susceptibility of some populations to climate change.

Key findings:

- Identify hotspots among neighborhoods or population segments using vulnerability factors such as income, ability to speak English, insurance levels, etc.
- Utilize existing and developing tools, such as The Pacific Institute's Social Vulnerability Index, which aggregates socioeconomic, demographic and built environment variables
- Once vulnerable populations are identified, support ongoing engagement to give these groups part ownership in the development of adaptation strategies

Financing a Resilient Philadelphia

Tight budgets, competing budget priorities and a lack of funds specifically allocated to adaptation create a financial obstacle to climate resilience. Funding adaptation requires a multifaceted approach that reflects the variety of adaptation needs and the absence of a single source of money for this issue. Funding of climate data acquisition is often the first challenge. Funding the implementation of adaptation strategies themselves is another. This section highlights a selection of programs, foundations, and funds that support adaptation planning and focuses on the diverse strategies needed to acquire adaptation dollars. Many leading practitioners of adaptation planning have found that funding adaptation planning requires creative planning. Whether the solution is to break a strategy down into individually funded components, partner with nearby cities, or change zoning laws to enact adaptation plans, strategies outlined in this section can stand alone or be combined to fund a comprehensive plan.

Key findings:

- Cast a wide funding net: divide adaptation planning into focused pieces and raise funds for each component individually using a variety of federal and state grants
- Cooperate regionally: lower the cost of adaptation planning by forming regional alliances to share cost burdens.
- Use building codes, design standards, and zoning regulations to spread out the cost of adaptation strategies and shift some of the burden to the private sector
- Capture funding that is available for mitigation strategies by focusing on plans that bridge the gap between mitigation and adaptation

The People and Processes Needed for Adaptation Planning

Climate change effects broadly impact a city's operations and infrastructure and the complex nature of these effects is such that any one City department cannot deal with them alone. Rather, collaboration among city agencies (and often the private sector, non-governmental entities and communities) is required. Cities that have most effectively planned for climate change have created new cross-sectoral structures to promote cross-sector and sometimes cross-jurisdictional collaboration. We discuss the strong leadership, working groups, and multi-stakeholder task forces that have been employed by cities considered leaders in adaptation planning.

Key findings

- Identify climate change “champions” who can engage multiple stakeholders and manage top-down communication.
- Establish focus areas of your adaptation strategy, and create multidisciplinary teams that encourage collaboration between departments to address each area.
- Identify external stakeholder groups and find allies within them. Groups such as private business owners will often respond more positively to guidance from other businesses than from city officials.
- Seek pro-bono services from private consultancies that have helped develop adaptation plans for other cities.
- Maintain an open dialogue with the epistemic community. Climate science findings evolve as more data is collected, and scientific advisory panels can translate new findings and the implications of those findings into layman's terms for city departments.

Communicating Adaptation and Getting Everyone to Buy-In

Cities developing and implementing adaptation plans face communication obstacles: a lack of understanding about risks and uncertainties, climate skepticism, and difficulty in obtaining and keeping stakeholders engaged. Dealing with these issues requires a sophisticated communications strategy. This section analyzes potential obstacles and offers techniques in messaging, targeted communication, and engagement strategies to achieve commitment and support for climate change adaptation.

Key findings:

- Make the issue real to Philadelphia's residents. Pointing out specific ways that climate change could affect daily life in the city can build support for adaptation planning.
- Clarify misconceptions by using the right words, simplifying data, and defining uncertainty carefully.

- Set feasible goals. Cautious but optimistic communication strategies that set out measurable goals can strengthen adaptation strategies.
- Engage stakeholder in a targeted way. Communication can be more effective when the city reaches out to an individual or small group of opinion leaders within a community, rather than approach the community as a whole. Opinion leaders that already have the implicit trust of a community can effectively get that community on board.
- Frame the conversation. Communicating adaptation strategies in terms of the financial benefit of prevention, or the public health and wellbeing, can motivate people to act.

Formulating and Maintaining a Resilience Strategy

Planning for climate change must include a strong commitment to integrating climate risk information into capital projects and operations. We lay out key strategies some cities have implemented to successfully integrate adaptation into their operations, including involving city agencies early, developing strong processes from the outset of planning, and remaining flexible and thinking long-term.

Key findings:

- Involve city agencies early. This will allow departments to shape the processes that will fit their own operations and organizational structure, and promote collaboration between departments.
- Be flexible. Climate models will evolve as new data becomes available. Anticipate from the outset of adaptation planning that strategies must be updated along the way.
- Build adaptation planning into long-term capital plans. New projects present the opportunity for city planners to address issues of climate change adaptation without explicitly calling it adaptation.
- Sponsor educational events for city departments. Host teaching events and workshops for the employees within city agencies who are building adaptation planning into their organizational structure.

Measuring Performance

We have stated that uncertainty is built into all climate science projections. Operating within this uncertainty requires that a city is able judge the value of an adaptation strategy, and that value can only be expressed if it can be measured. Metrics can be used to: define what is working well; develop strategies in response to what is not working well; and measure the improvement in performance as a result of those strategies. This section examines the use of metrics as a

feedback loop that will allow the city to modify its adaptation strategy and maximize its effectiveness.

Key findings:

- Align metrics with the structure of your adaptation planning process. Metrics should be based on both leading and lagging indicators. Leading indicators, such as the number of smog advisories or heat alerts issued, precede climate events. Lagging indicators indicate the impact of those events, such as the number of heat related deaths.
- Use metrics to update and redirect adaptation strategies to maximize their benefit.

CLIMATE RESILIENT PHILADELPHIA: THE LINK BETWEEN MITIGATION AND ADAPTATION STRATEGIES

Across the country, cities are finding significant overlap between actions they believe are important to address from an adaptation perspective and those typically associated with climate mitigation. Many cities are breaking down the barrier in between, bringing together adaptation and mitigation activities, and defining areas of overlap. Philadelphia is already adapting to climate change even if it doesn't formally think of its work in terms of climate resilience. The city's greenhouse gas emissions mitigation efforts, energy efficiency campaigns, strategies on reducing and dealing with heat impacts, its emergency management strategies, and measures related to flooding and water all bolster the city's climate resilience. Reframing Philadelphia's ongoing work in these areas in terms of climate resilience can help gain support for adaptation planning, secure funding, and can advance the integration of climate information in city operations and capital planning.

The City of Toronto offers useful definitions for distinguishing between climate mitigation and adaptation strategies, and for understanding where these strategies may overlap. **Mitigation actions** are efforts to *reduce* energy use and the build-up of greenhouse gases in the atmosphere, including switching to renewable energy sources and capturing landfill gases. Mitigation intends to slow climate change over time. **Adaptation actions** are programs that *reduce the effects of* climate change, including heat waves, flooding from intense rainstorms, high winds, expanding range of insect pests, and changes in water levels⁴. **Mitigation and Adaptation actions** reduce greenhouse gas emissions *and* protect against the climate changes already occurring, such as green roof and tree planting programs.⁵ To put it simply, adaptation efforts recognize that climate change is already occurring and will continue to occur, and focuses on planning ahead to reduce vulnerability and protect lives, health, property, and ecosystems. These combined mitigation and adaptation programs focus on creating city resilience.

It is important to note that sometimes mitigation and adaptation strategies contradict each other. While an adaptation strategy may be to increase the location of cooling centers to respond to heat waves, this strategy increases GHG emissions instead of mitigating them. For this reason it is helpful to focus on strategies that fulfill both requirements such as installing reflective roofs and using vegetation for shade and cooling. While there is no set standard for classifying an action as

⁴ Union of Concerned Scientists, *Climate Change in Pennsylvania: Impacts and Solutions for the Keystone State*. October 2008. Available at: http://www.northeastclimateimpacts.org/assets/climate-change-in-pennsylvania_impacts-and-solutions.pdf

⁵ Union of Concerned Scientists, *Climate Change in Pennsylvania: Impacts and Solutions for the Keystone State*. October 2008. Available at: http://www.northeastclimateimpacts.org/assets/climate-change-in-pennsylvania_impacts-and-solutions.pdf

solely mitigation or as mitigation and adaptation, looking to other city plans provides clear trends.

Before the City of Philadelphia formalizes adaptation strategies, the City must understand its climate risks and the magnitude of impact from those risks, as described in the Risk Assessment chapter. As the effects of climate change become more pronounced and adaptation planning is better understood, Philadelphia may be able to identify additional ways in which its ongoing work increases resilience. In each case, however, it will be important to account for changes in climate risk over time in order to gauge the effectiveness of this work in protecting the city from climate disruption.

INCREASING RESILIENCE: FLOODING AND DROUGHT

A report on climate impacts in Pennsylvania written by the Union of Concerned Scientists indicates that over the next several decades and through mid-century, precipitation is expected to increase statewide by more than 5 percent above the historical average, and by late century more than 12 percent. The report also states that rising summer temperatures, coupled with little change in summer rainfall, are projected to increase the frequency of short-term droughts⁶. Drought may jeopardize the city's water supply and may cause stress on vegetation and reduced electricity generation from hydroelectric power sources.⁷

These climate projections suggest that Philadelphia can expect both flooding and drought events to occur more frequently, highlighting the need to continue and strengthen programs that overlap both mitigation and adaptation. Programs for flooding and drought that overlap mitigation and adaptation include:

Green City, Clean Waters plan:

- The city's comprehensive plan to protect and enhance watersheds, and manage stormwater and combined sewer overflow control will strengthen the city's resilience when dealing with increased flood events.
- In particular, the components of the plan that cover implementation of green stormwater infrastructure to manage runoff strongly tie to adaptation: tree trenches, green roofs, rain gardens as well as initiatives like Green Streets, Green Alleys, and Green Parking.

⁶ City of Philadelphia Water Department, *Green City Clean Waters (Amended)*. June 1, 2011.

⁷ Union of Concerned Scientists, *Climate Change in Pennsylvania: Impacts and Solutions for the Keystone State*. October 2008. Available at: http://www.northeastclimateimpacts.org/assets/climate-change-in-pennsylvania_impacts-and-solutions.pdf

- Restoring streams and setting controls to maintain water quality standards strengthen the City’s resilience during times of drought, when quality and supply are critical.
- Not only do the strategies in this plan strengthen the City’s resilience to flooding and drought, they also support adaptation planning for other climate issues like urban heat island effect and energy efficiency. Nearly all of the components in the *Green City, Clean Waters* plan would be applicable to mitigation and adaptation strategies.

Moving Philadelphia Forward: Toronto’s innovative adaptation solutions include: the elimination of new reverse slope driveways to reduce flooding during extreme precipitation events, a citywide mandatory downspout disconnection to reduce flooding and the pressure it puts on stormwater systems; and subsidizing the costs of installing back-water valves and sump pumps on household sewer connections to provide additional protection against flooding from sanitary sewers.

Green 2015: An Action Plan for the First 500 Acres:

- *Green 2015* aims to further increase green space within the city, which aids stormwater management and improves resilience to flooding.
- Turning unused or vacant land into parks and recreation facilities reduces the amount of non-permeable surfaces in the city, helping with both stormwater management and urban heat island effect.

Increasing tree coverage, Plant One Million:

- The city’s goal of increasing tree coverage to 30 percent in all neighborhoods by 2025⁸ is expected to better manage stormwater runoff during flooding.
- Trees are sometimes at risk during times of drought. The tree maintenance training that is offered by Philadelphia Parks and Recreation is an adaptation response to reduce this risk⁹.

Moving Philadelphia Forward: Innovative solutions focus on efforts to promote healthy tree growth, as stronger trees are more likely to survive climate stresses such as drought and wind. Toronto’s adaptation plan calls for increasing systematic tree pruning services as part of their Integrated Plant Health Care Program.

⁸ City of Philadelphia, Mayor’s Office of Sustainability. *Greenwork’s Philadelphia: 2011 Progress Report*. 2011.

⁹ *Ibid*

Increasing state of good repair in resilient infrastructure:¹⁰

- The city's goal of repairing and upgrading infrastructure includes some strategies that may help Philadelphia better adapt to flooding. The use of technologies, such as porous pavement that was first installed on Percy Street in South Philadelphia, reduces stormwater entering the drainage system.¹¹ Porous pavement may also protect water quality, as it requires less salt to be used during snowstorms.

Moving Philadelphia Forward, Flooding:

The city of Toronto is seeking to engage its residents to change behavior in ways that can enable greater protection from flooding. The city identified recommends the following actions:

- Reduce consumption of water and energy to take pressure of water supply systems.
- Make private walkways and driveways from permeable materials.
- Participate in planting and care of trees at the neighborhood scale
- Participate in community stewardship organizations to enhance local parks and orphan spaces.
- Ensure homes can resist flooding by installing backflow valves and sloping the ground away from the house.
- Keep a 3-day emergency kit on hand in case of blackouts or weather emergencies.

¹⁰ *Ibid*

¹¹ City of Philadelphia, Mayor's Office of Sustainability. *Greenwork's Philadelphia: 2011 Progress Report*. 2011.

INCREASING RESILIENCE: ENERGY EFFICIENCY

The extent of future warming and severity of changes will depend largely on energy choices made in the next few decades.¹² Reducing emissions, conserving energy, and increasing efficiency are essential to combat global warming and limit the scope and cost of climate impacts. Reducing heat-trapping emissions and keeping carbon dioxide and other harmful pollutant levels low, are essential in helping Philadelphia ultimately adapt to future changes. Philadelphia must address emission reduction in its battle with smog, ground-level ozone and particulate matter. Smog is projected to become more commonplace in future emissions scenarios thus vehicle and industrial emission reductions must be targeted now. Cities including Boston, Chicago, Keene, Los Angeles, and King County all incorporate energy reduction and conservation, and improved air quality strategies into their adaptation plans.

City of Philadelphia Community GHG Breakdown by Source		
	eCO ₂	
Coal	20,480	0.1%
Diesel	777,636	5.1%
Electricity	5,924,422	39.2%
Food Waste	46,114	0.3%
Fuel Wood	199	0.0%
Gasoline	2,931,961	19.4%
Heavy Fuel Oil	341,435	2.3%
Light Fuel Oil	1,030,656	6.8%
Natural Gas	3,840,584	25.4%
Paper Products	85,071	0.6%
All Other Waste	127,979	0.8%
TOTAL		15,126,537

Reducing City Energy Consumption:

All strategies that reduce emissions by improving energy efficiency can technically fall under adaptation, as these strategies create less demand on the electrical grid during extreme climate events such as heat waves, reducing the potential for grid overload, failure and blackouts. This overlap makes it particularly difficult to differentiate between mitigation only and mitigation and adaptation strategies and cities have not yet set a standard or a best practice for categorizing. A comprehensive climate action plan covers both mitigation and adaptation, eliminating the need to distinguish between the two for energy efficiency. Therefore, the City must first establish its specific climate risks and associated impacts and then analyze the following programs for their ability to reduce vulnerability to these risks. The following Philadelphia energy efficiency programs can be considered to both reduce emissions and create further resilience.

- Energy Load Demand Response and Smart Meters. These programs sole purpose is to reduce demand on the grid and are especially important during heat waves. These programs help Philadelphia reduce vulnerability to power outages.

¹² Union of Concerned Scientists, *Climate Change in Pennsylvania: Impacts and Solutions for the Keystone State*. October 2008. Available at: http://www.northeastclimateimpacts.org/assets/climate-change-in-pennsylvania_impacts-and-solutions.pdf

Weatherization Efforts:

- Increased home weatherization lowers energy usage by preventing air leakage through air sealing, insulation, and window replacements, utilizing passive heating and cooling, and updating homes with Energy Star equipment. These updates, including day lighting and natural ventilation, allow buildings to be better prepared for resisting increasing heat and more comfortable during power outages. This reduces the potential for heat or cold-related illness and death during power supply disruptions. Philadelphia's Weatherization Assistance Program completed over 2,300 retrofits between 2010-2011 providing an average of 20% energy savings and reduced 9,653 GHGs.

LEED Legislation for City Buildings:

- Sustainable development practices, such as LEED Green buildings, reduce emissions through energy efficiency gains and could increase resilience to drought, flooding, and heat waves. Green buildings can boost resilience to drought by improving water efficiency and promoting water-efficient landscaping. Green building's increase of permeable materials and increased green space help create resilience to flooding. Green buildings reduce emissions and therefore heat by promoting and requiring alternative transportation and commuting, white/green roofs, increased green space, daylighting and energy-efficient lighting, and stressing energy conservation.

Renewable Energy Sources:

- Continued reliance on fossil fuels will keep Philadelphia and the world on a high emissions pathway, which is expected to exacerbate severe climate disruption. Transitioning from fossil fuels to clean, renewable energy resources could help curb emissions, reduce warming, and increase air quality. Renewable energy also reduces the vulnerability to widespread power grid outages by encouraging distributed generation from multiple sources. Philadelphia's Southeast Pollution Control Plant solar project and planned are concrete steps to reduce fossil fuel emissions.

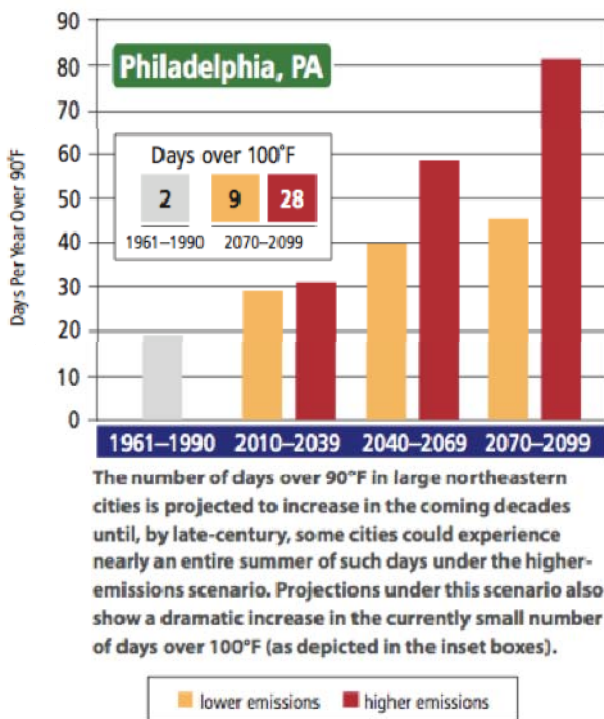
Moving Philadelphia Forward:

- Diversify current energy sources to improve resilience. Decreasing Philadelphia's dependence on fossil fuels will further enable the city to reduce emissions, improve air quality, and prevent increased heat. In addition, as oil is a finite resource, adding additional energy sources can create resilience to a predicted change in our energy future.
- As the intensity and frequency of storms increase, cities are looking at placing power lines underground where they are less likely to be damaged. A Duke Energy study found

that the frequency of outages on underground systems was 50% less than for overhead systems; however the duration of underground outages were 58% longer.¹³

- Perform a power vulnerability study. A vulnerability study identifies, quantifies, and prioritizes vulnerabilities in the energy system to assess potential hazards to the population and infrastructure in a proactive way.
- Further reduce emissions using zoning laws, building codes, and incentives to encourage the number of energy-efficient buildings and discourage sprawl.
- Encourage Pennsylvania to move from an observing to participating state in the Regional Greenhouse Gas Initiative (RGGI) to increase accountability and further cap emissions.
- Encourage technology that uses waste heat from commercial and industrial facilities to generate electricity in small combined-heat-and-power (CHP) plants. These CHP plants utilize more than 80% of the fuel’s energy content and greatly reduce emissions, compared with 30% efficiency for coal-fired plants and 50% for natural gas combined-cycle plants.

INCREASING RESILIENCE: HEAT



The IPCC’s latest report found that urban areas in North America will likely experience more severe and longer heat waves. The primary drivers of climate change are fossil fuel emissions and activities that release carbon dioxide and other heat-trapping GHGs into the atmosphere. Between 1970 and 2000 the U.S. Northeast has heated up at a rate of 0.5°F per decade¹⁴. According to the 2007 Union of Concerned Scientists report, which adapted IPCC high-emissions scenario A1FI and low-emissions scenario B1, Philadelphia is expected to experience 9 heat days over 100°F by 2070 in the low-emissions scenario and 28 heat days over 100°F by 2070 in the high-emissions scenario. Days over 90°F are projected to increase steadily in each scenario and these effects can already be seen in Philadelphia. The Department of

¹³ Union of Concerned Scientists, *Climate Change in Pennsylvania: Impacts and Solutions for the Keystone State*. October 2008. Available at: http://www.northeastclimateimpacts.org/assets/climate-change-in-pennsylvania_impacts-and-solutions.pdf

¹⁴ Union of Concerned Scientists, *Climate Change in Pennsylvania: Impacts and Solutions for the Keystone State*. October 2008. Available at: http://www.northeastclimateimpacts.org/assets/climate-change-in-pennsylvania_impacts-and-solutions.pdf

Public Health confirmed that in 2011, 9 total high-heat days were experienced causing the city to issue heat warnings.

As the climate warms, residents may experience heat stress, heat exhaustion, and heat stroke during prolonged periods of extreme heat. According to The Department of Public Health, 34 heat-related deaths occurred in the summer of 2011 and officials hypothesize that more would have occurred without the current preventative system. Increased warming can also worsen air pollution creating more days when national air-quality standards cannot be met. Philadelphia is currently failing to meet these air-quality standards and in the low-emissions scenario, ozone pollution days will increase by 50%. A decrease in these toxic emissions increases Philadelphia's ability to respond to climate change as providing clean air creates a healthier city. Cutting smog helps Philadelphia adapt to the effects of heat waves by keeping toxic levels low, therefore initiatives that reduce smog can be listed in the overlapping area between adaptation and mitigation. Philadelphia is currently working on many strategies that increase its resilience to the effects of increased heat, including heat-deaths and increased smog. Other cities focused on similar strategies Phoenix, Chicago, Toronto, Los Angeles, and London.

Cool Roof Ordinance, Green Streets, and Weatherization Assistance Program:

- These strategies help reduce heat-trapping emissions and manage the heat island effect, reducing neighborhood risks from heat waves.

Moving Philadelphia Forward:

- Focusing on increasing the number of green alleys and roofs
- Using highly reflective pavement
- Using satellite imaging/heat sensing to locate hot spots and target solutions to these areas

Smog Reduction and Ozone Response:

- Reducing the number of drivers in Philadelphia reduces both CO₂ and ozone emissions, which lowers smog levels. As heat waves cause emissions to rise to unhealthy levels, strategies focused on cutting emissions add to the City's preparedness. Reducing the number of miles traveled reduces the costs of repairing or replacing infrastructure (roads, bridges, etc) and leaves infrastructure more able to handle climate-related disasters.
 - Reduced Vehicle Miles Traveled & Bicycle Commuting
 - Anti-Idling Ordinance
 - City Car Management Plan including Electric Charging Stations through PhillyCarShare, Reduced City Fleet, and Increased MPG saves 10,780 metric tons of GHG emissions annually.
 - Hybrid Diesel Buses and Increasing Biodiesel cut 13,700 metric tons of GHG emissions annually.

- Air Management Services plan to reduce toxic air pollutants and smog

Moving Philadelphia Forward:

- Supporting public transit discount days especially during high-heat periods
- Ozone education: In Detroit ozone alerts are set out when ozone levels are expected to exceed federal standards the following day via press releases to the media along with a call to action during the weather forecast (ride transit or a bike). In Detroit ozone advisories are displayed on digitized highway signs to encourage alternative transportation the following day. Detroit also allows companies to sign up to be part of the Ozone Action program and each year these businesses receive posters, magnets and pamphlets to help their employees understand the program and sunglasses, sunscreen, and Frisbees as visual reminders of what to do on Ozone days.¹⁵ New Jersey Transit has started offering an OzonePass on ozone alert days where commuters can try transit instead of driving for a severely discounted price of \$2.70 round-trip.¹⁶
- Using only low VOC building materials.

40,000+ New Trees, Plant One Million, 100 Acres of Green Space, and Green 2015 500 Acres Goal:

- Planting trees in public spaces reduces heat-absorbing surface area in the downtown area and provides shade, reducing overall temperatures and reducing the risk of heat-related incidents. Tree planting increases the City’s resilience to severe heat and benefits the water systems by increasing the permeable surface area, reducing runoff and relieving stress from stormwater infrastructure.
- Similar to planting trees, providing open green space decreases overall temperatures and benefits water systems.

Moving Philadelphia Forward:

- In addition to planting trees, many cities have discovered plants that may improve adaptation by thriving in the newly anticipated climates.

Excessive Heat Plan and Heat Emergency Cooling Locations:

- As most heat related deaths are caused by lack of access to cooling, Philadelphia already employs many strategies that enable the population to be prepared.

¹⁵ <http://www.toolsofchange.com/en/case-studies/detail/80>

¹⁶ NJtransit.com

- **Emergency Cooling Centers** provide shelter for those without air conditioning on high-heat days.
- Philadelphia's renowned **Heat Alert System** provides heat warnings with direct outreach to the City's most vulnerable urban dwellers including the elderly, homeless, poor, and socially isolated. During heat alerts, health-department staff, including sanitation managers and nurses, first fax a heat-warning to all City agencies and partners, require cooling to below 81°F in all nursing homes and assisted living facilities, staff a heat hotline, ensure electric and water utilities are barred from shutting off services for non-payment during these times, and dispatch a mobile team to combat true health emergencies. The Department of Health also works with local media to publicize the heat hotline and tips for staying safe in heat emergencies.
- **Heat Education Campaigns.** The Department of Health focuses on public awareness about the risks of heat events and the need for preparedness. At the beginning of the heat season, the Department sends a preparedness notice to hospitals and community partners, makes website announcements, and publishes documents on minimizing exposure to heat related illness. The Health and Adult Services Unit also works year-round with shelters in the city to prepare them for heat emergencies and during heat warnings go to the streets to help homeless individuals find shelter.

Moving Philadelphia Forward:

- Publicized list of emergency cooling centers including hours and locations. Some locations may include libraries, schools, churches, and other public areas.

Emergency Plans:

- Incorporating emergency plans for flooding, winter weather, extreme heat, earthquakes, hurricanes, and including vulnerable populations in these plans are a strategy many cities, including Philadelphia, employ in order to increase preparedness.

Additional Solutions:

- An emergency and business continuity plan can strengthen resilience to economic factors.

Existing Adaptation efforts in Philadelphia

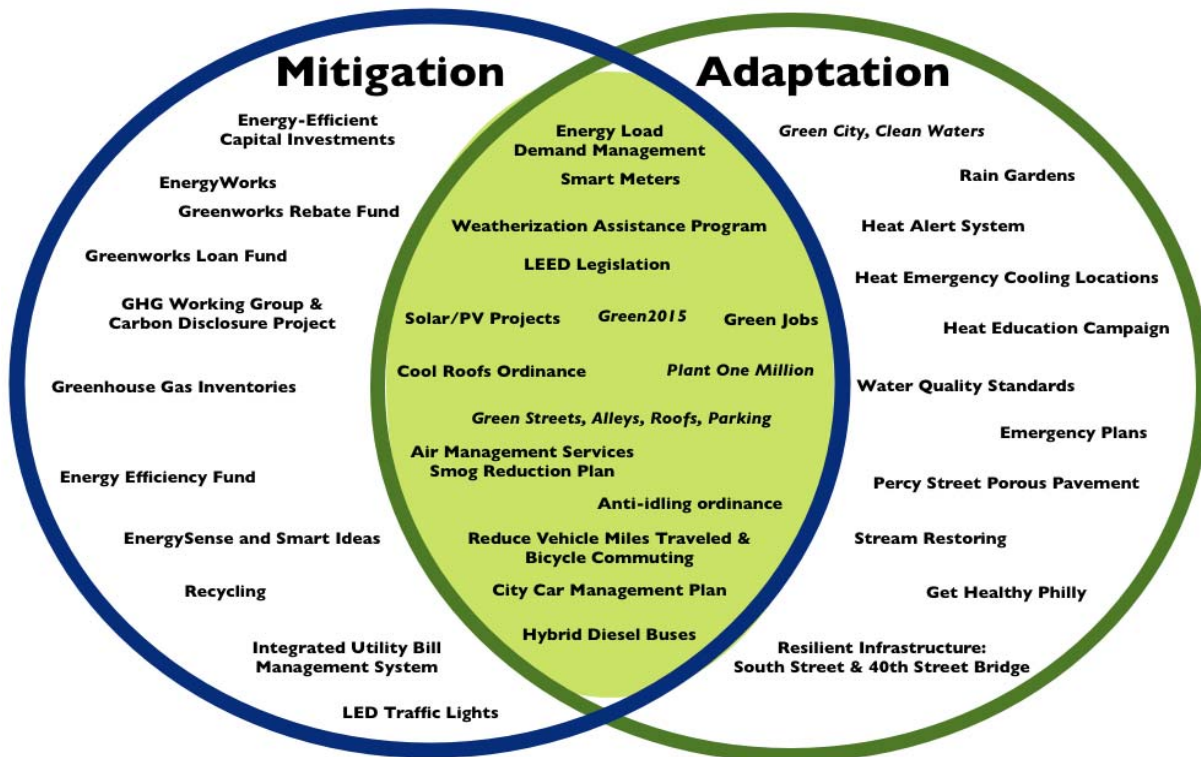
Philadelphia International Airport (PHL):

- In December 2010, a report by Urban Engineers for the City of Philadelphia's Division of Aviation outlined adaptation planning strategies for the airport. The report noted the airport's vulnerability to flooding. The report outlined nine strategies for incorporating

adaptation into planning at the airport, including tactical actions such as re-evaluating drainage design parameters in light of higher tide levels and more frequent storm events.¹⁷

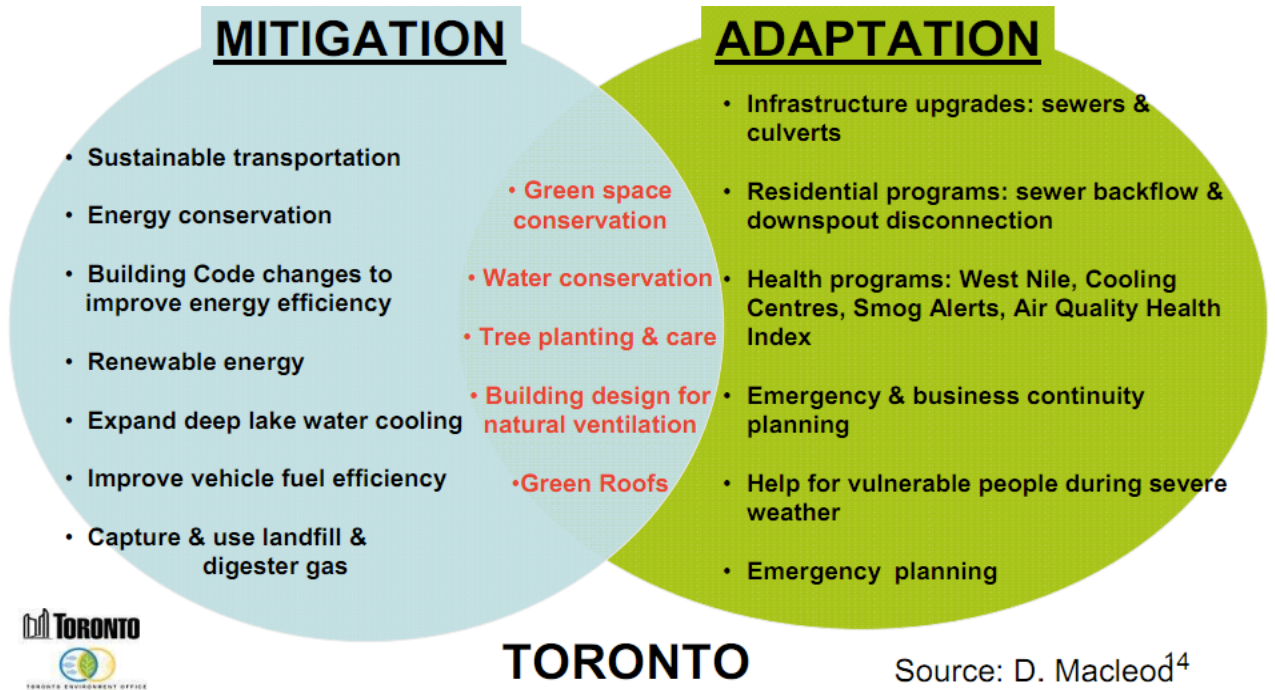
- Adaptation planning for PHL can serve as a leading example for the rest of Philadelphia and offer useful lessons to other city agencies. There is also the opportunity to make adaptation planning at PHL part of a larger adaptation planning effort in the city.

Philadelphia: Links between Mitigation and Adaptation



¹⁷ City of Philadelphia, Division of Aviation, *Climate Change: Impacts and Adaptation Strategies for Philadelphia International Airport*. December 2010.

Example - Toronto Mitigation and Adaptation Nexus



Example - Chicago Mitigation and Adaptation Nexus

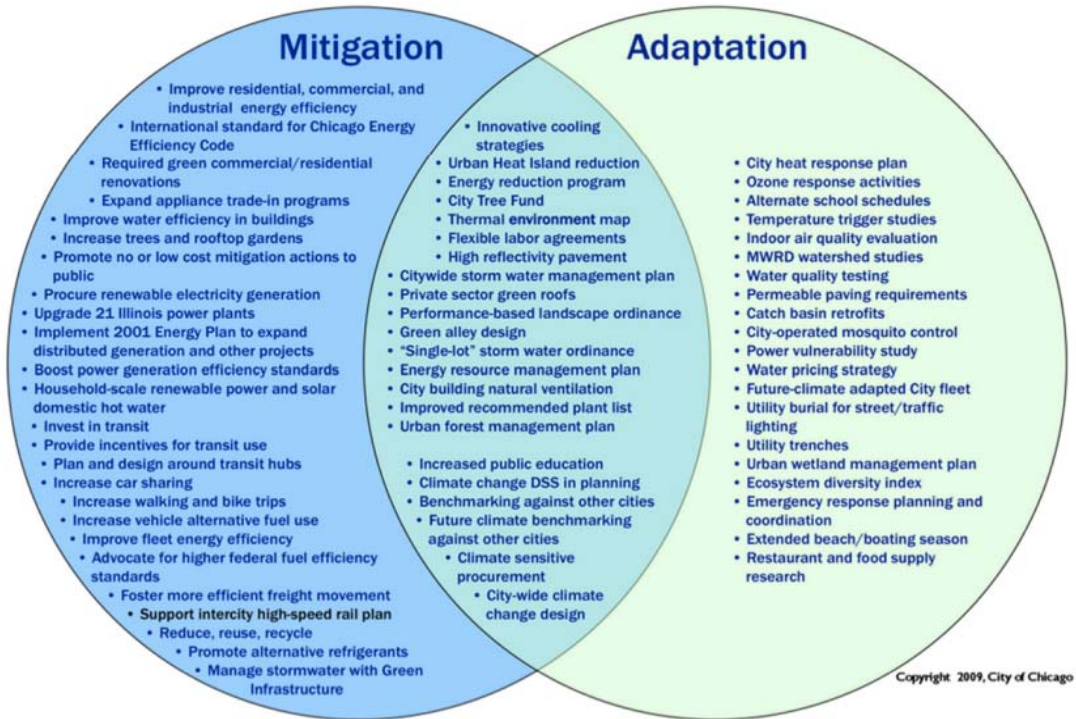


Fig. 2. Mitigation and adaptation nexus.

Key Findings:

- Engage climate scientists early in the planning process, because they can:
 - Provide climate projections
 - Make climate science understandable to the planning team and stakeholders
 - Provide recommendations on how to interpret climate projections
 - Keep Philadelphia up to speed with the latest climate science findings
- City-specific climate models provide high resolution, which can sharpen the focus of adaptation planning, but they do come at a higher cost and still cannot eliminate uncertainty.
- Establish early which set of climate data models will be used, to ensure that decisions across departments are made based on a common set of projections.
- State, regional, national and global models may not provide the most reliable data for city planning, but they offer a good starting point for taking action. In selecting climate data, there is often a tradeoff between the level of uncertainty (e.g. publicly available data for the state, region, or a neighboring city) and cost (e.g. localized data for Philadelphia).
- Plan adaptation efforts according to a range of scenarios.
- Combining projected data with geospatial mapping tools can help assess vulnerabilities.
- Collect information on past climate events and their impacts on the community, as a way to work within a limited budget.

Climate forecasts are the foundation of adaptation planning. Without knowing which climate change events will likely occur and when they will occur, decision-makers cannot plan properly. As climate projections continue to improve with new computing technology and methodologies, engaging the scientific community at early stages of the adaptation planning ensures that adaptation planning is based on the best available scientific information. The City can also work with the scientific community to help make climate science accessible to stakeholders, provide an initial impact assessment, inform the degree of confidence in climate projections and add credibility to the need for climate adaptation.

Cities and local governments have relied on a variety of scientific resources to obtain climate projections. For example, King County in the State of Washington, a pioneer in climate adaptation planning, worked closely with the University of Washington Climate Impacts Group. The Climate Impacts Group was federally funded by Regional Integrated Sciences and Assessments program (RISA) – part of the National Oceanic and Atmospheric Administration (NOAA). This program in the Northwest is equivalent to the Consortium for Climate Risk in the Urban Northeast (CCRUN), also funded by RISA (see below). King County also relied on peer-reviewed scientific research papers from the Intergovernmental Panel on Climate Change

(IPCC), U.S. EPA, U.S. Global Change Research Program (USGCRP), US Climate Change Impacts, RealClimate and the Pew Center on Global Climate Change.¹⁸ The City of Chicago worked with local scientists and received extensive guidance from Union of Concerned Scientists, an alliance of independent scientists and economists that publishes reports on climate change and other environmental issues.

There is regional climate data available for the Philadelphia area, including a publication by Union of Concerned Scientists titled: *Climate Change in Pennsylvania: Impacts and Solutions for the Keystone State*. Also, the latest scientific assessment by the USGCRP, titled: *Global Climate Change Impacts in the US (2009)*, includes a chapter on regional climate change impacts in the northeast.

It is important to note that climate projections are inherently uncertain. Climate forecasts are dependent on assumptions about various driving forces such as population, economy, technology, land-use, and agriculture. Given the infinite number of combinations and severity of driving forces, the IPCC has developed four families of emission scenarios, or storylines, based on different assumptions of the driving forces. Each scenario is equally probable and most importantly there is no ‘business-as-usual’ scenario.¹⁹ Thus, adaptation planning should consider a range of ‘low’, ‘medium’ or ‘high’ emissions scenarios.

Climate risk and weather predictions are a complex science, yet the information needed by a city must be in a form that planners can easily understand and use. It is important to establish the need for an open dialogue with climate scientists about the most effective use of their data and how it should be interpreted by city agencies and used in adaptation planning. Research conducted for this report found that several leaders in adaptation planning have developed on-going working relationships with climate scientists.

A Regional Resource: The Consortium for Climate Risk in the Urban Northeast (CCRUN)

CCRUN is a network of climate scientists from northeastern universities who coordinate and conduct stakeholder-driven research for the region. The CCRUN mission is to reduce climate-related vulnerability and advance opportunities for adaptation in the urban Northeast.²⁰ They also recognize that disadvantaged socio-economic groups can be at particular risk from climate change, and over the long-term CCRUN is looking to build the adaptive capacity of underserved populations. Stakeholders of CCRUN include a variety of public agencies at the federal, state, and local level, in addition to non-profit organizations and private utility providers.

¹⁸ King County. King County Climate Change Resources. Accessed on October 11, 2011 from <http://www.kingcounty.gov/environment/climate/climate-change-resources.aspx>. Accessed on October 11, 2011

¹⁹ Nakicenovic, N and Rob S. (2000). Emissions Scenarios. Intergovernmental Panel on Climate Change. Accessed on November 10, 2011 from ipcc.ch.

²⁰ CCRUN Website, available at: <http://ccrun.org>

CCRUN is funded under the National Oceanic and Atmospheric Administration's (NOAA) Regional Integrated Sciences and Assessments (RISA) program. During the initial years of this program, CCRUN will be primarily focused on the urban corridor from Boston to New York to Philadelphia. However the scope of the program covers Connecticut, Massachusetts, New Jersey, New York, Pennsylvania and Rhode Island.

In future years, CCRUN plans to increase emphasis on smaller cities within the region, as well as the broader water, food, and infrastructure 'sheds' that support it.²² The institutions involved with CCRUN are:

- Columbia University
- University of Massachusetts-Amherst
- City College of the City University of New York
- Stevens Institute of Technology
- Drexel University

As the City of Philadelphia moves forward with adaptation planning, CCRUN may be a resource for the City for needed climate risk data that is downscaled for risk assessment purposes.

CCRUN is still in its early stages, developing a framework for collaboration among stakeholders and the research teams from each academic institution.²¹ However, the following CCRUN projects in process or planned may be relevant to Philadelphia's adaptation planning work.

Coastal flood risk analysis for the urban Northeastern Corridor, today and with future sea levels²²

Summary: The Northeastern U.S. urban corridor of New York City, Philadelphia and Boston is threatened today by coastal storms, and climate change is likely to increase this threat due to predicted changes in sea-level rise. This project would merge the most successful existing tools for predicting coastal storm winds and storm surges and their evolution in a changing climate. The primary objective is to produce a probabilistic risk assessment for each city in the present, the 2050s and the 2080s, using stakeholder-defined metrics for urban watersheds.

Heat-related mortality risks in the urban Northeast under a changing climate

Summary: This project seeks to analyze current and projected temperature-related mortality impacts across a range of climate change models and scenarios. The project scope also plans to develop vulnerability indicators for the cities of interest, and test whether mortality impacts vary in association with these indicators. This study currently has preliminary results for Manhattan.³

²¹ CCRUN Website, available at: <http://ccrun.org>

²² CCRUN Website – project listing, available at: <http://ccrun.org/projects>

Reducing mortality from heat waves in the urban Northeast

Summary: Heat waves are a leading cause of weather-related mortalities, thus a good understanding of effective interventions is essential for public health adaptation to climate change in the region. However, the relationship between utilization of heat health warning systems and mortality during heat wave episodes has yet to be well understood and quantified. The project will address these challenges by documenting current use of climate information by stakeholder institutions in Boston, Philadelphia and New York and building detailed institutional maps of their decision making processes. The health team will also analyze the relationship between heat waves and mortality in the three cities and provide an assessment of the effectiveness of existing heat health warning systems.

Water and the public health connection in Philadelphia

Summary: The relationship between urban infrastructure, climate, and public health is being studied through a review of medical case histories (principally microbial illnesses and asthma) that have been strongly correlated with climatic conditions. Specifically, this project investigates the relationships between varying levels of climatically impacted infrastructure performance and key indicators of public health. These relationships will then be associated with forecasted climate change, and future potential for outbreak of disease assessed.

Space-time properties of extra-tropical storms along the US northeastern seaboard – present and future²³

Summary: Extratropical storms are associated with well-defined circulation patterns that affect the location of coastal impacts and their intensity. Using newly available re-analyses of weather data of the past century and more, this project will generate robust estimates of probabilities by frequency, spatial extent, track, and intensity of storms that affect the Northeast coast and close by inland regions, and determine trends and variability patterns.

Downscaling Climate Information

Global climate models (GCMs) are mathematical models that represent physical processes of the planet's climate systems. There are two types of downscaled models: regional climate models (RCMs) and statistically downscaled models.

- RCMs are simply global climate models viewed at higher resolution, which provide a depiction of land and water surfaces, as well as elevation.²⁴ The current generation of

²³ CCRUN Website – Project listings. Available at: <http://ccrun.org/projects>

²⁴ Horton, R., C. Rosenzweig, V. Ramaswamy, P. Kinney, R. Mathur, J. Pleim, and V.B. Rao, 2010: Integrated climate change information for resilient adaptation planning. EM Magazine, 14, no. 11, 14-25. Retrieved on October 20, 2011 from <http://ccrun.org/node/6>.

RCMs have resolution as high as 25 km, but can be expensive to obtain.

- This method can offer more detailed information than other methods because it allows non-stationary interactions between processes (i.e. land-sea temperature variable may modify coastal breezes in the projected period).²⁵
- Statistical downscaling methods involve establishing a statistical relationship - between observed local data and large-scale global climate model outputs. It assumes that this relationship is constant throughout the model time period, unlike RCMs where this relationship is not fixed.
 - The statistical downscaling method has range, cost and time saving advantages and projects climate in 30 year time periods.

Both Chicago and New York City developed projections using statistical downscaling. While downscaling global climate models are useful tools for impact and adaptation assessments, some key processes (i.e. convections and cloud) are still not completely understood.²⁶ Below is a summary of climate models used by cities and regions active in adaptation planning:

Entities	Scale of Model	Lead Scientists/Scientific Team
Chicago	City	Katharine Hayhoe, Texas Tech University; Donald Wuebbles, University of Illinois at Urbana-Champaign
Keene, NH	Regional/State	Dr. Cameron Wake, University of New Hampshire Climate Change Research Center; Union of Concerned Scientists
King County	Regional	University of Washington Climate Impact Group
London	National/City	United Kingdom Climate Impacts Programme (UKCIP), UK Research Council
New York City	City	Cynthia Rosenzweig (NASA, Columbia University), Radley Horton (Columbia University); additional scientists-
Toronto	Global	IPCC

London relies on UKCP09; UK climate projections also include London-specific projections

²⁵ Horton, R., C. Rosenzweig, V. Ramaswamy, P. Kinney, R. Mathur, J. Pleim, and V.B. Rao, 2010: *Integrated climate change information for resilient adaptation planning*. EM Magazine, 14, no. 11, 14-25. Retrieved on October 20, 2011 from <http://ccrun.org/node/6>.

²⁶ Horton, R., C. Rosenzweig, V. Ramaswamy, P. Kinney, R. Mathur, J. Pleim, and V.B. Rao, 2010: *Integrated climate change information for resilient adaptation planning*. EM Magazine, 14, no. 11, 14-25. Retrieved on October 20, 2011 from <http://ccrun.org/node/6>.

Olivia Cohn, Climate Action Plan Specialist at Global Philanthropy Partnership in the City of Chicago's Department of Environment, believes the benefits of using downscaled models specific to Chicago allow the City to "balance research with the need to act."²⁷ Some of the climate issues that are of concern at the national level may not be as relevant at the city level. Sea-level rise, for example, is a major concern for a country with large coastal populations, but it is irrelevant to landlocked Chicago. Localized models "bring urgency where it is needed" and may increase stakeholder engagement. The scientific team in Chicago found that, the probability of a heat wave, similar to the one in 1995 that likely contributed to almost 700 deaths, is 2 per decade under a low emissions scenario and 5 per decade under a high scenario. Each scenario is equally probable and there are no 'business-as-usual' scenarios due to the fact that carbon dioxide stays in the atmosphere, and even if all carbon emissions were reduced to zero, GHG levels would continue to rise.²⁸

The rate of emissions growth is uncertain, so climatologists use emissions scenarios to predict climate impacts under different conditions. In high-emissions scenarios, mitigation strategies are not implemented globally and emissions rise drastically, while in low-emissions scenarios mitigation techniques do control emissions and emissions are reduced.

Relating historical climate events to city-specific projections also creates incentives to act. Chicago illustrated possible climate change outcomes to its stakeholders, who then began to construct a set of issues that require attention in the adaptation planning process. For example, rising temperatures can result in infrastructure and material damage, which increases the number of potholes, a particular issue for Chicago stakeholders.²⁹

²⁷ Cohn, O, Chicago Climate Action Plan Specialist, Global Philanthropy Partnership at the City of Chicago's Department of Environment. Phone interview. November 4, 2011

²⁸ Nakicenovic. N and Rob S. (2000). Emissions Scenarios. Intergovernmental Panel on Climate Change. Accessed on November 10, 2011 from ipcc.ch.

²⁹ Cohn, O, Chicago Climate Action Plan Specialist, Global Philanthropy Partnership at the Chicago Department of Environment. Phone interview. November 4, 2011

Downscaling to City-Specific Level

Chicago

To prepare Chicago's baseline for a climate model, climate variables were collected from 14 National Weather Service weather stations in and around the metropolitan areas. These variables included temperature, precipitation, humidity, snow, and cloudiness. Local climate data was then applied to 3 GCMs out of the 23 included in the IPCC's Fourth Assessment Report.³⁰ The scientific team used two statistical techniques to downscale the global climate model from a resolution of hundreds of miles to tens of miles. High- and low-emissions scenarios were then simulated. In the high scenario, atmospheric carbon dioxide (CO₂) increases to 1000ppm by the end of the century, while in the low scenario CO₂ level increases to 550ppm. The outputs from the models were then used to assess the impact on key sectors in Chicago including the public health system, water supply, ecosystems, and infrastructure.³¹ The cost to produce the baseline, projections and sector impact analysis was \$225,000, which was funded with foundation grants.³²

New York City

In projecting temperature and precipitation changes, The New York City Panel on Climate Change (NPCC) also used IPCC-based methods. The baseline was derived from meteorological daily records from Central Park from 1971 through 2000. A total of 48 outputs were generated using 16 GCMs and 3 emissions scenarios. Sea-level rise projections were based on 7 GCMs. The mean annual changes and the likelihood of the change of each variable were then used to assess risk to infrastructure in New York City.³³ The Rockefeller Foundation funded the NPCC's work with a grant of \$350,000.³⁴

While it is preferable to use city-specific climate projections, it may not be possible to do so because of the costs involved. One of the ways to work with limited projected climate information is to collect information on past climate events and their impacts on the

³⁰ The City of Chicago. *Climate Change and Chicago: Projections and Potential Impacts*. November 7, 2011. Retrieved on October 1, 2011 from http://www.chicagoclimateaction.org/pages/research___reports/8.php

³¹ The City of Chicago. *Climate Change and Chicago: Projections and Potential Impacts*. November 7, 2011. Retrieved on October 1, 2011 from http://www.chicagoclimateaction.org/pages/research___reports/8.php

³² Parzen, J. (2009, July). *Lessons Learned Creating the Chicago Climate Action Plan*. Retrieved November 1, 2011. http://www.chicagoclimateaction.org/pages/research___reports/8.php

³³ New York City Panel on Climate Change. (17, February, 2009) *Climate Risk Information*. Retrieved on October 1, 2011 from www.nyc.gov/html/om/pdf/2009/NPCC_CRI.pdf

³⁴ Institute for Sustainable Communities, Climate Leadership Academy and Center for Clean Air Policy. (n.d.). *Promising Practices in Adaptation and Resilience*.

community.³⁵ Collecting information on impacts from past events, particularly extreme events, provides valuable insights into how climate change can impact the city's future.³⁶ Interviewing or distributing questionnaires to department heads and staff, consulting government records, and reviewing media archives, can provide information on past events.³⁷ The United Kingdom Climate Impacts Programme (UKCIP) developed a spreadsheet tool, Local Climate Impacts Profile (LCLIP), to help local authorities collect weather news stories and identify current vulnerability to weather events.³⁸ Some of the inputs are sources of information, type of reported weather events, responsible agencies, consequence, and significance of consequence. The LCLIP is also one of the methods the UK uses to benchmark climate change.

Systems already under stress will likely be more sensitive to climate change, and planning can then be targeted to the most vulnerable areas. New York City, for example, has focused its climate adaptation on infrastructure, since extreme events in recent history raised the awareness of the high social and economic cost of infrastructure disruption.

Recommendations for Philadelphia:

Global climate models (GCMs) have coarse spatial resolution; they are good for projecting global climate but are less useful for projecting the local temperature, rainfalls, and snowfalls relevant for planning. Downscaling is a method used to conduct impact and adaptation assessments.³⁹ The following options are currently available for Philadelphia:

- Work with scientists, preferably local scientists, to create Philadelphia specific climate projections.
- Use existing climate projections for the northeast prepared by CCRUN
- Use existing Pennsylvania state projections prepared by the Union of Concerned Scientists
- Use existing Pennsylvania state projections prepared for the Pennsylvania Department of Environmental Protection.

³⁵ Snover, A.K., L. Whitely Binder, J. Lopez, E. Willmott, J. Kay, D. Howell, and J. Simmonds (2007). Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments. In association with and published by ICLEI – Local Governments for Sustainability, Oakland, CA. Retrieved on September 20, 2011 from cse.washington.edu/db/pdf/snoveretalgb574.pdf

³⁶ Rosenzweig, Cynthia, and William Solecki. Chapter 1: New York City Adaptation in Context. *Annals of the New York Academy of Sciences* 1196.1 (2010): 19-. Retrieved on October 10, 2011 from <http://onlinelibrary.wiley.com/doi/10.1111/j.1749-6632.2009.05308.x/abstract>

³⁷ Snover, A.K., L. Whitely Binder, J. Lopez, E. Willmott, J. Kay, D. Howell, and J. Simmonds. (2007). *Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments*. In association with and published by ICLEI – Local Governments for Sustainability, Oakland, CA. Retrieved on September 20, 2011 from cse.washington.edu/db/pdf/snoveretalgb574.pdf

³⁸ UKCIP website. Environmental Change Institute (ECI), University of Oxford. Accessed on November 8, 2011 from <http://www.ukcip.org.uk/lclip/>.

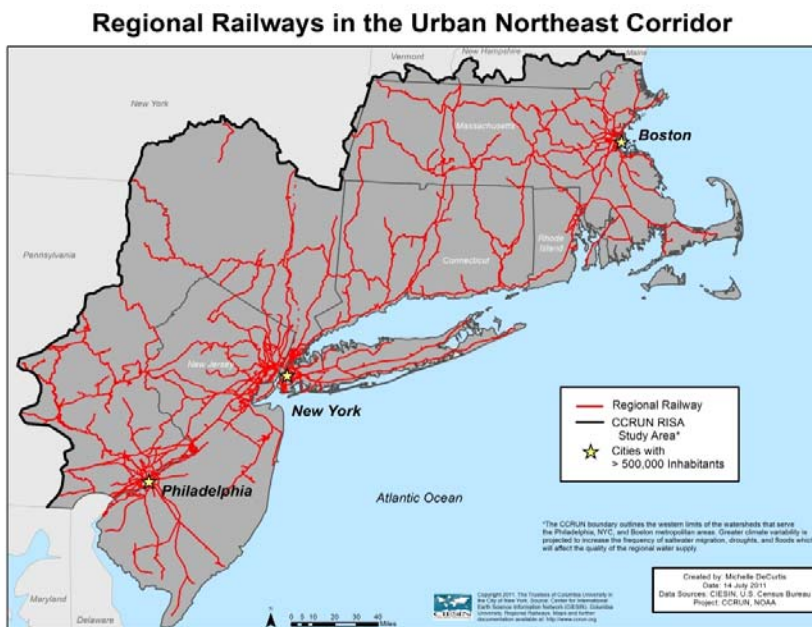
³⁹ Rosenzweig, Cynthia, and William Solecki. Chapter 1: New York City Adaptation in Context. *Annals of the New York Academy of Sciences* 1196.1 (2010): 19-. Retrieved on October 10, 2011 from <http://onlinelibrary.wiley.com/doi/10.1111/j.1749-6632.2009.05308.x/abstract>

While working with climate scientists to create Philadelphia specific climate projections is the best option from a data perspective, it requires funding.

In addition to the aforementioned CCRUN project new projects are planned to address Climate Change Scenarios and Downscaled Climate Projection and Climate Indicators and Monitoring. There is some regional modeling information currently available from CCRUN. They have compiled a variety of maps to illustrate climate change information for the Northeastern Urban Corridor for critical infrastructure systems, demographic maps to illustrate distribution of vulnerable populations, and climate change projection maps.

A sample of each of the types of maps is below, and all maps can be access from the CCRUN website at: <http://ccrun.org>

Infrastructure:



Demographics:

Visualizing Climate Risks

Climate models alone will not provide the City all the information that is needed in order to understand the specific risks to the City, its infrastructure, and its residents. The ability to use climate projections in understanding future impacts represents another component of data collection. Leading practitioners of adaptation planning can offer examples of how this can be done.

The Greater London Authority (GLA) aims to assist scientists in providing adaptation research. The GLA is interested in not only probabilistic scenarios of flooding in London, but also in learning where flooding is likely to occur and who and what will be affected.⁴⁰ The result is a map of flood risk areas overlaid with the number of people, properties, infrastructure, and emergency services residing in those areas. The GLA is also working with a consortium of universities on a Local Urban Climate model and its application to the intelligent design of cities, known as project LUCID, to develop an urban climate projection model.⁴¹ The objective of LUCID is to develop a model that can be used to assess the impact of climate change on the built environment, energy use, and health.⁴²

Additional governmental entities have combined climate projections with mapping tools to help transform scientific outputs and provide information relevant for policy. For example, the King County Department of Natural Resources and Parks used Light Detection and Ranging (LiDAR) data and Geographic Information Systems (GIS) technology to determine the elevation of wastewater facilities that are exposed to the risk of sea-level rise. The county assessed the flood risk of 30 facilities under different sea-level rise scenarios provided by the Climate Impact Group, and found that one facility in the design phase could flood as early as 2050. As a result the facility was redesigned with higher elevation requirements.⁴³ The tool is available on the King County website and may prove useful to Philadelphia:
<http://www.kingcounty.gov/environment/wtd/About/RespondingToClimateChange.aspx>.

The City of Olympia, Washington also overlaid climate projections on a high-resolution satellite map and found their city is two times more vulnerable to flooding than neighboring Seattle, even though the cities are only 65 miles apart.⁴⁴ Had the City of Olympia relied on regional data prepared for Seattle or global data with coarser resolutions, the magnitude of the risk would not

⁴⁰ Nickson, A. Strategy Manager for Climate Change Adaptation and Water, Greater London Authority. Phone interview. November 10, 2011

⁴¹ Nickson, A. Cities and Climate Change: Adaptation in London, UK. Case study prepared for Cities and Climate Change: Global Report on Human Settlements 2011. <http://www.unhabitat.org/grhs/2011>

⁴² Lucid. Accessed on November 10, 2011 from <http://www.lucid-project.org.uk/>

⁴³ King County. Department of Natural Resources and Parks. (2008, July). *Vulnerability of Major Wastewater Facilities to Flooding from Sea-Level Rise*. Retrieved on October 15, 2011 from <http://www.kingcounty.gov/environment/wastewater/CSI/Library/SeaLevelRise.aspx>

⁴⁴ Lowe, A., Foster, J. and Winkelman S. (2009, June). *Ask the Climate Question: Adapting to Climate Change Impacts in Urban Regions*. Center for Air Policy Urban Leaders Adaptation Initiative.

have been revealed. As a result of better data, the City was able to take a number of adaptation measures to protect its residents from sea-level rise, including the relocation of drinking water sources and choosing a less vulnerable site for the construction of a new City Hall.⁴⁵

The website of the National Oceanic and Atmospheric Administration’s Coastal Services Center (<http://www.csc.noaa.gov/digitalcoast/tools/index.html>) provides a number of geospatial and planning tools and free web-based training. Although it is mainly focused on coastal planning, there are tools and training sessions, including *Introduction to LiDAR*, that are applicable to other types of geographical areas.

Sample of Mapping and Analytical Tools	Description
CanVis	Visually simulates “what if” scenarios. Can be used to provide pictorial presentation of flooding.
Habitat Priority Planner	Assist with conservation, land use, and restoration planning
Impervious Surface Analysis Tool	Calculates the percentage of impervious surface area within user-selected geographic areas
Sea-level rise and Coastal Flood Frequency Viewer	Helps visualize potential impacts from sea-level rise. Currently, project covers Mississippi, Alabama, and parts of Texas and Florida, with additional coastal counties to be added in the near future.

⁴⁵ Thomas, K, Melillo, J, and Peterson, T,(eds.). (2009). *Global Climate Change Impacts in the United States* Cambridge University Press, Accessed on November 1, 2011 from <http://www.globalchange.gov/publications/reports/scientific-assessments>.

Climate information about sea-level rise, storms, drought or heat waves by itself is inadequate to help a city improve its resilience to climate change. Leading cities in climate adaptation use climate forecasts to conduct risk assessments that help to prioritize risks over several time horizons (i.e. by 2020, 2050, 2100). Without conducting a risk assessment, a city has no way of knowing the severity of the risks it faces, and, therefore, has no rational way to allocate resources to boost its resilience to those risks. This section describes the key components in risk assessment, discusses risk assessment methodologies used by leading cities, and offers scenario planning as a method for managing risk uncertainties in capital planning projects.

Key findings:

- Conduct a risk assessment based on the likelihood of a climate change, degree of confidence in the climate projection, magnitude of the consequence, and timing of the event.
- Prioritize risk using a matrix
 - High likelihood x high consequence = high priority
 - Low likelihood x low consequence = low priority
- Conduct benefit and cost analysis to prioritize risks
- Broadly group sectors for risk assessment according to human, built, and environment; subsectors can be created according to the organizational structure of the city
- Engage stakeholders as they are the key source of information for vulnerability and risk assessment
- Remember that risk assessment is an iterative process and consider scenario planning

Risk Factors

Risk, in this discussion, is defined as the probability of a climactic change multiplied by the consequence of occurrence. Probability is the likelihood that an event or change will occur and climate scientists assign these likelihoods. Consequence is the magnitude of impact of an event: who and what is impacted and to what degree.⁴⁶ The consequence of an event is affected by sensitivity and adaptive capacity (people living on a floodplain are sensitive but those residing on floodplain with have higher adaptive capacity). The purpose of conducting a risk assessment is to characterize the nature of the risk and establish information regarding the probability and consequence of an event. The purpose of conducting a vulnerability assessment is to understand the systems' degree of vulnerability.

Risk = Probability x Consequence

⁴⁶ Mayor of London. *The Draft Climate Change Adaptation Strategy for London. Public Consultation Draft*. February 2010. Available at <http://www.london.gov.uk/climatechange/>.

The risk profile is not a fixed value: advances in climate science affect the probability component, and new information (i.e., population growth, technology) affects the consequence component. It is therefore important that risk assessment be thought of as an ongoing process.

In addition to probability and consequence, other key criteria identified by the IPCC in risk/vulnerability assessment include, but are not limited to⁴⁷:

Degree of Confidence/Uncertainty: The IPCC makes a distinction between the concepts of likelihood and degree of confidence. Degree of confidence is “an expression of the degree to which a value (e.g., the future state of the climate system) is unknown,” while uncertainty can result from lack of information or from disagreement about what is known or knowable.⁴⁸ For example, if 9 out of 10 models agree the likelihood of temperature rising is 99.5%, the level of confidence is very high (9 out of 10) and the likelihood is virtually certain (probability > 99%). The implication for degree of confidence on planning is best illustrated by King County. The county focused its vulnerability assessment on extreme temperatures and less on winter precipitation because this area lacked model consensus on precipitation change.⁴⁹

Timing: Events that are likely to occur in the short term and/or events that are unavoidable in the long term should be addressed with adaptation planning and strategy development. Actions to address unavoidable long-term events should factor in the lead-time for implementation. For example, planning for a sea wall due for rehabilitation in 5 years should begin in 2 years if the lead-time for completion is 3 years.

Importance of Systems: Impacts on human and natural systems that have greater value to society should be flagged for risk assessment. For example, cultural centers, historical districts, and particular species may be of special importance to City residents.

Distribution/Vulnerable Population: The distribution of impacts on populations varies across a variety of categories including income, age, and gender. Elderly and low-income populations are particularly sensitive to climate change. Further information on strategies to address vulnerable populations is provided in the latter part of this chapter.

Persistence/Reversibility: Impacts to systems that are persistent and irreversible are key areas of focus. An example of persistence is intensified storms that were previously considered ‘one-off’ events. Extinction of species is an example of irreversible damage.

⁴⁷ Pew Center on Global Climate Change and the Pew Center on the State. n.d. Climate Change 101: Understanding and Responding to Global Climate Change. Available at http://www.pewclimate.org/docUploads/Adaptation_0.pdf.

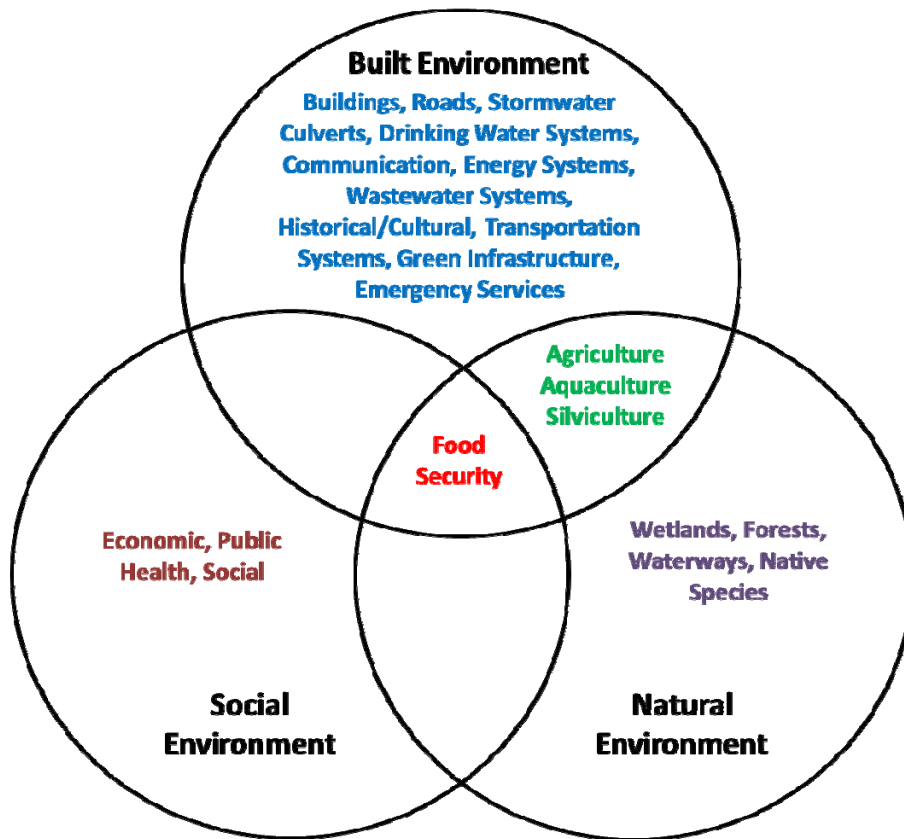
⁴⁸ Intergovernmental Panel on Climate Change. IPCC Fourth Assessment Report. Index. Accessed on November 15, 2011 on ipcc.ch.

⁴⁹ Snover, A.K., L. Whitely Binder, J. Lopez, E. Willmott, J. Kay, D. Howell, and J. Simmonds (2007). Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments. In association with and published by ICLEI – Local Governments for Sustainability, Oakland, CA. Retrieved on September 20, 2011 from ces.washington.edu/db/pdf/snoveretalgb574.pdf

Grouping Impacts by Sectors

In assessing impacts of climate change on the city of Keene, NH found it useful to categorize the impacts broadly into three areas: the built environment, the social environment and the natural environment.⁵⁰ During brainstorming sessions, Keene's climate change committee created additional subsectors and while overlap of these areas at first appeared to be a planning challenge, the committee understood it allowed single strategies to address vulnerabilities across multiple sectors. Keene's grouping can be seen in the visual below.

Other cities have used different categories: Chicago's Climate Action Plan categorizes the impacts by Water, Health, Ecosystem, and Infrastructure, London uses Health, Environment, Economy and Infrastructure, and New York City focuses on critical infrastructure including building, energy, transportation, water, and communication systems.



Source: *Adapting to Climate Change: Planning a Climate Resilient Community*, Keene, NH

⁵⁰ City of Keene, NH and Local Government for Sustainability. Keene, New Hampshire. (2007, November). *Adapting to Climate Change: Planning a Climate Resilient Community*. Available at <http://www.ci.keene.nh.us/sustainability/climate-change>.

Conducting Vulnerability and Risk Assessment

The climate change guidebook co-authored by King County and Local Governments for Sustainability (ICLEI) offers a step-by-step guide to assess vulnerabilities and prioritize actions. Leading cities in climate adaptation have referenced the guidebook to help with planning. Case studies showing how New York City and Chicago incorporated some of these steps are provided below.

Stakeholder engagement is a common element in each of the guidebook's recommended steps, as well as in other climate adaptation planning resources (Willows and Connell, the Pew Center, IPCC). Successful risk assessment relies on information provided by key stakeholders from multiple sectors. Additionally, stakeholders are directly affected by the outcome of the risk assessment and may end up carrying out the implementation plan.

The recommended steps provided in the guidebook that we found to be best practices are:

- **Identify planning areas**

Planning should focus around systems that are currently under stress as they are more sensitive to climate change. Stressors are “any physical, chemical, or biological entity that can induce an adverse response”.⁵¹ Examples of stresses in systems are:

- Increased invasive species due to warmer temperatures destroying crops
- A lack of funding for a system upgrade create further vulnerable infrastructure
- Economic downturns affect a community's ability to purchase air conditioning.

In addition to climate change, it is recommended that population growth, economic development, and major trends be considered in determining the threshold.

- **Conduct a sensitivity analysis**

A sensitivity analysis can reveal information on how sensitive the planning area is to climate change. The results can be quantitatively ranked as low, medium, and high. The following are some questions that can help evaluate the sensitivity of each system to climate change:

How exposed is the system? For example, communities in floodplains are exposed to higher precipitation and extreme storms.

What is the impact threshold of the system? Impact threshold is the point at which small changes in climate produce large responses in the systems. Some examples of impact thresholds are:

- Maximum sea-level that a sea wall is designed to handle.
- Minimum precipitation to maintain species survival.

⁵¹ The U.S. Climate Change Science Program. (June 2008). Adaptation Options for Climate-Sensitive Ecosystems and Resources. Accessed on November 15, 2011 from climatescience.gov

- Maximum temperature a human body can handle; temperature exceeding 100 may cause death or illnesses.

Will the system be able to handle supply shortage? For example, higher temperatures increase the demand for water.

- **Undertake an adaptive capacity analysis**

The purpose of adaptive analysis is to determine to what extent the systems can accommodate climate change. Although sensitivity and adaptive capacity are related (high sensitivity can also mean low adaptive capacity), there are cases where this relationship does not hold. For example, asphalt roads are highly sensitive to buckling from high temperature, however the capacity to adapt can also be high since it is fairly easy to repair if funds are available.

Existing and/or future constraints, including legal, biological, geographic, and physical, affect the system's ability to adapt. An example of a legal or regulatory constraint is the Federal Emergency Management Agency (FEMA) requirement that flood maps be based on historical precipitation and stormwater flows. This was an issue faced by the Seattle Public Utility (SPU) in trying to raise the awareness of residents regarding flood preparation. Recognizing this barrier, SPU sought FEMA's approval to revise the maps based on their own data.⁵² An example of a biological constraint is the temperature threshold of plants or animals.

In addition to constraints and existing capacity, potential resilience should also be identified. Some infrastructure may have capacity to accommodate a range of future climate change scenarios. For example, identifying the capacity above the impact threshold of a sea wall can help determine how much more stress the sea wall can handle.

- **Rank the vulnerability of the planning area**

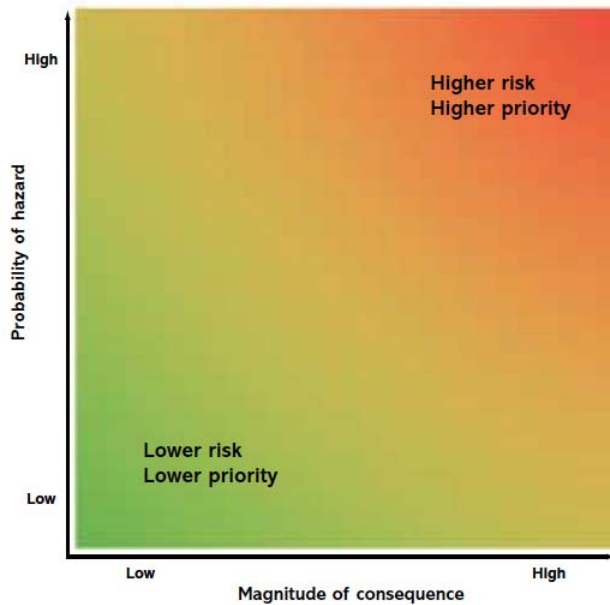
The sensitivity analysis is combined with the adaptive capacity analysis to form the vulnerability assessment. If sensitivity is high and adaptive capacity is low then the vulnerability of planning systems is high.

- **Perform risk analysis**

As discussed above, risk = probability x consequence. A qualitative (low, medium, or high) or quantitative (monetary value of damage) value might be assigned to the consequence. The likelihood terminology used by the IPCC (virtually certain, extremely

⁵² Snover, A.K., L. Whitely Binder, J. Lopez, E. Willmott, J. Kay, D. Howell, and J. Simmonds (2007). Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments. In association with and published by ICLEI – Local Governments for Sustainability, Oakland, CA. Retrieved on September 20, 2011 from ces.washington.edu/db/pdf/snoveretalgb574.pdf

likely, very likely, likely, etc.) can be ranked: a 5 can represent *virtually certain* and a 1 can represent *extremely unlikely*.



Source: Willows and Connell. May 2003. *Climate Adaptation: Risk, Uncertainty and Decision-Making*

- **Prioritize Actions and Developing Strategies**

The vulnerability analysis is then combined with risk assessment in a matrix to prioritize planning areas.

	Low Vulnerability	High Vulnerability
High Likelihood	May be priority areas	Should be priority areas
Low Likelihood	Are unlikely to be priority planning areas	May be priority planning areas

The risk assessment process allows for the prioritization of adaptation actions. Climate risks that have both high probability and high consequence in the short- or medium-term become high priorities. Conversely, risks with low probability and low consequence, or risks that are expected to manifest far into the future are low priorities. To account for the uncertainty of climate forecasts, the objective is to identify so-called no regrets, low regrets or win-win adaptation strategies. No regrets are those options that are viable under any climate scenarios, low regret options are those that have high benefits at low cost,

and win-win options inherently have environmental, social, or economic benefits.⁵³ Managing stormwater runoffs with green infrastructure and strengthening healthcare for the elderly are win-win options. It is also important to account for adaptation strategies that may be effective in dealing with one hazard, but which may exacerbate conditions elsewhere.⁵⁴ A strategy to use air-conditioning to reduce heat-related illnesses also increases peak summer energy use and GHG emissions. A better strategy might be to improve building insulation and install reflective roofing material.

London qualitatively ranks the risk of flooding, drought and overheating as low, medium or high. Although the ranking is simple, a lot of analysis has been done to understand the exposure and vulnerability of people and infrastructure. The Greater London Authority (GLA) has gathered information on the number and type of infrastructure at risk of flood, number of people of living on flood plain, overheating thresholds in buildings, and advance warning times for flood and urban heat island effects. For each risk, GLA has also identified the responsible agencies and obstacles to adaptation. Many of London's current strategies relate to gathering more information to understand the risk.

Case 1 - Chicago: Impact Assessment

A cost-benefit analysis is useful in prioritizing actions. Timing is important in ranking priorities.

Chicago hired two consulting firms to undertake an economic risk analysis and a risk assessment in an attempt to quantify the impacts of climate change and rank actions by probability and consequence. In addition to qualitatively ranking the risk, the financial implications of actions were also considered.

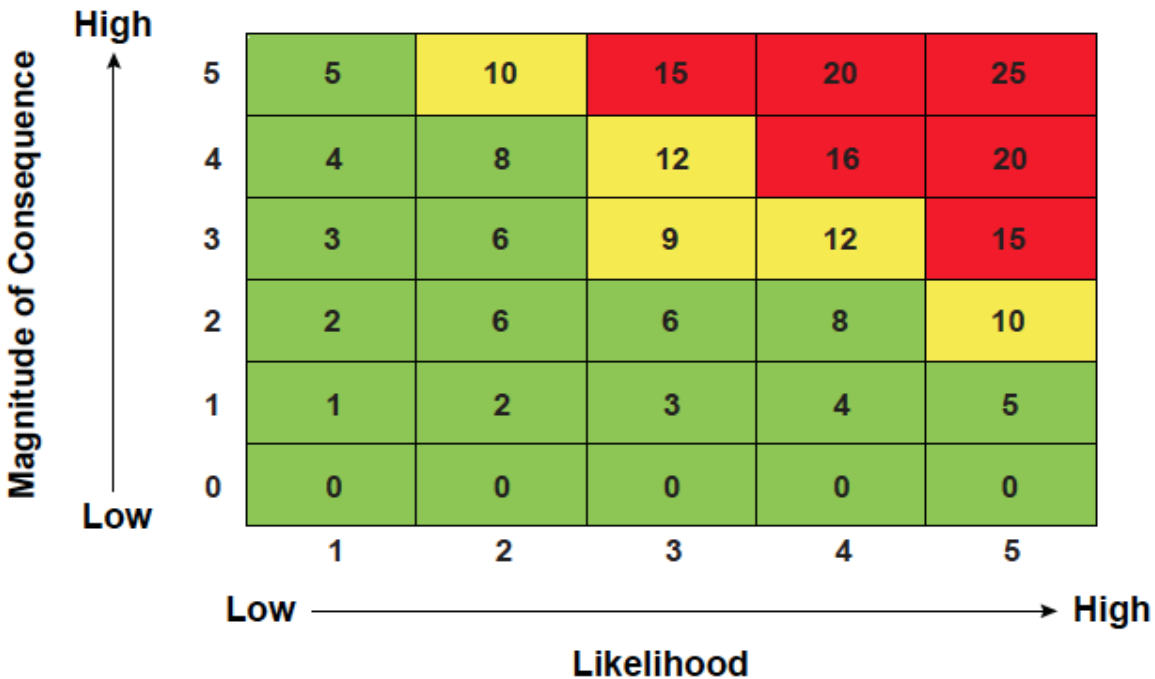
This economic risk analysis of climate risk was the first of its kind and may not be easily replicable given the high cost. However, according to Coffee et al., cities that are planning climate adaptation could benefit from the tools these consultants used to identify impacts on city functions and infrastructure and develop prioritizing actions. One consultancy, Oliver Wyman, interviewed personnel in 18 departments to determine how climate change could affect their operations, assets, personnel and services. The interviews helped to determine that the Chicago Park District, for example, could be affected by an increase in average temperature, which would extend seasonal maintenance of the landscape, athletic fields and the beach. The departments were also asked to estimate the economic costs and benefits of each set of impacts under each climate factor. The model uses Monte Carlo simulations, which take into account the timing, type and size of the expenditures as well as revenue opportunities, to derive a range of the financial impact. Oliver Wyman placed the cost of adapting to climate change at \$2.5 billion

⁵³ Snover, A.K., L. Whitely Binder, J. Lopez, E. Willmott, J. Kay, D. Howell, and J. Simmonds.(2007). *Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments*. In association with and published by ICLEI – Local Governments for Sustainability, Oakland, CA. Retrieved on September 20, 2011 from cses.washington.edu/db/pdf/snoveretalgb574.pdf

⁵⁴ New York State Energy Research and Development Authority. (2010). Responding to Climate Change in New York State. Retrieved on October 15, 2011 at nyscrda.org.

under the high emissions scenario and \$690 million under the low emissions scenario, and it recommended a focus on energy management and heat resiliency to avoid a bulk of the costs.⁵⁵

MWH, a global engineering firm, developed risk reduction strategies including action prioritization for Chicago. MWH used the findings from the scientific research team on climate projections and sector impacts, and the work of Oliver Wyman on infrastructure to assess and prioritize the risks. The methodology is the same: Risk = likelihood x consequences of occurrences. MWH ranked the sensitivity of the climate projections (likelihood) from 1 to 5, with 5 indicating that the specific climate factor is occurring now and 3 indicating that the prediction is driven by generally less reliable GCM output such as increased storminess. The consequences of over 80 identified potential impacts were also ranked from 1 to 5 (5 being a catastrophic consequence, such as major loss of life). Risks that have scores of 15 or higher are classified as high, risks with scores of 9 to 14 were classified as medium, and risks with scores of 8 or lower were classified as low as depicted in the below figure.⁵⁶

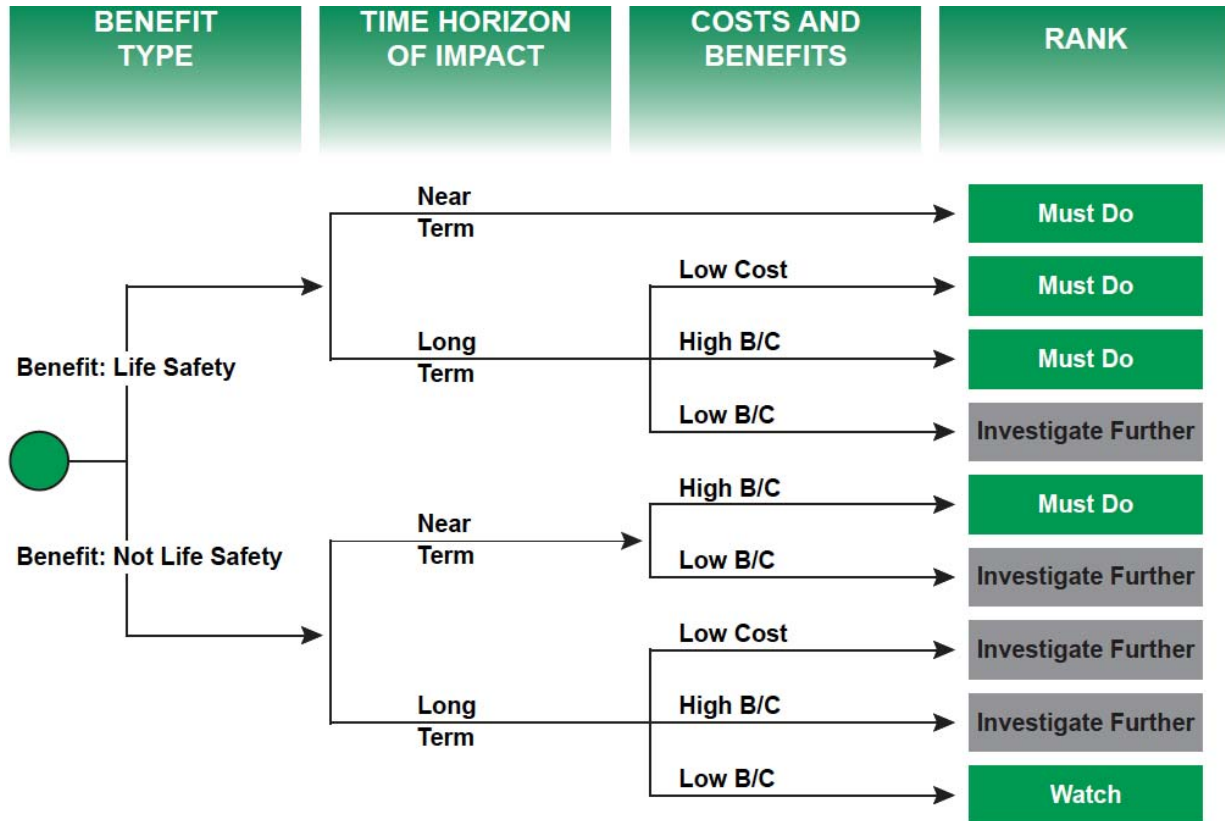


Similar to the guidelines discussed above, MWH focused on the impacts with highest risks in order to develop adaptation strategies and action recommendations. The strategies were broadly grouped according to the sector impacts identified by the scientific research team to reduce infrastructure vulnerability to extreme climate conditions and reduce vulnerabilities to extreme heat, precipitation, and ecosystem degradation. MWH identified specific actions by reviewing best practices of other cities and determined the feasibility of these actions by interviewing certain city departments. MWH then estimated the costs and benefits of each action. Working

⁵⁵ Oliver Wyman. (2008, July). Corporate risk case study: City of Chicago climate change task force. Available at Chicagoclimatechange.org.

⁵⁶ Parzen, J. (2008, March). Chicago area climate change quick guide: adapting to physical impact of climate change. For municipalities and other organizations. Available at Chicagoclimatechange.org.

with the Department of Environment, MWH developed a decision tree to prioritize the actions factoring in time horizon, benefit of the action, and benefit to cost ratio. Actions that have high benefits, such as life safety and near term (within 10 years) impacts were classified as *must do* actions. Actions that have high benefits, a long-term time horizon, and low cost or high benefit to cost ratios are also classified as *must dos*. Actions that have high benefit and a long-term time horizon but with low benefit to cost ratios are classified as *investigate further*. This process can be seen below.



Chicago has successfully implemented a number of tactics that were identified in their planning process including strategically planting trees in areas that would reduce heat island effects and investigating thermal environment maps.⁵⁷

⁵⁷ Coffee, Joyce E., et al. (2010) Preparing for a Changing Climate: The Chicago Climate Action Plan's Adaptation Strategy. Journal of Great Lakes Research 36 (2010): 115-7. Access on October 1, 2011 from www.chicagoclimateaction.org.

Case 2 – New York City: Infrastructure Risk and Vulnerability Assessment Tools⁵⁸

New York City's approach to risk and vulnerability is similar to the King County/ICLEI recommendations and emphasizes the reiterative method of risk assessment.

New York City's adaptation assessment process included these 8 steps:

- Identify current and future climate hazards
- Conduct inventory of infrastructure and assets
- Characterize the risk of climate change on infrastructure
- Develop initial adaptation strategies
- Identify opportunities for coordination
- Link strategies to capital and rehabilitation cycles
- Prepare and implement adaptation plans
- Monitor and reassess

Organization stakeholders were asked to assess the impact on infrastructure using a common set of climate change projections produced by the NPCC. Three tools, infrastructure questionnaires, risk matrices and prioritization frameworks, were developed to help organization stakeholders compile an inventory of at-risk infrastructure, assess risks, and prioritize actions.

1. **Infrastructure Questionnaires (IQ):** Sector-specific IQs are designed to identify which infrastructure is vulnerable to climate change. The sectors covered include communications, energy, transportation, water and waste, and policy. Factors such as infrastructure elevation and condition, as well as distance from current shorelines, help to determine how exposed the infrastructure is to climate change. Questions on potential impacts from rising air temperature, increasing precipitation, sea-level rise, and extreme weather, as well as question on insurance coverage, help determine vulnerability.
2. **Risk Matrix:** This tool helps characterize risks and prioritize actions based on the probability of climate hazard, likelihood of impact, and the magnitude of consequences. Although the tool has three components, the Task Force found it more useful to work with a two-dimensional matrix comprised of likelihood and consequence. The risk matrix is generated from a simple spreadsheet that contains (among other things) a column for likelihood of impacts and six columns for magnitude of consequence.⁵⁹ Within each column, there is dropped down menu of options from which stakeholders can choose.

Likelihood of Consequence:

Organizations are asked to rank the likelihood of impact occurring during the useful life

⁵⁸ Grady, Megan, David C. Major, and New York City Panel on Climate Change. ADAPTATION ASSESSMENT GUIDEBOOK: New York City Panel on Climate Change. *Annals of the New York Academy of Sciences* 1196.1 (2010): 229-. Retrieved on October 2, 2011 from <http://onlinelibrary.wiley.com/doi/10.1111/j.1749-6632.2010.05324.x/full>

⁵⁹ Sarrinikolaou, G, The Institute for Sustainable Communities, Climate Leadership Academy and Center for Clean Air Policy. (n.d.). *Promising Practices in Adaptation and Resilience*.

of the infrastructure. The ranking options are Virtually Certainly/already happening, High likelihood, Moderate likelihood and Low likelihood.

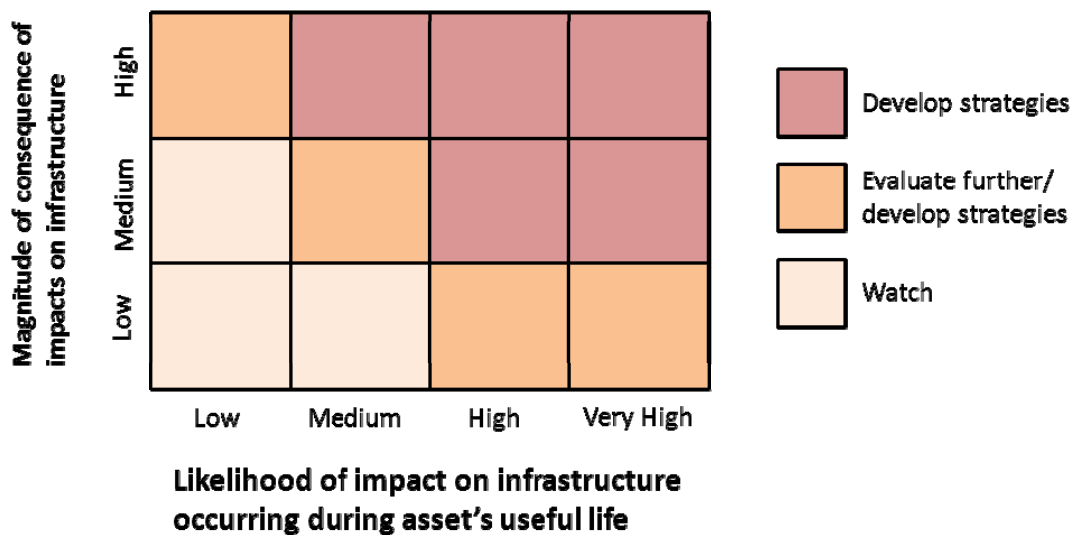
Magnitude of Consequence:

For each category, stakeholders are asked to rank the magnitude of impact. The options are low, medium, high. The overall magnitude of consequence is generated depending on the ranking of each category.

Internal operations	Capital and operating costs	Number of people affected	Public health and worker safety	Economy	Environment
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The spreadsheet has built-in macros that automatically generate a recommended strategy based on choices made in the likelihood and consequence categories, shown graphically below. The recommended output might be to develop strategies, evaluate further, or watch and stakeholders have the ability to override the recommended strategy with explanatory notes.

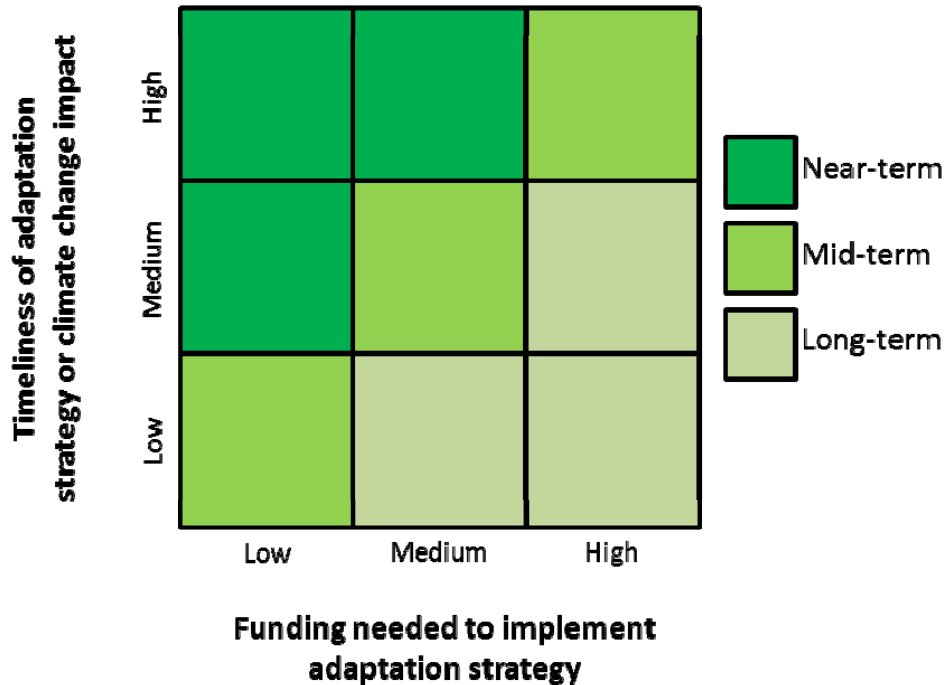
New York City Risk Matrix



Source: *Adaptation Assessment Guidebook, NPCC*

3. **Prioritization Framework:** The same spreadsheet can be used to generate a prioritization matrix. The adaptation section asks stakeholders to provide a description of the adaptation strategy, identify stakeholders that should be involved in the implementation, and estimate the cost of the strategy and the timing of the impact (based on menu of time horizon and cost ranges).

New York City Prioritization Matrix



Source: *Adaptation Assessment Guidebook, NPCC*

A lesson learned from New York City is that the risk assessment process provides awareness about climate change impacts to organization members and imparts the importance of incorporating climate change into the maintenance, planning and construction of infrastructure. However, New York’s reliance on government practitioners to identify the likelihood of impact and magnitude of occurrence of climate impacts could lead to understating the risks. That’s because practitioners may not wish to be the ones that reveal the climate risks of their own organizations, or to commit their organizations to developing costly adaptation strategies. To counter these weaknesses in this approach, a system may be put in place to reward stakeholders for identifying vulnerabilities in infrastructure and identifying the full costs of taking action.⁶⁰

⁶⁰ Sarrinkiolaou, G, The Institute for Sustainable Communities, Climate Leadership Academy and Center for Clean Air Policy. (n.d.). *Promising Practices in Adaptation and Resilience*.

Case study 3: City of Melbourne

The City of Melbourne, Australia's climate adaptation plan is based on a project risk management process, in accordance with the Australia and New Zealand standard (AS4360). The approach is similar to those undertaken by other leading cities. However, the method of mapping out consequences of climate events, categorizing consequences according to responsible agencies, and the ranking of risk and consequences considering three different time frames are unique. The following is a brief description of Melbourne's approach:

Step 1: Identify key climate risks

Melbourne identified four main climate events relevant to the city based primarily on climate projections for the state of Victoria:

1. Drought and reduced precipitation events
2. Heat waves and bushfires
3. Intense rainfall and storm events
4. Sea-level rise

Step 2: Map consequences of climate events

For each climate event, the cascading consequences of the event scenario were mapped. The scenarios were based on extensive consultation with key members of city management and function stakeholders. The sectors covered included water, transport and mobility, buildings and property, social health and community, business and industry, energy and communications and emergency services. The responsible city departments are highlighted on the map. Please see appendix

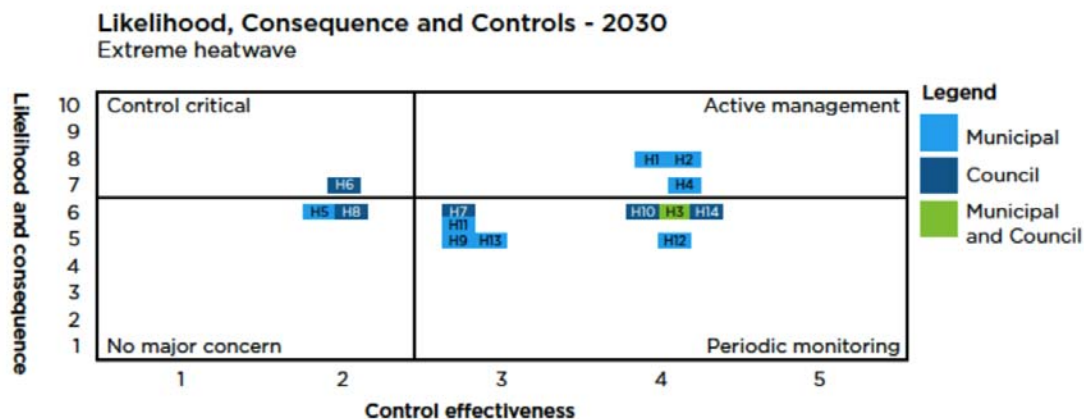
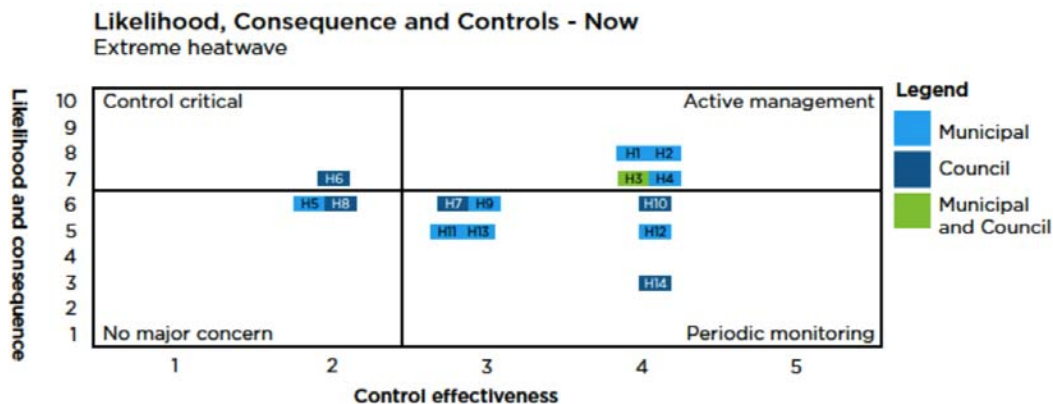
Step 3: Identify, assess and rank risks

The risk assessment includes sensitivity and adaptability analyses of the entire system. The analyses consider whether the current system is one of stress or resilience, and any particular processes or pressures that might offer opportunities for better collaboration between key stakeholders. All risks are given a combined rating of up to 10 based on likelihood of occurrences and magnitude of consequences. The consequence rating considers the impacts of climate events on business, environment, people, economic, reputation of the city, infrastructure and assets, political influence (loss of power to influence decisions making), and liability to the city (fines, prosecution). For example, a catastrophic event is one where the city is unable to deliver its services, the environmental damages are irreversible, the financial cost is greater than 10% of the city's revenue, death toll is greater than 5 and infrastructure lost are valuable (city hall, IT infrastructure). Areas with ratings of 7 or higher were deemed critical. The risks are mapped on the consequence diagram, which helps identify the areas that need to be addressed to mitigate the consequence. The risks are ranked for three timescales: today, 2030, and 2070.

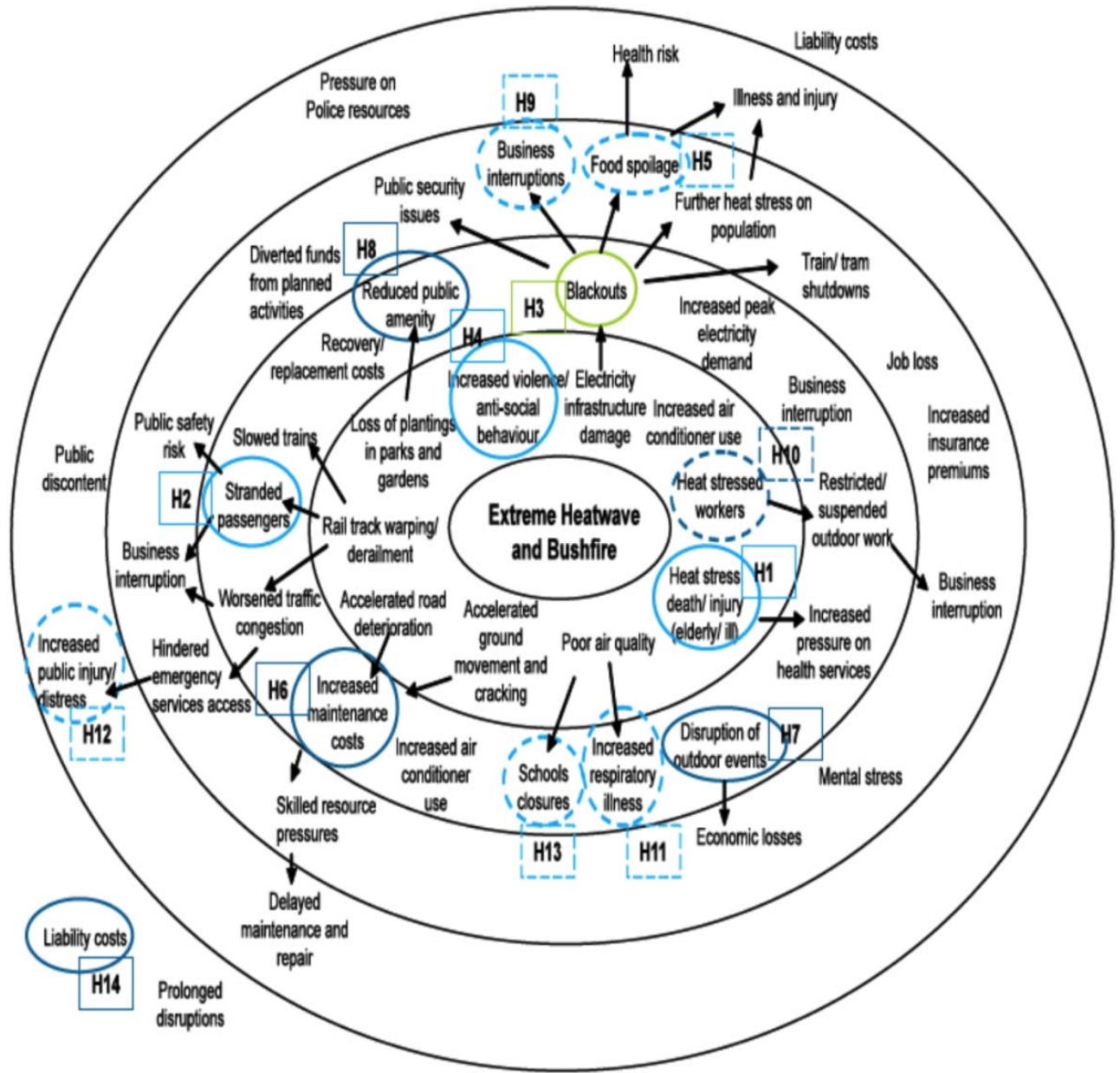
Risk number	Risk title and rating	Now	2030	2070
H1	Increased heat stress related death / illness among at risk population groups	8	8	9
H2	Passengers become stranded as trains and trams to the City of Melbourne are delayed / cancelled in hot weather	8	8	9
H3	Blackout	7	6	6
H4	Increased violence / anti-social behaviour causing increased public nuisance and hospital admissions	7	7	7

Step 4: Rank controllability and Prioritization of Planning Areas

For each assessed risk, the current measures to reduce the risks were identified. For extreme heat wave and bushfire events the control measures include weather warnings, air conditioning, heat wave response plans, occupational health and safety responsibilities for aged care and activity suspension threshold for schools and outdoor events. The ability to control the risks were ranked 1 to 5 and placed on matrix against the risk. Those risks with 3 or higher were high priority areas.



City of Melbourne Risk Assessment



- Legend
- Critical
 - Non critical
 - Municipal
 - Council
 - Municipal and Council

Using scenario planning in long term capital projects

A comprehensive adaptation planning process must utilize methods for dealing with uncertainty. Scenario planning is one way to manage climate uncertainty in long-term projects. It is a strategic planning method that involves the development and use of representations of plausible futures and pathways for decision making.⁶¹ Since November 2007, the U.S. National Park Service has been developing scenario planning as a structured framework to manage climate uncertainty.⁶² Several water departments in the U.S., including Tucson Water, Phoenix Water Services, Denver Water, and Palm Beach County Water Utilities Department - have also utilized scenario planning.⁶³ The Victorian Centre for Climate Change Adaptation Research (VCCCAR), which published the comprehensive report *Scenarios for Climate Adaptation*, identified 33 cases of scenario planning used in adaptation planning in Victoria, Australia. Scenario planning originated in the military following World War II and was popularized in the business world by Royal/Dutch in 1970, when the oil company pre-empted the energy crisis by using scenario planning.⁶⁴

Scenario planning is about developing plausible and logical stories about the future rather than about making predictions. It contrasts with the traditional decision-making method based on probability; instead, each story in scenario planning is assumed to be equally plausible. Scenario planning is appropriate in situations where there is low control over future outcomes and high uncertainty.⁶⁵ The goal is to identify the common elements or “no-regrets” solutions in the pathway. Strategies are then developed along the common element route, ensuring that they will remain viable in all scenarios. The approach is flexible, as it allows organizations to move from one path to another depending on how the future unfolds. By developing a flexible path, organizations could delay expensive projects until more information becomes available. Scenario planning can also help build a common understanding of issues and visions and help foster a culture of “future oriented” thinkers.⁶⁶

⁶¹ Wiseman, J., Biggs, C., Rickards, L. and Edward, T. (2011, June). *Scenarios for Climate Adaptation*. Victorian Centre for Climate Change Adaptation Research. Retrieved on October 5, 2011 from vcccar.org.au.

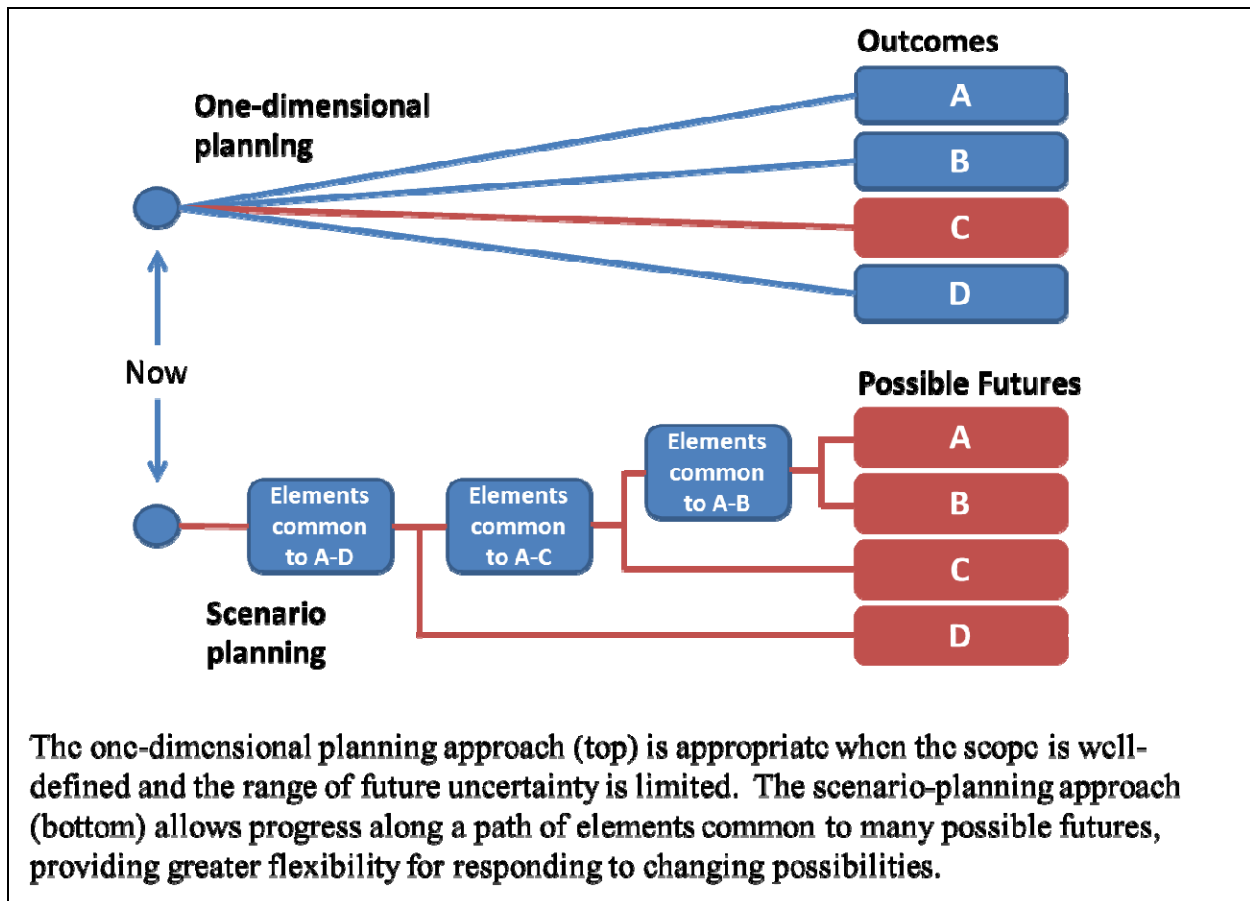
⁶² National Park Service. U.S. Department of Interior. n.d. Climate Change Response Program. Scenario Planning Brief. A Tool for Decision-Making in an Era of Uncertainty. Accessed on November 10, 2011 from www.nps.gov.

⁶³ Means III, E., Laugier, M., Daw, J., Kaatz L. and Waage, M. (2010, January). *Decision Support Planning Methods: Incorporating Climate Change Uncertainty Into Water Planning*. Water Utility Climate Alliance. Retrieved on October 10, 2011 from www.wucaonline.org

⁶⁴ Schwartz, P. (1991). *The Art of Long View*. New York : Doubleday/Currency.

⁶⁵ National Park Service. n.d. Climate Change Scenario Planning Workshop. Joshua Tree National Park and Kaloko-Honokohau National Historical Park. November 13-15, 2007. Accessed on October 10, 2011 at www.nps.org.

⁶⁶ Wiseman, J., Biggs, C., Rickards, L. and Edward, T. (2011, June). *Scenarios for Climate Adaptation*. Victorian Centre for Climate Change Adaptation Research. Retrieved on October 5, 2011 from vcccar.org.au.



Source: Mara R., *Scenario Planning: Making Strategic Decisions in Uncertain Times*, Southwest Hydrology May/June 2009

Case 4: Tucson Water Use of Scenario Planning to Develop Long Term Water Plan⁶⁷

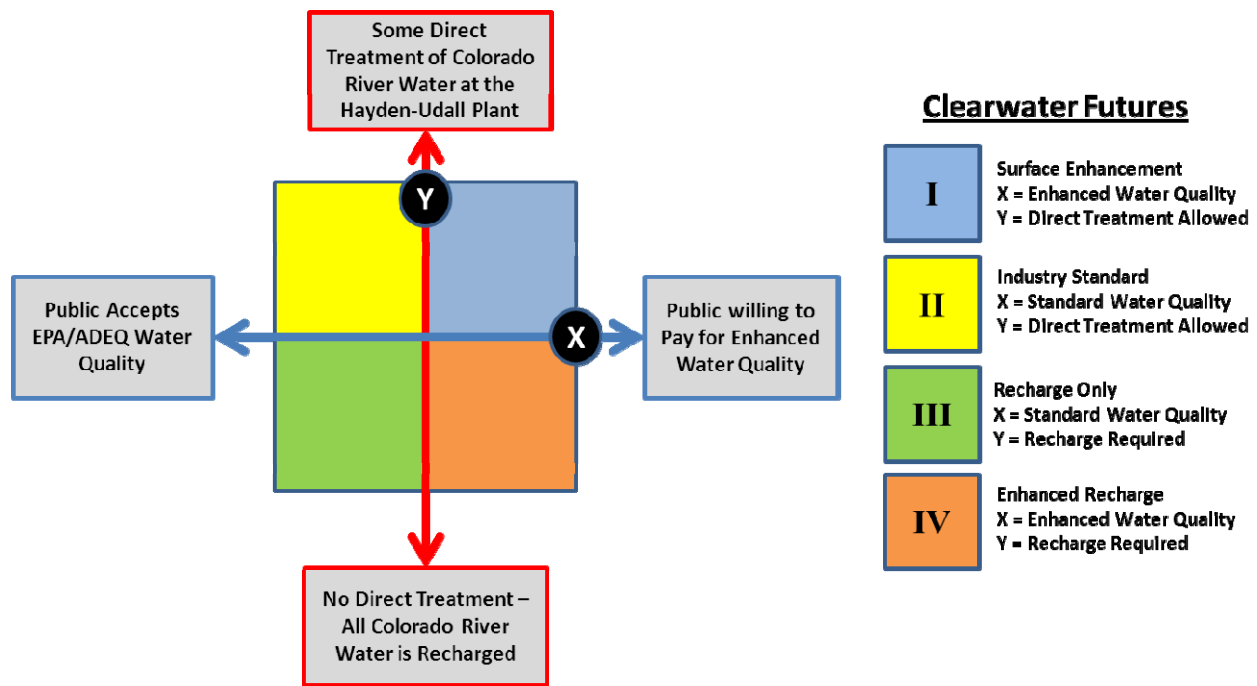
While developing Water Plan: 2000-2050, Tucson Water adopted a scenario planning approach guided by Peter Schwartz's *The Art of the Long View*, and the National Park Service are currently using a similar method. Tucson Water's planning team conducted scenario planning assessments for clear water imported from the Colorado River and municipal effluent in an attempt to maximize water use. The two assessments were then combined to create 14 pathways leading to 28 possible futures. For the purpose of simplicity and illustration, only the clear water assessment is described below.

The planning team took eight steps to create the scenarios for each assessment: (1) frame the question/identify central issue, (2) identify the driving forces, (3) rank the driving forces, (4) identify critical uncertainties, (5) create the scenario matrix, (6) describe the scenarios, (7) create paths to the scenarios, and (8) identify common elements. Driving forces refer to external forces

⁶⁷ City of Tucson Water Department. (2004, November 22). Water Plan 2000-2050. Accessed on October 12, 2011 at <http://cms3.tucsonaz.gov/water/waterplan>.

that can impact the outcome of the central issue, like moving the plot of a scenario. These forces might be social, technological, economic, political or environmental. The critical uncertainties are driving forces with the highest importance and uncertainty. Generally, 2-3 uncertainties are used to frame the scenarios, as using more than 3 is difficult to manage.

The central question for the clear water assessment was how to maximize allocated water from the Colorado River by blending it with ground water. The planning team identified 14 drivers, which included ground water availability, environmental issues and tolerance of residents, system robustness, water quality of source waters, etc. After ranking the forces, two critical uncertainties were identified: public willingness to pay for enhanced water and public acceptance of treated water. These were placed on a matrix with 4 quadrants, each representing a scenario. The next step was to imagine what the scenarios might look like and identify the obstacles and uncertainties. Step seven involved the creation of strategies for each future scenario. The final step was to identify the common strategies and the critical decision points where the pathways diverge. When a critical point is reached a decision must be made.



Source: Tucson, Water Plan 2000-2050.

Scenario planning would not have been used at Tucson Water without supportive and forward-thinking leaders. The department had not done strategic planning before, yet the team guided itself throughout the process by consulting Schwartz's book. Department leaders supported the vision and participated in some of the early brainstorming sessions. The process required members to be creative, imaginative and collaborative and as the team was large (20-25 members) and comprised of members from different jurisdictions, it was necessary to build

group consensus. When the plan was revisited six years later with the new team came up with different futures demonstrating the need for a flexible and dynamic plan.⁶⁸

⁶⁸ Marra, R. Water Administrator, Water Resources Management, City of Tucson. Phone Interview. October 26, 2011.

Climate change events can present considerably higher risk to certain segments of urban populations, and socioeconomic factors must be a consideration in any adaptation planning process. Measures should be identified during the adaptation planning process to help alleviate the burden of these climate change events on vulnerable groups. Some communities evaluate this in their adaptation risk assessment process, and often identify specific strategies for those most susceptible to climate change risks.

Demographics particularly vulnerable to climate change impacts include:

- Low-income
- Elderly
- Non-English speaking
- Those with chronic illness or disabilities
- Those without access to a car
- Those without insurance

There can be many vulnerability factors associated with each issue related to climate change, such as extreme heat or flooding. Some vulnerability factors, such as income, cut across all climate issues.⁶⁹ Other vulnerability factors are specific to a particular issue, such as factors that increase a person's susceptibility to health effects from climate change. A common example of one such health effect is the prevalence of asthma in neighborhoods with poor air quality. The following steps represent best practices in reducing climate risk impacts in vulnerable communities.

Identify hotspots among neighborhoods or population sectors using vulnerability factors

The Pacific Institute, located in Oakland California, conducts research to advance environmental protection, economic development, and social equity. Over the past decade, it has conducted research specific to sea-level rise projections and the socioeconomic factors that affected communities would encounter as a result. Through this work, the Institute has identified a series of factors that would increase a community's vulnerability if sea levels were to rise (i.e. income, ability to speak English, owning a car, etc.). To better understand the socioeconomic impacts that could result from sea-level rise, climate data was overlaid with vulnerability factors (using

⁶⁹ Cooley, H. Pacific Institute. Personal communication. November 7, 2011.

Census data) to gain an understanding where the most vulnerable populations were on along the California coastline.

Using a similar approach at a local level would allow Philadelphia to include vulnerable populations in a risk assessment. It would identify hotspots among city neighborhoods or population sectors where priorities may be higher in terms of making investments to infrastructure, or for implementing more aggressive or unique awareness, communication, and engagement campaigns.

The Pacific Institute has expanded its original work on populations vulnerable to sea-level rise, to examine socioeconomic impacts of other climate change issues. Most recently, the Institute has identified a series of vulnerability factors for a variety of climate related issues: sea-level rise, flooding, extreme heat, and drought. With these factors, they are developing a **“Vulnerability Index”** that aggregates information from 19 vulnerability factors and overlays them with US census and climate data. In this early stage of work around the Index, they have chosen to weight all vulnerability factors equally. The Vulnerability Index, as well as the factors and methodology behind it, have not yet published, but will be made available on the Pacific Institute website (<http://www.pacinst.org/>) during the first part of 2012, and should be a valuable tool for adaptation planners.

Model existing work in the field

The Pacific Institute’s work on the Vulnerability Index was modeled after SoVI – the Social Vulnerabilities Index for the United States – released by the Hazards and Vulnerabilities Research Institute at the University of South Carolina in 2006. The SoVI statistically examined the underlying social and demographic characteristics of the US population and how they negatively impact certain segments with regard to climate-change related hazards.⁷⁰ The methodology behind the index is based on an aggregation of 42 socioeconomic, demographic, and built environment variables.⁷¹

To further the statistical work contained in the SoVI, Oxfam America, an international relief and development organization, commissioned a study to create layered maps for 13 Southeastern states that depict social and climate-change related hazard vulnerability. The intent of this mapping is to identify hotspots that are at particular risk from four climate change related hazards: drought, flooding, hurricane-force winds, and sea-level rise.⁷² Although they are only available for a portion of the United States, they serve as a good model for the information that

⁷⁰ Oxfam America. Vulnerability and Climate Change in the US Southeast. Available at: <http://adapt.oxfamamerica.org/>

⁷¹ Press Release: SC's Hazards & Vulnerability Research Institute releases Social Vulnerability Index (SoVI). December 13, 2006. Available at: <http://www.start.umd.edu/start/announcements/announcement.asp?id=52>

⁷² Oxfam America. Vulnerability and Climate Change in the US Southeast. Available at: <http://adapt.oxfamamerica.org/>

can be gathered on vulnerable populations, with the purpose of incorporating it into risk assessment and adaptation strategy development. The maps can be viewed at: <http://adapt.oxfamamerica.org/>

Accounting for risk to vulnerable populations:

The degree to which communities are incorporating vulnerability factors and risks into their adaptation planning varies. Some examples of current practice include the following.

- The City of London has identified vulnerable populations and is focused on understanding how to adapt their strategies differently to account for them. As an example, flooding is one of the three major risks they have identified for the City, and they have compiled data to look at who is most at risk from flooding.
 - The city has developed flood risk maps based on socioeconomic factors, finding that the poorest and richest areas of the city are at the greatest flood risk. The City then considers appropriate adaptation strategies informed by these socioeconomic factors. They recognize that the rich are more likely to have insurance and mental capacity to withstand flooding, and that the poor are at greater risk after the flood, without the means to pick up and start anew.⁷³
 - London also examined notification times and flood warnings for different neighborhoods. As the City's surfaces become less permeable through normal urban development and construction, the ability to provide warnings of flood/flash flood conditions decreases, adding to vulnerability. Some areas experience less than 3 hours between rainfall flooding.⁷⁴
 - The city assesses the capacity to react for all those who are vulnerable: Do they have information? What are the warning times? Do they have insurance? This information helps develop flooding responses.⁷⁵

- The City of Toronto identifies vulnerable population groups within its adaptation planning report. This is a best practice when combined with utilizing vulnerability factors in an overall risk assessment process. In particular, Toronto has found that the homeless are most exposed to extreme weather events; and isolated and low-income seniors are the most exposed to extreme heat. It has also identified those with low income and/or no savings and insurance, as susceptible to long recovery times from events that can damage

⁷³ Nixon, A. Greater London Authority. Video talk available at: <http://www.21stcenturychallenges.org/media-gallery/view-video/alex-nickson-greater-london-authority/>

⁷⁴ *Ibid*

⁷⁵ *Ibid*

housing, belongings, or health.⁷⁶ While risk to vulnerable populations may not be formally incorporated into a risk assessment process, several of Toronto's strategies related to Heat Health Warning Systems and other emergency response strategies aim to reduce the effects and/or suffering to certain vulnerable populations.

- Seattle has established a Race and Social justice initiative, and it has formed a Race and Social Justice team. When City programs are developed, including those dealing with climate and adaptation, socioeconomic factors are now considered, although the extensiveness of this work varies from agency to agency. In Seattle's Water Utility, they are beginning to overlay flood risk data with demographic information, looking at hotspots for vulnerable populations to flooding.⁷⁷

Support sustained resiliency in vulnerable populations with upfront and ongoing engagement

- Maximize the effectiveness of the programs that aim to protect vulnerable groups by engaging them in the program development process. Increasing resilience is largely about changing behaviors, and giving vulnerable populations some ownership in the development of adaptation strategies can enable greater uptake in solutions when climate events do occur.
- One-time assessment will not engender lasting results. Supporting sustained resiliency in vulnerable populations requires ongoing engagement with each segment of the population that is at risk, coupled with utilization of new climate data and updated demographic information.

The methodologies used to apply risk to vulnerable populations will likely continue to evolve, especially as more downscaled climate data is made available. However, it is important to acknowledge socioeconomic factors in risk assessment approaches and response strategies, regardless of how much or little data is available.

⁷⁶ Toronto Environmental Office, Toronto Climate Adaptation Steering Group, and the Clean Air Partnership. *Ahead of the Storm. Preparing Toronto for Climate Change: Development of a climate Change Adaptation Strategy*. 2008. http://www.toronto.ca/teo/pdf/ahead_of_the_storm.pdf

⁷⁷ Fleming, P. Seattle Public Water Utility. Personal communication. November 9, 2011.

Finding money to pay for adaptation projects is one of the biggest obstacles facing cities. Municipal budgets are often strained with competing priorities and when climate money is available, it is mainly dedicated to fund mitigation strategies. To date, most climate projects in cities across the United States have focused exclusively on mitigation of greenhouse gases. Now, due to mounting evidence of climate change effects, cities increasingly turn to adaptation and long term planning.

The World Bank has estimated that as much as 80 percent of the expected \$80-100 billion per year in adaptation costs will be solely borne by urban areas across the globe.⁷⁸ In order for cities to cover these high costs, a multifaceted approach will be required, as one type of funding mechanism alone is insufficient for meeting a city's needs. Financial sources range from federal and state grants and loans to philanthropic groups with vested interest in the communities they are aiding. More innovative techniques such as public/private partnerships and soft techniques, such as zoning and other options that fall within the cities regulatory control or existing programs, should also be considered. Although these techniques will lighten the financial burden on the City, adaptation planning can be expensive, but must be started.

Research conducted for this report revealed that the four most common and successful best practices in financing strategies include splitting adaptation plans into smaller pieces and funding those pieces; obtaining regional funding; changing zoning codes, design standards and regulations; and emphasizing the link to adaptation and mitigation when seeking funding. Details on these strategies and additional solutions are highlighted below.

The Big Four:

- The best strategy we have found in our research is to break adaptation planning into distinct pieces and to raise funds for specific projects. Oakland suggests focusing on only one issue at a time and chose sea-level rise. They received a specific NOAA grant for a portion of this project (see case study) and worked with smaller NGOs to fund adaptation pieces. Similarly Boston worked with the Conservation Commission on sea-level rise, the Coastal Management Department on wetland protections and split their strategies amongst many different funding partners (see case study).
- Regional cooperation: A vulnerability assessment may be done as part of a regional plan, in which case resources can be pooled. Milwaukee has participated in the Wisconsin Initiative

⁷⁸ World Bank Group. Web. 11 Nov. 2011. <<http://www.worldbank.org/>>.

on Climate Change Impacts and receives free data and climate modeling through this partnership. San Francisco and Oakland have partnered with the Bay Conservation Development Commission (BCDC) and are receiving a no-cost sea-level rise study and corresponding adaptation implementation strategies.

- Changing land-use regulations, zoning codes, and design standards is often the most efficient way to implement adaptation strategies because it allows cities to affect change at relatively low cost.⁷⁹ While adaptation deals with long-term issues such as infrastructure life, it can have immediate effects on redevelopment and retrofitting. One example is mandating larger lot sizes to increase urban green space. New York City and London have used zoning laws to encourage or require vegetation-covered green roofs.
- One observed best practice is to understand the programs that both reduce GHG emissions and serve adaptation goals and to emphasize this link. This allows municipalities to widen their nets while searching for financing mechanisms, and attract investors interested in developing a more productive, healthy, serviceable and valued urban area. Funding can be obtained for an improvement in one area and applied towards a solution that responds to both mitigation and adaptation.

Setting the Tone for Adaptation:

- Dividing adaptation plans into distinct and manageable parts does not mean foregoing a comprehensive strategy. As mentioned, Oakland obtained financing for projects related only to sea-level rise, the current focus of their adaptation plan. However, they made this comprehensive by considering regional participation, wetland protection, coastal management, and developer needs.
 - Resilience upgrading is an interconnected strategy, in which improving the conditions and performance of the urban area for all investors, residents, and other users can attract more investment.⁸⁰ Resilience upgrading aligns adaptation goals with Brownfield development, green building, urban re-generation, and urban development. See the Financing Appendix for particular areas of resilience upgrading that will require innovative financing. A multi-sector strategy allows municipalities to recruit finance from a variety of both public and private sector investors.
- Political stability and long-term confidence in subsidies and project eligibility reassures equity investors and capital lenders. In Germany government mandates and subsidies have

⁷⁹ Black, Elizabeth C. "Climate Change Adaptation: Local Solutions for a Global Problem." *Georgetown International Environmental Law Review* 359.22 (2010). *Lexis Nexius*. Web. 14 Oct. 2011.

⁸⁰ Brugmann, Jeb. *Financing the Resilient: A Demand Driven Approach to Development, Disaster Risk Reduction, and Climate Adaptation*. Rep. Bonn: ICLEI, 2011. Print.

pushed 17 percent of electric power generation to alternative energy sources such as wind, solar and biomass, compared with just one to two percent in the United States. Assuring companies that the dollars they spend on infrastructure projects will not be spent in vain and setting up dispute resolution creates a culture in which investors want to invest.

Here's Where the Planning Department Comes In:

- Set up voluntary, incentive-driven programs for green buildings, including direct financial transfers, tax incentives, and increased flexibility in zoning and building laws.
- Los Angeles, Washington D.C. and San Diego are using non-monetary incentives, such as expedited permitting, density bonuses, free technical consultations, and awards programs. These must be carefully implemented to ensure developers do not become accustomed to them and later oppose mandatory controls and regulation.⁸¹
- Change design standards and building codes. Risks in cities are *manufactured* by the way that we locate, design, construct, and service urban places and systems.⁸² Updating building design standards serves mitigation and adaptation: a code may mitigate by reducing fuel consumption and reduce demand on energy infrastructure creating resilience.⁸³
- Streamline the permitting process. Creating a more efficient and a shorter permitting timeframe will allow renewable energy infrastructure and other major projects to save money. It took Cape Wind, a large offshore wind project in Massachusetts, nearly nine years to obtain a final permit from state and federal agencies, while projects in China are expedited to ensure companies that obtain financing are not bogged down.⁸⁴

Traditional Methods: Bonds and taxes

- Municipal, environmental, and climate bonds. Bonds have historically been a reliable way for municipalities, states, and the federal government to raise the money needed for expensive infrastructure projects. Both general obligation bonds and revenue bonds have the potential to aid municipalities in funding adaptation strategies. San Francisco voted in a \$100 million dollar revenue bond to pay for solar panels, energy-efficiency technologies, and wind turbines for public facilities. In 2009, Clean Edge and Green Americas began to discuss the

⁸¹ www.naiop.org/foundation/greenincentives.pdf

⁸² Brugmann, Jeb. *Financing the Resilient: A Demand Driven Approach to Development, Disaster Risk Reduction, and Climate Adaptation*. Rep. Bonn: ICLEI, 2011. Print.

⁸³ Black, Elizabeth C. "Climate Change Adaptation: Local Solutions for a Global Problem." *Georgetown International Environmental Law Review* 359.22 (2010). *Lexis Nexius*. Web. 14 Oct. 2011.

⁸⁴ Goldfarb, By Daniel. "How Public Land Can Jumpstart Clean Energy." *Americans for Energy Leadership*. Web. 12 Dec. 2010. <<http://leadenergy.org/2010/10/howgovernment-land-can-help-foster-a-clean-energy-economy/>>.

possibility of *Clean Energy Bonds*, based on the Victory Bonds issued by the United States during WWII. Clean Energy bonds would allow investors to support adaptation projects at low-risk. The *Global Climate Bond* is another proposed bond that would put investors' money toward renewable energy projects.

- Employ specialized and generalized taxes that can be used to aid the city in securing financing for adaptation strategies. These tax programs can be applied to the general public in the form of property taxes or be specialized, focusing on the sale of a specific item or service. King County's city council voted to increase property taxes by \$0.10 per \$1,000 in assessed property value in order to fund adaptive flood-plan work.

Getting Additional Sector Interested:

- Explore strategic partnerships between the City and large companies able to invest capital and which have an additional business interest in the implementation of adaptation and renewable projects. These might be gas and oil companies, or electric utilities working to meet Pennsylvania Renewable Portfolio Standards. Clear communication upfront can help prevent contract issues and set a path for both parties to reach acceptable terms.
- Partner with universities. Philadelphia is home to numerous universities and the University of Pennsylvania has a legitimate climatology department. Use these educational resources to get localized data, risk prioritization studies, City planning studies, and advice on implementation.
- Public-Private Partnerships (PPPs), a long-term contract between the government and a private entity that is building and operating the facility, are currently used to address infrastructure needs such as roads, bridges, schools and hospitals. The use of PPPs to finance adaptation efforts is not yet common, however is a promising framework for developing high cost adaptation strategies. Utilizing PPPs would allocate risk to both the public and private sector parties, allow cost and incentives optimization, and provide technological specialization. In England and throughout Latin American, PPP's have enjoyed success in the deployment and expansion of renewable infrastructure. This would also include Build, Own, Transfer (BOT) projects where private companies finance, build, and run the project and then sell it back to the government in 20-30 years.
- Collaborate with insurance providers. The insurance industry has a lot to lose from climate disruption. The National Association of Insurance Commissioners requires that the largest U.S. insurance companies disclose the financial risks they face from climate change and any

potential actions to address these risks. Mutually beneficial projects may provide opportunities for funding between these insurance companies and the City.⁸⁵

- Private sponsorship of adaptation strategies: setting up an Adopt-a-greenway program, similar to current Adopt-a-highway programs could bring in a portion of the adaptation improvement cost.
- Engage the real estate sector, as they will need to deal with the negative effects of climate change. Large firms currently working in Philadelphia, including CBRE, Cushman & Wakefield, and Grubb & Ellis, may be interested in being part of a working group or contributing dollars for adaptation changes.
- Funding from private foundations, philanthropic organizations and NGO's. Chicago's adaptation strategy reveals the significant financial potential of these organizations in funding data collection, risk assessment and implementation. NGO's like the Red Cross may have overlap in areas of public health and emergency preparedness. According to the NYC Mayor's Office of Long-Term Sustainability a combination of federal, private, and philanthropic organizations was crucial to the success of the city's adaptation strategy.⁸⁶
- Engage and build partnerships with insurance providers who have a vested interest in protecting properties and limiting their financial losses. There is great potential to align the goals of the city and the insurance industry by working together.

Federal and State Dollars:

Securing federal and state funds to finance adaptation strategies presents a number of challenges. Programs provided by the federal and state governments have limited availability and time horizons.

Steps to take when pursuing grant funding⁸⁷:

- Evaluate inaction. This includes the cost of infrastructure, real estate, local economic activity, and natural system functions that could be lost due to climate change events.

⁸⁵ ICLEI, Financing Adaptation

⁸⁶ Telephone interview. Leah Cohen, Policy Advisor, NYC Mayor's Office of Long-Term Planning and Sustainability. 18 Nov. 2011.)

⁸⁷ ICLEI, comp. *Financing Climate Change Adaptation A Fact Sheet from ICLEI-Local Governments for Sustainability USA's Climate Resilient Communities™ Program November 2010*. ICLEI, 2010. Print.

- Work with FEMA. FEMA can supply updated 100-year flood maps that incorporate projected changes in sea level rise and storm intensity and frequency, and supplies Pre-Disaster Mitigation Grants (used by Miami-Dade & Nassau Counties). This program provides funds to communities for hazard mitigation planning and the implementation of mitigation projects prior to a disaster event. See Appendix for Ranking Factors and criteria.
- Office of Sustainable Housing and Communities grant programs: Sustainable Communities Regional Planning Grants (to improve regional planning efforts that integrate housing and transportation decisions, increase capacity to incorporate livability, sustainability, and social equity values into land use plans and zoning) and Community Challenge Grants (reducing barriers to achieving affordable, economically vital, and sustainable communities through planning, zoning, and building codes).

Low-cost or free strategies:

- Rely on an existing data report to save money in data collection. Many cities rely on state, federal, or a scientific report until further vulnerability assessments can be completed. Boston has used the *Union of Concerned Scientists 2007* report, which also features Philadelphia. San Francisco and Oakland relied on a California state report.
- Join the Urban Leaders Adaptation Initiative. Current cities, including Chicago, King County, L.A., and NYC, received grants from the Rockefeller and Surdna Foundations through the Center for Clean Air Policy
- Proactive adaptation: Assess the potential negative economic effects of climate change consequences on the City's revenues and budgetary health and communicate this to the public. An example of this is King County's inclusion of proactive adaptation in their water treatment facility.

This table represents available programs and funds at the Federal and State level that address issues associated with climate change adaptation. While this list is not inclusive it represents some of the options that can be utilized when making decisions on how to secure financing for the city of Philadelphia’s adaptation efforts.

Available Federal Programs	Grant	Description
<p>The Energy Efficiency and Conservation Block Grant (EECBG) Program</p> <p>www1.eere.energy.gov/wip/eeecbg.html</p>	<p>Grant to Reduce Energy Consumption and Greenhouse Gas of Municipal Buildings and Operations</p>	<p>Provides grants to cities and counties for projects that improve energy efficiency and reduce GHG emissions and total energy use.</p>
	<p>Greener, Greater Buildings Loan Fund Grant</p>	
<p>The Federal Emergency Management Agency (FEMA)</p> <p>www.fema.gov/government/grant/index.shtm</p> <p>www.fema.gov/government/grant/hma/index.shtm</p> <p>Accepting applications for fiscal 2012 starting in June 1, 2011.</p>	<p>Pre-Disaster Mitigation Grant Program (PDM)</p>	<p>Provides proactive funding for disaster mitigation planning and implementation that reduces the overall risks to populations and structures. See appendix for program requirements.</p>
	<p>Interoperable Emergency Communications Grant Program (IECGP)</p>	<p>Funds the improvement of communications systems used during natural disasters or acts of terrorism, and other man-made disasters</p>
	<p>Hazard Mitigation Grant Program (HMGP)</p>	<p>Provides grants to States and local governments after a major disaster has occurred to implement long-term hazard mitigation measures to reduce the loss of life and property due to natural disasters.</p>

	<p>Flood Mitigation Assistance (FMA)</p>	<p>Assists states in implementing initiatives that reduce or eliminate long-term risk to flooding. These include buildings, manufactured homes, and other buildings covered under the National Flood Insurance Program.</p>
	<p>Repetitive Flood Claims Program (RFC)</p>	<p>Provides funds to States and communities to reduce the flood damage to insured properties that have one or more claim to the National Flood Insurance Program.</p>
<p>U.S. Environmental Protection Agency Center for Environmental Finance www.epa.gov/efinpage/</p>	<p>Environmental Finance Center Network (EFCN)</p>	<p>University based organization that serves states aiding them in the creation of innovative solutions to the costs of environmental protection and improvement. They do this by sharing information, tools and techniques and by working with public and private sectors on finding solutions to pay for initiatives that promote environmental sustainability. Philadelphia is in region three, which is served by the University of Maryland. www.efc.umd.edu/</p>

	The Environmental Financing Information Network (EFIN)	Provides state and local environmental programs with information on financing alternatives. The EFIN provides information via website and its publications, links and contacts that are made available.
Centers for Disease Control and Prevention www.cdc.gov/climatechange/climate_ready.htm	Climate-Ready States and Cities Initiative	Funds the development of models to predict the health impacts of climate change, to monitor resulting health effects, and identify vulnerable areas. New York City is using this grant to understand heat impacts and flooding on public health. This program funded 8 state health departments and 2 city health departments. According to the CDC they award approximately \$7 Billion in over 14,000 grants and contract actions annually. This is just one example of those grant initiatives.
U.S. Department of Housing and Urban Development http://portal.hud.gov/hudportal/HUD?src=/program_offices/sustainable_housing_communities/sustainable_communities_regional_planning_grants	Sustainable Communities Regional Planning Grant Program	Provides funds for planning that integrates housing, land use, economic and workforce development, transportation, and infrastructure investments. These efforts must consider economic competitiveness and revitalization, social equity, inclusion and access to opportunity, energy use and climate change, and public health and environmental impact.

<p>DOT/HUD/EPA Partnership www.epa.gov/smartgrowth</p>	<p>Sustainable Communities Partnership</p>	<p>Program seeks to improve access to affordable housing, create more transportation options, reducing transportation costs while protecting the environment.</p>
<p>U.S. Economic Development Administration www.eda.gov/InvestmentsGrants/FFON.xml</p>	<p>Investments for Public Works and Economic Development Facilities</p>	<p>Provides funds that work towards the construction or rehabilitation of essential public infrastructure and facilities. The goal of the program is to support projects that create jobs, drive innovation, bolster competition in the global economy and help ensure resiliency.</p>
<p>U.S. Department of Agriculture-Natural Resources Conservation Service www.nrcs.usda.gov/programs/EWP/</p>	<p>Emergency Watershed Protection</p>	<p>The program is designed to help conserve natural resources by exposing the imminent hazards to both life and property that could be caused by floods, fires, windstorms and other natural events. The NRCS offers several other programs that reduce soil erosion, enhance water supplies and quality, and reduce the damages caused by floods and other natural events.</p>

<p>National Oceanic and Atmospheric Administration (NOAA)</p> <p>www.climate.noaa.gov/cpo_pa/</p>	<p>Four major programs for fiscal 2012</p> <ol style="list-style-type: none"> 1. Climate Observations and Monitoring (COM) 2. Earth System Science (ESS) 3. Modeling, Analysis, Predictions, and Projections (MAPP) 4. Climate and Societal Interactions (CSI) 	<p>NOAA funds priority climate science research that advances the knowledge of the Earth's climate system, which advances the knowledge about climate variability and the effect it has on the health, economy and well being across the United States.</p>
<p>U.S. Department of Housing and Urban Development</p> <p>http://portal.hud.gov/portal/page/portal/HUD</p>	<p>HOME Investment Partnerships Program</p> <p>www.hud.gov/offices/cpd/affordablehousing/programs/home/</p>	<p>The HOME Program allocates more than \$2 billion annually grants to States and localities in partnership with local non-profits. The funds are used to build, buy, and/or rehabilitate affordable housing for either rent or ownership or to provide rental assistance to low-income individuals and families. Thus helping vulnerable populations within the city.</p>
	<p>Rehabilitation Mortgage Insurance</p> <p>www.hud.gov/offices/hsg/sfh/203k/203k--df.cfm</p>	<p>Allows homebuyers and homeowners to finance both the purchase of the dwelling as well as the cost of the structures rehabilitation or modernization. Properties financed under this HUD program must meet basic energy efficiency and structural standards. Rehabilitating and modernizing existing dwellings within the community can aid in the resiliency building of the city.</p>

Department of Transportation www.fta.dot.gov/grants.html	Urbanized Area Formula Program	Provides funding for planning, engineering design and evaluation of transit related projects and studies. As funds can be used for capital investments in bus and bus related activities such as the replacement and overhaul of existing buses.
	Fixed Guideway Modernization	Provides capital investment assistance to modernize existing rails systems, new and replacement buses and facilities, and fixed guideway systems (light rail, trolley busses, air trams, cable car, HOV lanes etc.)
Available Federal Loan	Fund	Description
Federally Funded State Revolving Programs	Clean Water State Revolving Fund	Both of these programs provide low interest loans to municipalities and communities for water quality and public water infrastructure projects.
	Drinking Water State Revolving Fund	
Searchable Federal Grant Databases		
Catalogue of Federal Domestic Assistance www.CFDA.gov		
www.Grants.gov		
Federal Facilities Environmental Stewardship & Compliance Assistance Center www.fedcenter.gov/		
Available State Grant and Loan Programs	Description	
Infrastructure Development Program	Grant and loan program for both public and private infrastructure improvements. I.E. Transportation facilities, airports, water and sewer systems.	
Alternative and Clean Energy Program	Grant and loan program that focuses on clean energy, energy efficiency and energy conservation projects.	

Water Supply and Wastewater Infrastructure Program	The program seeks to secure a safe water supply and ensure that there is proper wastewater infrastructure in place.
Solar Energy Program	Grant and loan program open to municipalities to promote the use of alternative forms of energy.
Tax Increment Financing (TIF) Guarantee Program	Program seeks to provide credit enhancement for TIF projects that lead to the development, redevelopment and revitalization of Brownfield and Greenfield sites in accordance with the TIF Act. Uses include infrastructure, environmental projects, utilization of abandoned and under utilized industrial sites, etc.
Renewable Energy Program – Geothermal and Wind Projects	Grant available to municipalities to promote the use of alternative energy utilizing geothermal or wind technologies. This program covers planning and feasibility studies to the acquisition of land and buildings to the purchase, installation, and construction of energy facilities.
Searchable State of Pennsylvania Grant and Loan Database www.newpa.com/find-and-apply-for-funding/funding-and-program-finder	

Funding Adaptation - City Case Studies:

Chicago:

The city of Chicago engaged and developed partnerships with foundations, philanthropic groups, and private businesses such as consulting firms that provided pro-bono work. The most critical partnership was with a local non-profit, the Global Philanthropy Partnership (GPP). GPP facilitated access to the resources that were needed and ushered in access to climate and business leaders. They also provided grant support and kept the process organized. Beyond the economic benefit that GPP provided, they also supplied long-term strategic and technical expertise.

To fund planning research, Chicago engaged both local and national foundations, garnishing more than \$1.5 million in philanthropic support to cover the early-stage cost of the Chicago Climate Plan. For Chicago, building relationships with foundations was a crucial component of a successful climate adaptation plan.

Another important factor in Chicago's plan was the inclusion of both mitigation and adaptation strategies side by side. Many actions are part of both mitigation and adaptation strategies, and by exploiting this fact, Chicago's plan seized the opportunity to secure more funds for adaptation actions. This was possible because many federal, state, and foundation funds are designated to be spent on either mitigation or adaptation efforts, and by designing crosscutting strategies, Chicago was able to cast a wider funding net.

Boston:

Boston's funding strategy involved dividing the plan into pieces and integrating as much as possible into existing departments and processes. The City took the approach that costs and benefits for adaptation planning and implementation must be shared equitably, and will be asking city residents, businesses and institutions for financial support.

In splitting their adaptation projects into smaller goals and partnering with city and state organizations, they raised grant funding in specific areas by:

- Responding to sea-level rise, the City worked with Boston Conservation Commission, which protects wetlands and open space, and received a technical assistance grant;
- Partnering with the Massachusetts Office of Coastal Zone Management to establish various ways that government can require/provide guidance on changes in building design and wetland areas. This enabled the City to develop long-range plans in light of sea-level rise projections.
- Working with Harvard Law Schools' Environmental Law and Policy Clinic to examine how new ordinances and other legal instruments might enhance wetland protection;

- Receiving grants from the Barr Foundation and Boston Foundation to launch Renew Boston and the Climate Action Leadership Committee.

Boston focused on integration so that new funds would not be needed. These projects include: Boston Water & Sewer's twenty-five year capital plan that includes adaptation in the scope of work around stormwater and sea-level rise; and The Office of Emergency Preparedness updated emergency plans to include risk from flooding and heat in their regular process into the natural hazards mitigation plan that is updated every five years. Boston also received a Department of Energy grant for energy assurance planning and critical infrastructure and worked adaptation strategies into that grant even though the grant specified only mitigation.

Boston also secured free data. They used the 2007 Union of Concerned Scientists *Confronting Climate Change in the U.S. Northeast* as a free source for the science behind adaptation, levels of impact, and solution suggestions. Keene, NH used this same report and Philadelphia is one of the cities mentioned. Boston received additional data from a Tufts and Boston University 2004 report that provided the economic impacts of climate change and economic benefits of various solutions. Boston was included as an ICLEI USA inaugural city and therefore received free online adaptation tools, technical support, and other resources.

Oakland:

Oakland is an interesting case study because it had absolutely zero resources to work on an adaptation plan. The City has undergone extensive layoffs and added furlough days to all employees, thus all of their funding came from external agencies. Oakland received free data from the state. Oakland used data from the California Climate Action Team and worked with scenarios prepared by the California Energy Commission. Maps for their plan came from the San Francisco Bay Conservation Development Commission (BCDC) and the Pacific Institute.

Oakland has received local analysis from UC Berkeley and the Pacific Institute and hope to receive a study on further climate impacts from these groups. Both UC Berkeley and the Pacific Institute decided to do climate impact studies and the Office of Sustainability jumped at the chance to be featured. The Office continues to encourage these groups to do place-based studies, however now requires that the organizations build in and pay for City staff time. As they are under-staffed, they realized they could not spare hours on climate issues unless they were paid for this time.

Oakland is also participating in a regional project. The City is part of Adapting to Rising Tides (ART) led by BCDC and the National Oceanic and Atmospheric Administration (NOAA) with a supporting grant from the Federal Highway Department. This project was created to advance regional understanding of how sea-level rise and other climate change impacts will affect the Bay Area's ecosystems, infrastructure, and economy. The ART project also includes implementation strategies, which will benefit Oakland and the region. Oakland had to apply to be part of this project and engaged in some proactive lobbying in order to be included. Oakland is

also involved in another regional group, the Bay Area Sustainable Community Strategy, which works to reduce vehicle travel in the area.

Oakland involved many stakeholders in the pre-planning stage of adaptation, which opened up the doors for possible funding. Members involved in drafting the plan include NGOs, institutions, and private businesses: Oakland Climate Action Coalition, AC Transit, StopWaste.org, QUEST, Energy Solutions, Beyond Compliance, Pacific Institute, other cities and counties (Berkeley, Hayward, Alameda County), and ICLEI.

Oakland plans to use existing staff time to plan for many of the projects. Current City staff may receive refocused roles including integrating adaptation. The City of Oakland is also pushing its own departments to find funding. For instance, the City pushed the Port of Oakland to find its own funding for GHG response.

The City also implemented a transportation impact fee (TIF) to support low-carbon transport infrastructure and planning. These TIFS are single payments required by developers or builders at the time of approval and calculated as a proportionate share of the capital project or operational cost of providing service to that development. For a list of Oakland's list of potential funding opportunities, please see the Appendix 1.2.

San Francisco

SF Environment staff developed the San Francisco plan and ICLEI staff, SF Public Utilities staff, Brown, Vence & Associates consultants, and several experts reviewed it at no charge. The City also created a Business Council on climate change, which includes more than 200 private companies in San Francisco focused on climate change.

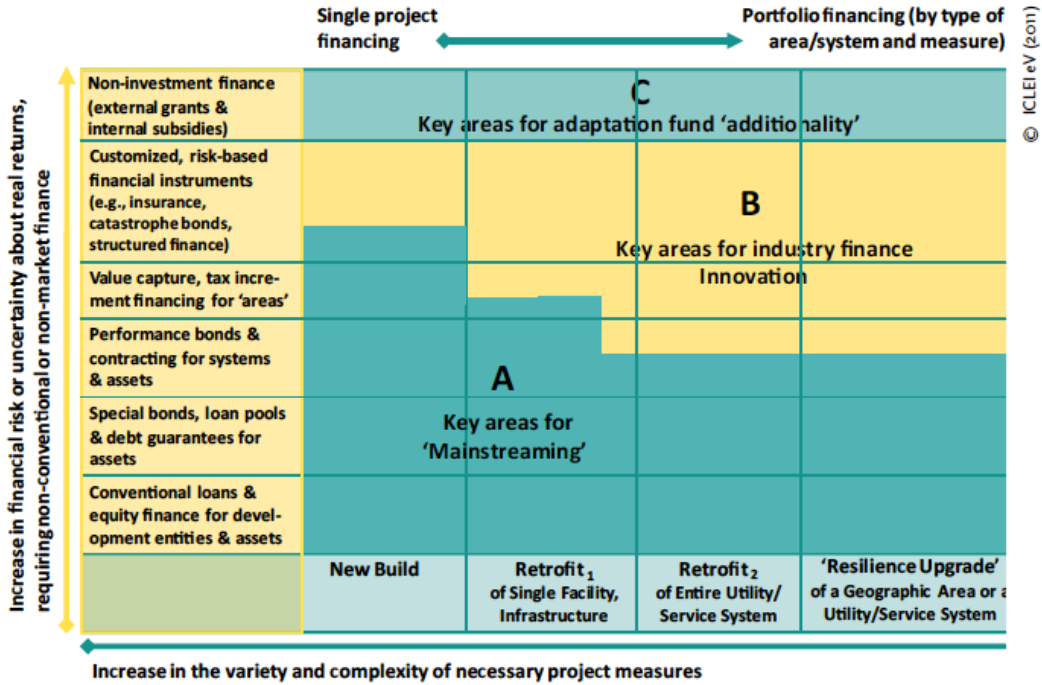
Like Oakland, San Francisco is also a member of the ART project and focused around regional strategies. Similar to Boston, San Francisco split up goals into smaller projects receiving grants in certain areas:

- A \$140,000 grant from NOAA's coastal services center
- \$175,000 from the federal Coastal Impact Assistance Program for sediment planning
- \$585,000 USGS funding for long-term sediment management strategy
- \$600,000 from the EPA estuary partnership grant to understand flood control benefits of wetlands and the vulnerability of wetlands to sea-level rise
- Working with the EPA on a pilot project to assess key vulnerabilities to climate change in the SF estuary system,

San Francisco used data from the State National Academy of Science report commissioned by Governor Schwarzenegger and the BCDC was able to hire experts from the Netherlands to work on adaptation planning for the city funded by the Dutch Government.

Financing - Appendix

Innovative Financing for Resilience Upgrading⁸⁸



⁸⁸ http://www.environmental-finance.com/download.php?files/pdf/4e1c155b960f6/Report-Financing_Resilient_City-Final.pdf

Example – King County Proactive Funding

**King County’s Brightwater Project:
A Best Practice of Example for Proactive Action**

To supply the increased demand for water in King County in spite of projected decreases in water supply as a result of climate change impacts, the county added water reclamation and distribution technology to the Brightwater infrastructure plans. Scheduled for completion in 2010, the advanced membrane bioreactor technology to be installed at Brightwater will treat water to Class A standard. The project adds \$28 million to the \$1.8 billion price tag of the facility, less than 2 percent of total costs.

Also, by installing the reclaimed water distribution infrastructure, or “backbone,” now during the construction of the Brightwater Tunnel, the county will avoid the need to dig an entirely new trench to install this infrastructure at a later date. County officials view this \$28 million project as “climate insurance” – an investment in the future needs of county residents that makes both economic and environmental sense.

FEMA Pre-Disaster Mitigation Program Ranking Factors

**Hazard Mitigation Assistance
Pre-Disaster Mitigation Program
FY2012 National Ranking Factors**

FY2012 National Ranking Factors
The priority assigned to the subapplication by the Applicant in their PDM grant application
Whether the Applicant has a FEMA approved enhanced State/Tribal hazard mitigation plan by the application deadline
Community mitigation factors such as Community Rating System class, cooperating technical partner, participation as a Firewise community, and adoption and enforcement of codes including the International Code Series and National Fire Protection Association 5000 code
Assessment of frequency and severity of hazards.
The percent of the population benefitting from the mitigation project, which equals the number of individuals directly benefitting divided by the community population
Whether the project protects critical facilities
Status of the subapplicant as a small, impoverished community

Example - Oakland's Identified Potential Funding Opportunities

Potential Funding Opportunities

Through a variety of partnerships, Oakland has been successful in receiving resources to support new energy and climate programs. These programs include support for residential energy retrofits and expanded weatherization services, downtown commercial energy retrofits, and the launch of a new downtown free shuttle.

Opportunities to seek funds are available. Assuming that capacity to seek funds exists, Oakland will continue to be competitive. Examples of funding sources the City should continue to explore include:

- State and Federal energy grants
- Air District & CA Air Resources Board grants
- Foundation support
- Emerald Cities Collaborative support
- Federal appropriations
- HUD Sustainable Communities planning grants
- EPA Climate Showcase Communities grants
- State and Federal transportation funds
- MTC directed regional transportation dollars
- Additional ARRA funding opportunities
- Regional gas tax/green investment fee
- Surcharges on GHG intensive energy use
- Parking rates
- Landfill disposal fees
- Federal tax credits
- EPA Clean Water Revolving Loan Fund
- Reformulated Gasoline Settlement Fund
- Development impact fees
- Permit fees
- Tax increment financing

Example - Chicago's Funding Sources

Figure 4.
Products of the Chicago Climate Action Planning Process and Potential Use to Other Cities

Product	Cost	Source	Potential Use to Other Cities
Chicago Area Impacts of Climate Change (Professors Don Wuebbles and Katharine Hayhoe)	\$225,000	Lloyd A. Fry Foundation, Joyce Foundation, and Grand Victoria Foundation	Results apply to cities throughout the Chicago Metropolitan Area
Economic Costs of Action and Inaction for City Government (Oliver Wyman)	\$800,000 pro bono	Oliver Wyman	Methodology applicable to other cities (only summary available)
Chicago and Chicago Metro Area Baseline Emissions and Emissions Growth Projections (Center for Neighborhood Technology)	\$150,000	Lloyd A. Fry Foundation, Joyce Foundation, and Grand Victoria Foundation	Methodology applicable to other cities
Chicago's Best Opportunities to Reduce Emissions (Center for Neighborhood Technology and Delta Institute)	\$125,000	Lloyd A. Fry Foundation, Joyce Foundation, and Grand Victoria Foundation	Methodology applicable to other cities
Preparing for Climate Change in Chicago (MWH)	\$50,000; \$40,000 pro bono	City of Chicago Department of Environment	Adaptation process applicable to other cities; results apply to cities throughout Chicago Metropolitan Area
Energy Efficiency Retrofits Implementation Strategy (Center for Neighborhood Technology, Delta Institute)	\$207,000, plus Katzenbach pro bono	Lloyd A. Fry Foundation, Nathan Cummings Foundation, and Katzenbach	Methodology and strategy applicable to other cities (in process)
Green Jobs Implementation Strategy (Center for Urban Economic Development at University of Illinois in Chicago, Center on Wisconsin Strategy, Green for All, and Chicago Jobs Council)	\$175,000	Lloyd A. Fry Foundation and Nathan Cummings Foundation, and Chicago Department of the Environment, Mayor's Office of Work-force Development, and Department of Planning and Development	Methodology and strategy applicable to other cities (in process)

Figure 4.

Products of the Chicago Climate Action Planning Process and Potential Use to Other Cities (cont.)

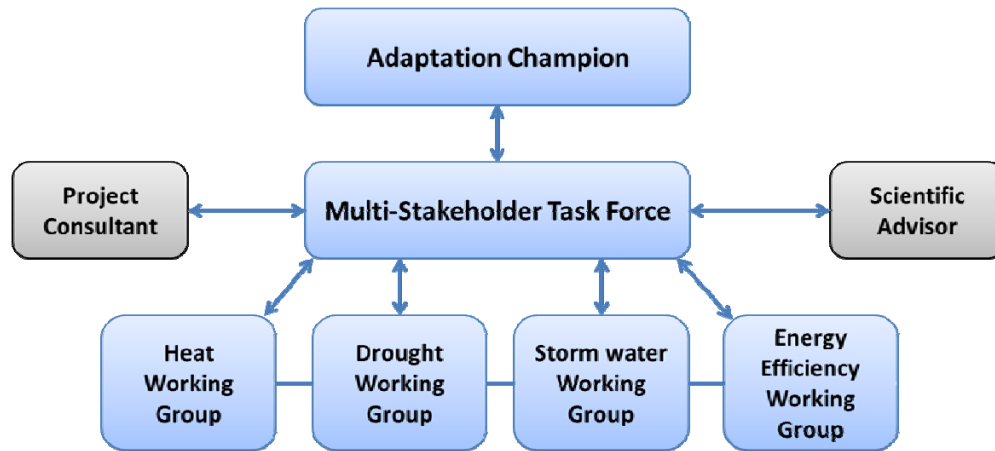
Product	Cost	Source	Potential Use to Other Cities
Renewable Energy Implementation Strategy (Environmental Law and Policy Center of the Midwest, Chicago Manufacturing Center, and Chicago Manufacturing Renaissance Council)	\$275,000	Northern Illinois Energy Project (NIEP)	Methodology and strategy applicable to other cities (in process)
Communications Planning and Implementation (Edelman, Jasculca Terman, MK Communications, and DOE)	\$400,000	The Legacy Fund, Chicago Community Trust, Illinois Department of Commerce and Economic Opportunity, and Chicago Department of Environment	Strategy applicable to other cities (in process, available upon request)
Staff Support for the Green Ribbon Committee and Annual Public Meeting (Salcon Consulting)	\$67,000	The Legacy Fund	Strategy applicable to other cities (in process)
Chicago Carbon Offsets Fund (Delta Institute)	\$200,000	The Legacy Fund	Approach applicable to other cities (in process)
Global Philanthropy Partnership Advisor First Six Months, Including Facilitating Chicago Climate Task Force (Julia Parzen)	\$75,000	Clinton Climate Initiative, the Chicago Department of Environment	Partnership with a non-profit civic leader applicable to other cities

Getting the right people involved and setting the right organizational processes are imperative steps to creating a successful climate action plan. This process includes collaboration within City departments and engagement of outside organizations. The right mix will vary depending on the City's climate risks, i.e. if flooding and sea-level rise are not concerns it would not make sense to include experts in these fields. Adaptation is a new field and many organizational systems have only been in place for a short term. As such, Philadelphia must decide for itself on the structure that best meets its needs based on intimate knowledge of the workings of each department and capability with regards to collaboration. However, many themes can be found in overall organization and the below best practices are provided based on numerous cities' successful implementation.

It is important to engage internal stakeholders (City departments, employees, individuals involved in climate planning and operations) and external stakeholders (the public, media, organizations, churches, nonprofits, and businesses) differently in order to form targeted communication and engagement plans. Stakeholder engagement is a dialogue and the process consists of identifying stakeholders, apprehending their views and concerns, answering these concerns, including their feedback in decisions and planning, and continuing the engagement. This process is ongoing: groups change, new stakeholders appear, and stakeholders' views, concerns, and needs evolve. It is a demanding practice, in terms of time and financial investment, however is key to facilitating clear communication and fostering acceptance and support of decisions.⁸⁹

⁸⁹ Gardner, J, Dowd, A-M., Mason, C. and Ashwoth, P. (2009). A framework for stakeholder engagement on climate adaptation. CSIRO Climate Adaptation Flagship Working Paper N0. #. Retrieved October 21, 2011 from www.csiro.au/resources/CAF-working-papers.html.

People and Processes:



Strong leadership at the top

Climate change ‘champions’ are needed to advance adaptation, break down barriers, engage multiple stakeholders, and ease top-down communication. Mayoral support establishes the plan as a top priority and demonstrates to the public that this plan is worth pushing forward.

- Successful examples of key leadership include King County’s Mayor Ron Sims, Chief of Staff Kurt Triplett, and Director of National Resources and Parks Pam Bissonette; Mayor Bloomberg and the City Council in New York City; and in Chicago Mayor Daley and Commissioner of DOE Sadhu Johnston.

Multi-stakeholder task force

Executive support should be reinforced with multidisciplinary teams to foster dialogue between all agencies, encourage collaboration and dissemination of knowledge, and set feasible goals and adequate performance indicators. The makeup of this task force may vary depending again on climate risks and existing structure. Jen Pagach with the CT DEP agrees that multidisciplinary teams help keep communication open: “One of the big problems is that everyone is in their silo. When things don’t make sense it might be that a wall is up and people are not getting information.”⁹⁰

⁹⁰ NASA/GISS Conference 11.17.11

- If departments are unenthusiastic, education can increase participation. San Diego organized internal training to encourage sustainable behavior and increase the number of sustainability champions interested in being involved.⁹¹
- Let the agencies involved choose their processes, goals, and plans, and ensure that they work closely with researchers.
- Elect or appoint a task force chair or co-chairs to be responsible for keeping the committee on track and organized. A clear and solid internal setup and frequent meetings will increase communication and reduce confusion.
- Responsibilities, performance indicators and timeframes must be clearly set to facilitate communication and implementation. In Keene and Oakland a Sustainability Coordinator's role is to track and implement climate and sustainability efforts, set up working groups, and coordinate with appropriate departments.

Examples of task forces:

- After creating the Mayor's Office of Long-Term Planning and Sustainability, New York also created a Climate Adaptation Task Force (CCATF), which includes members from several municipal agencies as well as many private sector, academic, legal, engineering, and insurance industry representatives;
- Phoenix's task force led by the Planning Department is responsible for recommending downtown redesign policies to account for climate change heat impacts;
- San Francisco's Taskforce includes City departments and NGOs;
- Miami Dade's Climate Change Advisory Task Force included 250 stakeholders representing academia, NGOs, and the public and private sector;
- Boston's Leadership Committee included 22 members from science, businesses, and neighborhood organizations, including two co-chairs from Ceres and the Office of Environment and Energy.

Working Groups

Once a taskforce is established, working groups for each issue area can be appointed to increase the level of focus needed to address each concern. It is imperative to set up regular working group meetings as inconsistency in the schedule can lead to poor attendance and timeline headaches.

- Chicago City agencies identified five primary focus areas and divided each area among City departments based on the functional role in City operations. These working groups

⁹¹ Environmental Services Department City of San Diego. (2005, July). City of San Diego Climate Protection Action Plan. Retrieved October 21, 2011 from <http://www.sandiego.gov/environmental-services/sustainable/pdf/100401ActionPlan.pdf>

set 39 specific tactical adaptation implementation plans. The Office of Emergency Management leads the extreme heat working group, while the Departments of Transportation, Buildings, and Aviation co-lead the buildings, infrastructure, and equipment group. The Department of Environment assigned one staff person to be in charge of tracking each strategy in the plan.

- Boston’s adaptation working group consisted of eight city departments: Environment, Redevelopment, Parks, Transportation, Water & Sewer, Public Works, Emergency Management, and Public Health.
- Keene’s working groups develop goals (broad expectations) and targets (specific statements that provide a standard of measurement to evaluate progress) for each priority opportunity.

External stakeholders provide key input to the adaptation process and must be identified early on. Businesses often respond better to advice and support from other businesses than from City staff. City officials should engage these individuals using public meetings, surveys, presentations, and one and one meetings.⁹² Starting late can be risky. Santa Monica only worked with community organizations, elected officials, and City staff to build its climate change plan, and was ultimately forced to redo a 15-month stakeholder engagement process, adding in schools, businesses, and organizations.⁹³

Consultancy Assistance

A project consultant with outside experience in project management and climate adaptation has led many of the successful climate plans. Many cities secured pro-bono services.

- San Francisco, the Boston Group
- Boston, Raab Associates and Interaction Institute for Social Change
- Chicago, Oliver Wyman and Global Philanthropic Partnership
- New York City, Boston Consulting Group

Scientific Advisory Panel

- Having ongoing technical expertise and scientific advice is a useful way to keep up to date on climate issues, impacts, and changes.

⁹² Gardner, J, Dowd, A-M., Mason, C. and Ashworth, P. (2009). A framework for stakeholder engagement on climate adaptation. CSIRO Climate Adaptation Flagship Working paper No.3. <http://www.csiro.au/resources/CAF-working-papers.html>.

⁹³ City of Santa Monica. (2006, October 24). Sustainable City Plan City of Santa Monica. Retrieved October 21, 2011 from <http://www.chicagoclimataction.org/>.

- Scientific advice adds weight to the plan. As climate adaptation is dynamic, it is important to have an unbiased scientific group supporting plans and implementation.
- This panel may also assist in securing data. Using existing data and applying it to regional levels can be done if funding for local data has not yet been secured.
- Cities including San Francisco, Boston, Keene, Chicago, and New York City took advantage of a scientific advisory panel. These experts came from university staff, state planning departments or department of energy staff, non-profit science or climate groups, and for-profit scientific groups.

The best practices above can also be supplemented with one-off innovative City decisions.

- Boston created a Community Advisory Committee to encourage residents to get involved. This committee was appointed by the Leadership Committee, included 39 members representing each neighborhood in the city, and was supported by the facilitators involved.
- Boston also made all of their meetings open to the public and made all presentation materials available on their climate action website.
- New York City limited its engagement to an advisory board during the building of PlaNYC. They did, however, focus on broad public outreach once the plan was published. The OLTPS remained available to meet with constituents, and stayed flexible in adding recommendations.⁹⁴

⁹⁴ ICLEI - Local Governments For Sustainability USA and the City of New York. (2010, April). The Process Behind PlaNYC. Retrieved October 27, 2011 from http://nytelecom.vollnwd.net/015/agencies/planyc2030/pdf/iclei_planyc_case_study_201004.pdf

Obtaining data, funding, and understanding risk are all critical components in the adaptation planning process. Equally important is the ability to talk to people about climate change effectively and persuade them that taking action is important. Effective communications strategies apply both to those working within city government, as well as to the general public. The adaptation planning process involves multiple stakeholders, all with different expertise, backgrounds, and expectations. Proper communication is vital as financial decisions based on uncertain climate futures can lead to public confusion or outrage. Successful communication strategies garner both public support for adaptation and prompt action from stakeholders and community leaders. Before building adaptation communication materials and strategies, local governments should familiarize themselves with constituents' perspectives and concerns on climate change issues and the different mental models used to apprehend these topics.

I. People & Climate Change

More than 90 percent of Americans have heard of climate change, but only one third is worried or concerned about it.⁹⁵ Climate change is considered a moderate risk:⁹⁶ in recent surveys, only 18 percent of Americans thought that it could threaten their community.⁹⁷ Other global issues including healthcare and economic health outweigh climate change.⁹⁸ The *Six Americas* report finds that the way people assess climate change issues may vary according to their values and beliefs⁹⁹. This thorough analysis conducted annually divides Americans in six groups based on their belief and concerns on climate change: the Alarmed, Concerned, Cautious, Disengaged, Doubtful, and Dismissive¹⁰⁰ as depicted in Figure 1.

⁹⁵ Moser, S.C and Dilling, L. (2007). *Creating a Climate for Change: Communicating Climate Change and Facilitating Social Change*. New York: Cambridge University Press. P45

⁹⁶ Moser, S.C and Dilling, L. (2007).

⁹⁷ Center for Research on Environmental Decisions - CRED. (2009). *The Psychology of Climate Change Communication*. Cred Columbia, New York: USA.

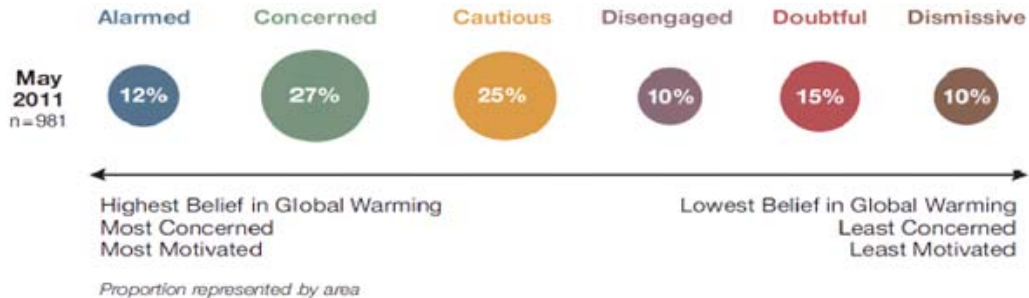
⁹⁸ Center for Research on Environmental Decisions - CRED. (2009).

⁹⁹ Yale Project on Climate Change & the George Mason University Center for Climate Change Communication. (2009, May 20). Global Warming's Six Americas. Retrieved November 1, 2011 from <http://www.americanprogress.org/issues/2009/05/pdf/6americas.pdf>

¹⁰⁰ Yale Project on Climate Change & the George Mason University Center for Climate Change Communication. (2009, May 20).

Figure 1: Proportion of the U.S. adult population in the Six Americas, May 2011

Proportion represented by areas¹⁰¹



Yet, at a local level, all individual efforts count, and all constituents' support will be needed for both planning and implementing adaptation strategies, regardless of age, gender or social background. As not all segments of population are equally worried about climate change, public officials cannot communicate one single message and one single goal on climate change adaptation and expect everyone to respond. Reaching all segments of the population requires time and substantial financial means: with numerous outreach campaigns, Santa Monica increased its climate change awareness from less than 4 percent in 1998 to 40 percent in 2008.¹⁰²

One stakeholder group that concerns cities is composed by the dismissive and doubtful, or climate change contrarians, which make up 25 percent of the U.S. population.¹⁰³ These skeptics do not believe in climate change and claim that scientific evidence or data used to assess global warming is not strong enough. They value the economy more than the environment and believe policies used to fight climate change could be detrimental.¹⁰⁴

To overcome dissent between supporters and opponents of climate change, public officials should:

- Shift the debate from a *conflict over science* to a *conflict over very different values*.¹⁰⁵ Dismissive and doubtful can adopt adaptation behavior if it makes sense to them economically, whether or not they agree on climate change.
- Keep up with the latest and best scientific evidence available,¹⁰⁶

¹⁰¹ Yale Project on Climate Change & the George Mason University Center for Climate Change Communication. (2011, May 12). Global Warming's Six Americas in May 2011. Retrieved November 1, 2011 from <http://environment.yale.edu/climate/files/SixAmericasMay2011.pdf>

¹⁰² Moser, S.C and Dilling, L. (2007).

¹⁰³ Yale Project on Climate Change & the George Mason University Center for Climate Change Communication. (2011, May 12).

¹⁰⁴ Yale Project on Climate Change & the George Mason University Center for Climate Change Communication. (2011, May 12).

¹⁰⁵ Moser, S.C and Dilling, L. (2007).

- Increase targeted communication as 74% of the population feels that they need more information on climate change.¹⁰⁷

II. Messaging Climate Change Adaptation

Misconceptions and Biases on Climate Change

Communicating about climate change differs from advocating other global issues, such as public health or economic wellbeing. For example, air is a public good and while it belongs to everyone and stays free for everyone, no one feels responsible for its quality. Greenhouse gases and pollution are not visible, and climate change cannot yet be observed in most parts of the United States. Public officials and scientists must remember how difficult it is to understand the cause, effects, and risks associated with climate change and respond to the reluctance and difficulties in understanding. The process of building effective messages to raise awareness and change behaviors starts with choosing adequate language, and then defining priorities, goals and strategies that matter to local populations. Table 1 defines misconceptions and biases that may prevent populations from grasping the challenges of sustainability, resilience, and adaptation.

Table 1: Biases and Errors¹⁰⁸.

“Confirmation Bias”	“Most people look for evidence that confirms existing beliefs and tend to reject contradictory information.”
“Misplaced Confidence”	“It is easy to assume the future will be similar to the past, making it difficult to identify mistakes and alter behavior when conditions change.”
“Wishful Thinking”	“We tend to believe favorable outcomes are more likely to happen than undesirable ones.”
“Belief Polarization”	“Many choose to associate only with people who share their views.”

To combat these biases, increase awareness and build support, four tactics should be used:

1. Clarify misconceptions and uncertainty
2. Make climate change real
3. Propose solutions

¹⁰⁶ Moser, S.C and Dilling, L. (2007).

¹⁰⁷ Yale Project on Climate Change & the George Mason University Center for Climate Change Communication. (2011, May 12).

¹⁰⁸ Pike, C. Dopplet, B. Herr, M. (2010). *Climate Communications and Behavior Change: A Guide for Practitioners*. The Climate Leadership Initiative.

4. Use adequate communication channels and target adequate audiences

Clarify Misconception and Uncertainties

- **Differentiate between weather and climate.** All people look to short-term weather to describe climate change and using pictures of extreme weather to illustrate climate change may reinforce this misunderstanding. The goal is to create messaging that conveys that adaptation addresses long-term climate impacts.
- **Simplify data** using meaningful imagery and easy-to-grasp scientific graphs in climate change reports and communications materials. Boston uses a table to track the carbon dioxide levels and graphs the number of hot days, helping people understand their role.¹⁰⁹ New York brings together scientific data and images of local flooding.
- **Communicate uncertainty.** This will ensure transparency and build trust. San Francisco's Bay Conservation and Development Commission communicates that sea level will indeed rise, although it will be between 20-55 inches.

Make Climate Change Real to Promote Adaptation Strategies

- **Translate climate change into meaningful local effects for residents.** If possible, describe climate change in terms of existing local impacts.^{110 111} London describes flooding and warns that temperature increase “could make future tube travel difficult forcing a major retrofit of the London Underground”.¹¹² King County mentions that changes in snow pack, stream flows, water supplies and sea level will affect agriculture, stormwater, wastewater, wildfire risk, forest health, infrastructure, hydropower production, health, salmon and biodiversity.¹¹³
- **Translate risks in terms of public health.** Boston focuses on health consequences and Los Angeles mentions climate change will cause “poor air quality, heat-related deaths, and more strain on those with respiratory and cardiovascular diseases”.¹¹⁴ New York

¹⁰⁹ City of Boston. (2011, April). A Climate of Progress. Retrieved November 1, 2011 from http://www.cityofboston.gov/Images/Documents/A%20Climate%20of%20Progress%20-%20CAP%20Update%202011_tcm3-25020.pdf

¹¹⁰ Gardner, J, Dowd, A-M., Mason, C. and Ashworth, P. (2009).

¹¹¹ CRED. (2009).

¹¹² London Sustainability Development Commission. (2007, October 12). A Greater London: Making it Happen. Greater London Authority, London: UK. Retrieved October 20, 2011 from:

http://www.londonsdc.org/documents/making_it_happen_scn_12Oct07.pdf

¹¹³ King County Interdepartmental Climate Team. (2009). 2009 Climate Report. Retrieved October 20, 2011 from http://your.kingcounty.gov/dnrp/climate/documents/2009_King_County_Climate_Report.pdf

¹¹⁴ The City of Los Angeles Mayor Antonio R. Villaraigosa. (2007, May). Green LA an Action Plan to Lead the Nation in Fighting Global Warming. Retrieved October 1, 2011 from <http://www.ladwp.com/ladwp/cms/ladwp010314.pdf>

describes the cause (urban infrastructure/heat island) and then translates climate change in terms of public health risks to foster action.¹¹⁵

List Achievable Solutions

- **Provide feasible strategies and clear goals.** Both Chicago and London provide clear targets and insist on their feasibility and cost-effectiveness. London's SMART acronym describes "specific, measurable, achievable, realistic and time bound."¹¹⁶ Boston tells citizens to plant a tree to do their part in adaptation.
- **Continue communication on mitigation** as it may put light on near term financial benefits and improved quality of life. Keen County and California Natural Resources Agency communicate on both mitigation and adaptation.^{117 118}
- **Stay away from alarmist messages** that can lead to inaction and emotional numbing.¹¹⁹
- **Focus on cautious and optimistic discourse** emphasizing that local resident action does matter. London first lists everything that is going well, before mentioning what remains to be done.¹²⁰ Chicago Climate Action Plan describes climate change as both a challenge and an opportunity.¹²¹ PlaNYC praises New Yorkers for having one of the "lowest per capital greenhouse gas (GHG) emissions levels" and highlights the success of recent initiatives in reducing emissions.¹²²
- **Delay communicating on climate adaptation after an extreme weather event.** It will let residents and agencies focus on immediate emergency measures before thinking of long-term planning. This provides more time to process and people may see the benefits of adaptation for themselves after destruction.¹²³

¹¹⁵ The City of New York Mayor M. Bloomberg. (2011, April). PlaNYC A Greener Greater New York. Retrieved October 1, 2011 from

http://nytelecom.vo.llnwd.net/o15/agencies/planyc2030/pdf/planyc_2011_planyc_full_report.pdf

¹¹⁶ Greater London Authority. (2011, October). Managing Risks & Increasing Resilience, The Mayor's Climate Change Adaptation Strategy. Retrieved October 27, 2011 from: <http://www.london.gov.uk/sites/default/files/Adaptation-consultation-report.pdf>.

¹¹⁷ City of Keene. (2007, November). Keen New Hampshire, Adapting to Climate Change: Planning a Resilient Community. Retrieved November 1, 2011 from

http://www.ci.keene.nh.us/sites/default/files/Keene%20Report_ICLEI_FINAL_v2_0.pdf

¹¹⁸ California Natural Resources Agency. (2009). 2009 Climate Adaptation Strategy. Retrieved November 15, 2011 from <http://www.energy.ca.gov/2009publications/CNRA-1000-2009-027/CNRA-1000-2009-027-F.PDF>.

¹¹⁹ CRED. (2009).

¹²⁰ London Sustainability Development Commission. (2007, October 12).

¹²¹ City of Chicago. (n.d.) Chicago Climate Action. Retrieved October 21, 2011 from <http://www.chicagoclimataction.org/>.

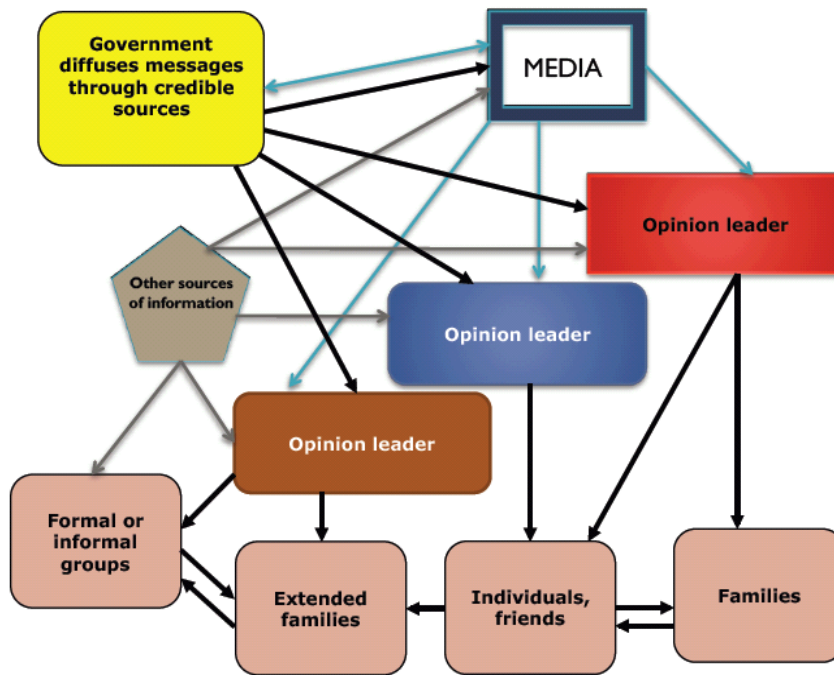
¹²² The City of New York Office of Mayor M. Bloomberg. (2011).

¹²³ Whitmarsh, L., O'Neill, S., Lorenzoni, I. (2011). *Engaging the Public with Climate Change. Behaviour Change and Communication*. Earthscan: London, UK. P24.

Use Adequate Communication Channels and Target Audiences

- **Identify and engage key stakeholders** (organizations, churches, communities, schools, universities, businesses, etc.) and let *them* reach out to their members. This cost-effective strategy worked in New York City, Miami-Dade, and London.

Figure 2: Using Credible Sources to Transmit Messages¹²⁴



- **Test outreach materials and messages.** Portland Oregon identified key storytellers and tested materials in focus groups.¹²⁵
- **Rely on communication systems** used by local stakeholders.¹²⁶ Oakland already uses a Disaster Awareness campaign with neighborhood captains and is using this avenue to pull in adaptation. New York City launched emergency communications via email, text messages and recorded phone call in 2009 and have already sent more than 1,000 messages.¹²⁷

¹²⁴ Nicholls, S., Cork, S. (2010, June 29-July 1). Communication and the Resilient Community. Presentation at Australia 21. Retrieved November 1, 2011 from <http://www.nccarf.edu.au/conference2010/wp-content/uploads/Susan-Nicholls.pdf>

¹²⁵ Institute for Natural Resources Oregon State University. (2007,). Climate Change Outreach Project. Final report. Retrieved November 1, 2011 from <http://library.state.or.us/repository/2009/200902101159522/index.pdf>

¹²⁶ Sala, S. (n.d.). Information and Communication Technologies for climate change adaptation, with a focus on the agricultural sector. Retrieved November 1, 2011 from <http://www.egfar.org/egfar/website/new/newspage?contentId=2686>

¹²⁷ SWN Communication (2011, April). NYC Office of Emergency Management Announces that Notify NYC Sends 1,000 messages. Retrieved November 18, 2011 from <http://www.sendwordnow.com/Company/BlogPost/NYC-Office-of-Emergency-Management-Announces-That-Notify-NYC-Sends-1-000th-Message>

- **Ensure that information is publicly available** to demonstrate that all decisions are informed. Boston lists all adaptation information on their website and all Adaptation Working Group meetings are open to the public. The ART project in the San Francisco area developed a website to involve the public in its process of adapting to the sea-level rise.¹²⁸

Encourage Collective Action

- **Encourage networking¹²⁹ and communal initiatives.** Adaptation cannot be only tackled individually. The ability of societies to adapt is determined in part by the ability to act collectively.¹³⁰
- **Collective action is key to becoming a Climate Resilient Community™** and implementing the five key milestones defined by ICLEI: “Initiate a Climate Resiliency Effort, Conduct a Climate Resiliency Study, Develop a Climate Resilient Action Plan, Implement a Climate Resilient Action Plan, Monitor, Motivate, and Re-evaluate.”¹³¹
- **Best Practices:** Public incentives and information led to a collective success in water conservation on Los Angeles: while the population has increased 35 percent since 1970, water use only expanded 7 percent.¹³² The Low Carbon Diet implemented in Portland Oregon also succeeded because of its community-focused aspect and because early adopters spread the word.¹³³

III. It All Comes Down To Wording

Local residents and City employees must understand adaptation. Working with local experts can help alleviate distrust, as people often feel disconnected and reject theories coming from distant scientific organizations or international experts.¹³⁴ Once solid data support the adaptation plan, it all comes down to wording, and these best practices work to help cities get adaptation language

¹²⁸ Bay Conservation and Development Commission. (2010, December 17). Adapting to Rising Tide in San Francisco Bay California. Retrieved November 1, 2011 from <http://www.cakex.org/case-studies/2737>

¹²⁹ Sala, S. (n.d.).

¹³⁰ Ager, W. N. (2003). Social Capital, Collective action & Adaptation to Climate change. *Economic Geography*. 79(4): 387-404,2003.

¹³¹ City of Keen. (2007, November). Keen New Hampshire, Adapting to Climate Change: Planning a Resilient Community. Retrieved November 1, 2011 from http://www.ci.keene.nh.us/sites/default/files/Keene%20Report_ICLEI_FINAL_v2_0.pdf

¹³² IPCC. (2007). Climate Change 2007: Working Groups II: Impacts, Adaptation and Vulnerability. Retrieved November 1, 2011 from http://www.ipcc.ch/publications_and_data/ar4/wg2/en/ch14s14-4-6.html#box-14-3

¹³³ Moser, S.C and Dilling, L. (2007).

¹³⁴ CRED. (2009).

right. City officials should focus on the three “Rs” of a successful communication on climate change adaptation: Robust, Redundant and Rapid information.¹³⁵

Robust information

- **Develop the right collaboration with local scientists to limit scientific jargon** and ensure that communication materials only have understandable scientific language and carefully framed uncertainty.
- **Remind people of the rationale for action.** King County and Toronto use the strong IPCC statement: “Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global mean sea level”, before focusing on local effects.¹³⁶
- **Communicate uncertainty carefully.**¹³⁷ Boston acknowledges that trends are uncertain, but re-emphasizes the idea that uncertainty is only on the speed of climate change, not on the reality of the issue.¹³⁸ King County justifies uncertainty by reinforcing that in areas of less certainty, planning will include early and low-cost provisions.¹³⁹ City official should avoid using likely or very likely and rather phrase uncertainty in terms of risks.

Redundant information (same idea, presented under different angles or emphases)

- **Adapt vocabulary, language and tone to appeal to audiences using either a promotion or prevention focus.**¹⁴⁰ King County insisted on *preventing* the worst consequences of climate change in 2007, and switched to *promoting* efficiency, sustainable practices and new green jobs and services in 2009.¹⁴¹
- **Link actions and benefits at the individual level** to foster motivation and behavioral change. Identify benefits that matter to local constituents, and adapt language, goals, and future benefits to meet these interests. Chicago, San Diego, and King County chose cost effective initiatives and job creation, while Santa Monica focused on meeting environmental, economic and social needs without compromising future generations.¹⁴²
- **Include the price of *doing nothing* to help understand adaptation costs:** San Francisco Bay evaluates the cost of protecting against a 55-inch sea-level rise at \$14

¹³⁵ Nicholls, S., Cork, S. (2010, June 29-July 1). Communication and the Resilient Community. Presentation at Australia 21. Retrieved November 1, 2011 from <http://www.nccarf.edu.au/conference2010/wp-content/uploads/Susan-Nicholls.pdf>

¹³⁶ King County. (2011, June). Toward a Sustainable Prosperous King County. P 5. Retrieved October 21, 2011 from <http://your.kingcounty.gov/dnr/library/dnr-directors-office/climate/2010-annual-green-report.pdf>

¹³⁷ Gardner, J, Dowd, A-M., Mason, C. and Ashwoth, P. (2009).

¹³⁸ City of Boston. (2011)

¹³⁹ King County. (2007, February).

¹⁴⁰ CRED. (2009)

¹⁴¹ King County. (2007). King County. (2009)

¹⁴² City of Santa Monica. (2006, October 24). Sustainable City Plan City of Santa Monica. Retrieved October 21, 2011 from <http://www.chicagoclimataction.org/>.

billion, and the cost of doing nothing at \$36 to \$62 billion. Keen County assesses the cost of poor air quality at \$1 billion per year and the cost of the 2005 flooding at \$16 million.^{143 144}

- **Frame adaptation opportunities** in terms of resilience, financial benefits of prevention, preparedness/readiness, health and wellbeing or better future based on what matters to local stakeholders.¹⁴⁵
- **Frame adaptation challenges** in terms of urgency, collective actions and pre-determined milestones according to local populations.¹⁴⁶ For example, in the San Francisco Bay, the project Adapting to the Rising Tide involving multiple local and national stakeholders first aims at assessing impact of sea-level rise on communities, and at developing local and regional actions.¹⁴⁷

Rapid information

- **Rapidity is a characteristic of a resilient system** and communication strategies should adapt to, and cultivate this feature.
- **Most recent information should be shared in a structured exchange**, to ensure that it will continue even if teams change. King County still organizes internal meetings either once a week or once a month; London still communicates regularly with stakeholders.
- **City officials must be prepared for quick response.** For example when new data comes to light. As the ultimate goal is to build flexible and resilient communities, communications methods have to adapt to these features.

Communicating on Climate Change Adaptation: Specific terminology

Many terms can be used to describe climate change and climate change adaptation. There is little research available on how to better communicate climate change adaptation, however, some recommendations can be formulated.

¹⁴³ San Francisco Bay Conservation and Development Commission. (2011, September 23). Living with a Rising Bay: Vulnerability and Adaptation in San Francisco Bay and on its Shoreline. Draft staff Report. Retrieved November 1, 2011 from <http://www.bcdc.ca.gov/BPALivingWithRisingBay.pdf>

¹⁴⁴ NOAA Coastal Service Center and San Francisco Bay Conservation and Development Commission. (n.d.) Today's Flood is Tomorrow's High Tide. Retrieved October 20, 2011 from http://risingtides.csc.noaa.gov/documents/ART_Poster_2.pdf

¹⁴⁵ Pike, C. (2010, November 15). Communicating about Adaptation and Preparation. Presentation Stanford University. Retrieved November 1, 2011 from http://www.stanford.edu/group/peec/cgi-bin/docs/events/2010/bccc/presentations/1A_CaraPike.pdf

¹⁴⁶ Pike, C. (2010, November 15).

¹⁴⁷ NOAA Coastal Service Center and San Francisco Bay Conservation and Development Commission. (n.d.) Adapting to the Rising Tide. Retrieved October 20, 2011 from <http://risingtides.csc.noaa.gov/about.html>

When talking about adaptation to climate change:

- **Use climate change rather than global warming** to avoid bringing more emphasis to short term hot or cold weather episodes.¹⁴⁸ California uses the expression global warming only once in its 200-page 2009 report. Chicago, Keen County, San Francisco Bay Conservation and Development Commission, and the State of Oregon also rely more on the expression climate change than global warming in their adaptation reports.
- **Use preparedness or preparation in addition to (but not instead of) adaptation.** Being prepared sounds proactive and hopeful.¹⁴⁹ Everyone wants to be prepared, and every citizen is familiar with the expression “better safe than sorry”. Cities can capitalize on this desire to be prepared to increase support of their adaptation strategies.

When using adjectives to describe adaptation to climate change:

- **Terminology should reflect the City’s goal.** To become a *resilient community*, increase quality of life, secure economic benefits, or create jobs. While New York uses the term *resilience* numerous times often with a call to action.¹⁵⁰ Toronto and Boston use it less than 5 times, while Los Angeles, Chicago, and San Diego do not use it at all. In general, resilience has become a trendy term used to clarify the expected goal of mitigation and adaptation strategies.¹⁵¹
- **Explain each word before using it.**¹⁵² As evoked previously, the message should be redundant to ensure that all populations will understand it. Public official should not hesitate to explain the vocabulary used in simple, accessible, terms. California Natural Resources Agency, Keen County and The San Francisco Bay Conservation and Development Commission added a glossary in their adaptation report.^{153 154 155}
- **Only use one or two of these adjectives** to avoid overloading audiences with definitions. None of all the climate change and adaptation reports read used more than two adjectives to evoke the concept of vulnerability.

¹⁴⁸ CRED. (2009).

¹⁴⁹ Pike, C. (2010, November 15).

¹⁵⁰ The City of New York Mayor M. Bloomberg. (2011, April).

¹⁵¹ Moser, S.C. (2011, November 11). Phone Interview.

¹⁵² Moser, S.C. (2011, November 11). Phone Interview.

¹⁵³ California Natural Resources Agency. (2009). 2009 Climate Adaptation Strategy. Retrieved November 15, 2011 from <http://www.energy.ca.gov/2009publications/CNRA-1000-2009-027/CNRA-1000-2009-027-FPDF>.

¹⁵⁴ City of Keen. (2007, November). Keen New Hampshire, Adapting to Climate Change: Planning a Resilient Community. Retrieved November 1, 2011 from http://www.ci.keene.nh.us/sites/default/files/Keene%20Report_ICLEI_FINAL_v2_0.pdf

¹⁵⁵ San Francisco Bay Conservation and Development Commission. (2011, September23). Living with a Rising Bay: Vulnerability and Adaptation in San Francisco Bay and on its Shoreline. Draft staff Report. Retrieved November 1, 2011 from <http://www.bcdc.ca.gov/BPA/LivingWithRisingBay.pdf>

- **Choose between exposure, sensitivity, and vulnerability based on stakeholder familiarity.** New Yorkers are more familiar with climate impacts than other urbanites and may better comprehend the technical term exposure when used in PlaNYC.

IV: Stakeholder Engagement

If the message is inadequate, audiences will not respond to it. If the message is too difficult to comprehend, audiences will invest so much energy trying to understand it, they will lose interest.¹⁵⁶ To determine adequate messages, Portland, London, New York City, Chicago, Boston, and San Diego engaged stakeholders to better understand local needs and ease communication on climate change and adaptation issues. San Diego, for example, struggled with engagement after implementing a communication campaign based on being a good neighbor.¹⁵⁷ After surveying their stakeholders and receiving feedback, they switched the campaign to instead focus on economic incentives and have seen increased engagement.¹⁵⁸

According to Ellen Douglas, a hydrologist and engineer who teaches at the University of Massachusetts, ‘There is nothing like a flood map to get people engaged.’ However, Jen Pagach, with the Connecticut Department of Energy and Environmental Protection, cautions the need to create ‘a delicate balance between instilling fear and guiding people so people are motivated to help and not hurt.’ (NASA Conference) Stakeholder engagement is even more crucial for adaptation policies as it will:

- Strengthen relationships between city officials and constituents and pave the way to support collective actions when they are needed.
- Ensure the support of public decisions, even when difficult policies are implemented.¹⁵⁹
- Encourage buy-in of local populations rather than only top-down support.¹⁶⁰

A challenge for climate change adaptation is to keep stakeholders engaged over the long term. Boston and New York City suggest building bold goals in the beginning and London recommends letting stakeholder decide when they want to stop the engagement process.¹⁶¹ Choosing the right intermediaries can also help foster a lasting dialogue. Best practices are:

- Develop aspirational goals,

¹⁵⁶ Moser, S.C and Dilling, L. (2007).

¹⁵⁷ Moser, S.C and Dilling, L. (2007).

¹⁵⁸ Moser, S.C and Dilling, L. (2007).

¹⁵⁹ Gardner, J, Dowd, A-M., Mason, C. and Ashwoth, P. (2009).

¹⁶⁰ Gardner, J, Dowd, A-M., Mason, C. and Ashwoth, P. (2009).

¹⁶¹ Nickson, A., Daniels, J. Greater London Authority and London Climate Change Partnership. (2011, November 9) Phone interview.

- Set performance indicators and meaningful milestones,¹⁶²
- Regularly communicate with stakeholders using well targeted messages,
- Re-engage stakeholders every few years to re-establish goals based on new trends.

Additional Best Practices in Stakeholder Engagement:

- **Develop outreach programs in schools.** Boston designed a climate change education curriculum in schools, San Diego created the Green Action Plan, and Chicago organized a Climate Summit and an \$800 Savings Challenge Kit for students.¹⁶³
- **Engage during transition times** when a window opportunity for behavioral change opens. Starting at a new school, university, job, house, or city are great occasions to establish new sustainable behaviors.¹⁶⁴
- **Develop websites to inform populations who might be less interested,** but who will need to be engaged sooner or later. All of the cities studied had posted information online for an easy access. Best practice is to make sure that data and reports stay up to date. King County, Keen New Hampshire, San Francisco Bay Conservation and Development Commission, Miami-Dade, Portland ... all have posted their latest adaptation initiatives on websites.
- **Conduct a survey and use feedback as a public relation tool** to increase awareness through media exposure, like San Diego and London.

Engaging low-income communities

Lower income populations might be the most affected by climate change in the United States. Ellen Douglas, the hydrologist and engineer working with Boston's low-income neighborhood Everett described the successful engagement process in this community. "Once you give people education and help them understand, once you tell them what the science is and show them that it is a part of their lives and affects them every day, you can get these communities of people involved to bring the project along."¹⁶⁵ Best practices in engaging these communities include:

¹⁶² Pike, C. (2010, November 15). Communicating About Climate Adaptation & Preparation. Presentation. Stanford University. Retrieved November 1, 2011 from http://www.stanford.edu/group/peec/cgi-bin/docs/events/2010/becc/presentations/1A_CaraPike.pdf

¹⁶³ Parzen, J. (2009, July). Lessons Learned Creating the Chicago Climate Action Plan. Retrieved November 1, 2011 from http://www.sanjoseca.gov/planning/gp_update/meetings/10-19-09/reading_materials/Climate%20Change/Chicago%20Climate%20Action%20Plan%20Lessons%20Leamed.pdf

¹⁶⁴ Whitmarsh, L., O'Neill, S., Lorenzoni, I. (2011)

¹⁶⁵ NASA/GISS Conference 11.17.2011

- **Collaborate with well-established local organizations as intermediaries.** Toronto teamed up with nonprofits to set priorities.¹⁶⁶ Los Angeles joined forces with local organizations in low and middle-income neighborhoods to develop training for green jobs.¹⁶⁷ Chicago worked with community organizations and nonprofits to increase energy savings in low-income neighborhoods.¹⁶⁸
- **Use a community member as a messenger.** As these populations may have a low trust level, the messenger is as important as the content of the message.¹⁶⁹ Intermediaries must understand the local groups or populations well and be able to answer all questions to ensure credibility.
- **Frame environmental issues around important and present issues to combat skepticism.** Concerns may be related to jobs, public health or extreme weather events, as many low-income residents do not have health or home insurance. Roxbury, MA emphasized the increased risk of asthma as it was a local concern.¹⁷⁰ Southwest Oregon framed the discourse on the increasing financial and social costs of wildfires on poor communities.¹⁷¹
- **Start community outreach early to prevent worry.** An early stakeholder engagement is the best practice and should especially be implemented when stakeholders are likely to have trust issues.
- **Understand local adaptation issues, secure additional funding to help these communities, and build trust through communication.** Chicago worked with local communities and provided bill payment assistance, thus gaining an access point to the public.¹⁷² In Manchester, UK, energy efficiency was implemented in a housing cooperative project as a consequence of community engagement. Local tenants were heavily involved from beginning to finish, ensuring the success of the project.¹⁷³

¹⁶⁶ Toronto Environmental Office, the City of Toronto Climate Adaptation Steering Committee, the Clean Air Partnership. (2008, April 18).

¹⁶⁷ The City of Los Angeles Mayor Antonio R. (2007, May).

¹⁶⁸ City of Chicago. (n.d.)

¹⁶⁹ Moser, S.C and Dilling, L. (2007).

¹⁷⁰ Moser, S.C and Dilling, L. (2007).

¹⁷¹ Moser, S.C and Dilling, L. (2007).

¹⁷² City of Chicago. (n.d.)

¹⁷³ Greater London Authority. (2011, October).

V: Influencing Behavior

Communication campaigns that aim at changing habits do not grab audience attention.¹⁷⁴ Habits are hard to break but behavioral changes do occur when there is a major alteration in someone's life. Therefore it is imperative to:

- **Understand that the human tendency** is to stick with the option that is selected automatically, the default option.¹⁷⁵ Translate and explain adaptation behaviors in such a way so they can become the default option.¹⁷⁶
- **Provide near term benefits or incentives**, including: financial savings, improved quality of life, or additional green spaces. As adaptation strategies may not have near term benefits, it is common to communicate both adaptation and mitigation strategies at the same time.¹⁷⁷
- **Change the norm.** When people feel that their community, school, business, or another group they value is interested in adaptation, their behavior changes.¹⁷⁸
- **Recognize that public commitments and pledges in front of peers** are a great tool to further this change.¹⁷⁹ Public challenges with prizes work very well to induce changes in behaviors.
- **Remove barriers.** When using public transportation, people are mostly concerned about the uncertainty and wait time. The Chicago Transportation Authority designed a tracking tool so that people can receive an email when the bus is nearby, allowing them to spend time on other things. The website currently receives 2 million visits per day and received an innovation award in 2010.¹⁸⁰

¹⁷⁴ Whitmarsh, L., O'Neill, S., Lorenzoni, I. (2011)

¹⁷⁵ CRED. (2009).

¹⁷⁶ CRED. (2009).

¹⁷⁷ Marvin, K.K. (n.d.). New Research Initiated on Climate Change Adaptation. Retrieved November 1, 2011 from <http://www.centerforceansolutions.org/news-events/featured-stories/new-research-initiated-climate-change-adaptation>

¹⁷⁸ Whitmarsh, L., O'Neill, S., Lorenzoni, I. (2011).

¹⁷⁹ Whitmarsh, L., O'Neill, S., Lorenzoni, I. (2011).

¹⁸⁰ Chicago Innovation Award. (n.d.). Chicago Transit Authority Bus Tracker. Retrieved October 21, 2011 from http://www.chicagoinnovationawards.com/past_winners/chicago-transit-authority/

Becoming climate resilient requires a lasting commitment. Adaptation must be woven into each City department, into each City process, and climate risk information must become a strategic part of operations and capital planning. Below are best practices in integrating adaptation throughout City offices, getting everyone on board, and obtaining this commitment.

Involve city agencies early.¹⁸¹

- Ask each department to begin the climate adaptation planning process with their own vulnerability assessment. This will aid engagement and allow each department to see the need for adaptation strategies for themselves.
- Allow City agencies to come up with their own ideas and realize their own limits; they are the experts and this will set the stage for collaboration.
-

Create internal mechanisms and processes first.¹⁸²

- Set up support and capacity for data collection, the evaluation process, policy frameworks, and awareness raising.¹⁸³
- Engage senior leadership, assess staff and budget allocations, bring on a steering committee or task force, create issue-based working groups, secure local expertise, and collaborate regionally.
- Decide who will be responsible for advising departments on the development of adaptation strategies. In Chicago the Climate Change Adaptation team handles this. This team includes volunteer participation from employees of the Executive Office, Natural Resources and Parks Department, Department of Development and Environmental Services, Public Health Department, Transportation Department, as well as members from the university system.¹⁸⁴

Stay flexible.

¹⁸¹ Parzen, Julia. *Lessons Learned: Creating the Chicago Climate Action Plan*. 2009.
<http://www.chicagoclimateaction.org/filebin/pdf/LessonsLearned.pdf>

¹⁸² Toronto Environmental Office, Toronto Climate Adaptation Steering Group, and the Clean Air Partnership. *Ahead of the Storm. Preparing Toronto for Climate Change: Development of a Climate Change Adaptation Strategy*. 2008. http://www.toronto.ca/teo/pdf/ahead_of_the_storm.pdf

¹⁸³ Parzen, Julia. *Lessons Learned: Creating the Chicago Climate Action Plan*. 2009.
<http://www.chicagoclimateaction.org/filebin/pdf/LessonsLearned.pdf>

¹⁸⁴ Parzen, Julia. *Lessons Learned: Creating the Chicago Climate Action Plan*. 2009.
<http://www.chicagoclimateaction.org/filebin/pdf/LessonsLearned.pdf>

Adaptation planning and integration of these plans into City operations and capital plans is an ongoing and evolving process.

- City Departments must be flexible to meet the changing needs and desires of the community
- Updates should be made regularly as new data is collected. Taking incremental steps forward ensures the City is capable of responding to dynamic climate change risks.

Incorporate climate change into the formal planning process.

- In Boston before issuing a permit, license, or giving administration approval all agencies must consider climate change impacts. In addition, all new municipal construction and major renovation must include an evaluation of risks posed by climate change through 2050, including a description of potential steps planned to avoid, minimize, or mitigate these risks.¹⁸⁵
- Boston also encourages the private sector to follow suit and is in the process of an Adaptation Checklist, which will require all large developments to formally address climate change impacts. Spaulding Rehabilitation Hospital moved to Boston's Navy Yard and submitted plans indicating raising the base level of their new facility to account for increased flooding risks due to sea-level rise.¹⁸⁶
- Chicago planning tactics included a business decisions guide and a procurement checklist. The guide is a quick snapshot to allow decision makers to quickly review decisions with reference to ability to adapt to climate change. The procurement checklist helps Chicago ensure they are purchasing products and services in alignment with adaptation objectives.¹⁸⁷
- Philadelphia has weaved adaptation into the planning and review process in the RFP for the Master Plan Study for the Lower Schuylkill River.¹⁸⁸

¹⁸⁵ Climate Action Leadership Committee and Community Advisory Committee, *Sparking Boston's Climate Revolution*. 2010. http://www.cityofboston.gov/Images_Documents/BCA_full_rprt_r5_tcm3-19558.pdf (Boston Plan)

¹⁸⁶ Climate Action Leadership Committee and Community Advisory Committee, *Sparking Boston's Climate Revolution*. 2010. http://www.cityofboston.gov/Images_Documents/BCA_full_rprt_r5_tcm3-19558.pdf (Boston Plan)

¹⁸⁷ Parzen, Julia. *Lessons Learned: Creating the Chicago Climate Action Plan*. 2009. <http://www.chicagoclimateaction.org/filebin/pdf/LessonsLearned.pdf>

¹⁸⁸ Philadelphia Industrial Development Corporation, *Request for Proposals, Master Plan Study for The Lower Schuylkill River District, Philadelphia, PA*. 2011.

Planning 2.0.

- In Boston, city planners identified no-regrets, low-cost, and wait-and-see strategies. The Comprehensive Emergency Management Plan was reviewed and updated to include climate risks and adaptation strategies, and planners came up with a Complete Streets Advisory Committee to make sure street design guidelines addressed the effects of climate change.¹⁸⁹
- Keene adopted smart growth principles in their Comprehensive Master Plan to avoid new development in high-risk areas, reduce sprawl and promote infill development and redevelopment.¹⁹⁰
- Chicago made sure they asked if each projects' risk management analysis took into account changes due to climate change and if the proposed plan included a specific commitment to keeping up-to-date with the changing understanding of climate change and its implications.¹⁹¹
- Keene Building Department adopted a new building energy code, which incorporated sustainability, green building materials, and energy conservation for both new projects and major renovations.¹⁹²
- Toronto includes climate change considerations and adaptation goals in plans, programs, strategies and assessment procedures including: Toronto's Official Plan, Transit City Plan, Parks, Forestry, and Recreation Strategic Plan, Emergency Plan, Green Development Standard, and Long Term Fiscal Plan.¹⁹³

Long-range capital plans.

Capital projects are new construction project that add new or improved capacity to the city: repairing roads, replacing bridges, expanding transportation systems, etc. New projects present an opportunity for city planners to address issues of climate change adaptation without explicitly calling it adaptation. Adaptation strategies can be incorporated into land use and transportation plans, urban design, utility plans, building practices, and infrastructure development.

¹⁸⁹ Climate Action Leadership Committee and Community Advisory Committee, *Sparking Boston's Climate Revolution*. 2010. http://www.cityofboston.gov/Images_Documents/BCA_full_rprt_r5_tcm3-19558.pdf (Boston Plan)

¹⁹⁰ City of Keene and ICLEI, *Keene, New Hampshire. Adapting to Climate Change: Planning a Climate Resilient Community*. 2007. http://www.ci.keene.nh.us/sites/default/files/Keene%20Report_ICLEI_FINAL_v2_1.pdf

¹⁹¹ Parzen, Julia. *Lessons Learned: Creating the Chicago Climate Action Plan*. 2009. <http://www.chicagoclimataction.org/filebin/pdf/LessonsLearned.pdf>

¹⁹² City of Keene and ICLEI, *Keene, New Hampshire. Adapting to Climate Change: Planning a Climate Resilient Community*. 2007. http://www.ci.keene.nh.us/sites/default/files/Keene%20Report_ICLEI_FINAL_v2_1.pdf

¹⁹³ Toronto Environmental Office, Toronto Climate Adaptation Steering Group, and the Clean Air Partnership. *Ahead of the Storm. Preparing Toronto for Climate Change: Development of a Climate Change Adaptation Strategy*. 2008. http://www.toronto.ca/teo/pdf/ahead_of_the_storm.pdf

- The Port Authority of New York voluntarily evaluates all capital projects using the NYC Climate Projections, building 18 inches above the mandatory one-foot for one 100-year flood set by the Federal Emergency Management Agency.¹⁹⁴
- Boston Water & Sewer is focused on long-term capital planning for sea-level rise and storm intensity impacts on sewer and storm water system.¹⁹⁵
- King County Building Department initiated a Green Building and Sustainable Development Ordinance and incorporated projected climate impacts into the Department of Transportation's infrastructure design in regards to dealing with wastewater and road infrastructure. The Department is choosing pavement materials that are more resilient to heat.¹⁹⁶
- King County Water & Sewer is sizing stormwater facilities to accommodate increasing flows from extreme weather events, and collaborating with climate science experts to incorporate climate information planning into their five-year capital plan. Capital improvement projects include Vashon's Dockton Seawall Replacement and the Duwamish Combined Sewer Overflow¹⁹⁷.
- King County long-term capital plans that incorporate adaptation strategies include: The County Comprehensive Plan, Regional Hazard Mitigation Plan, River and Floodplain Management Program, coordinated water system plans in Regional Water Supply Planning process, and the Road Services Division's Road Standards Manual, Design Procedure Manual, Surface Water Design Manual, etc. The City has also incorporated adaptation strategies into the protection of historic buildings.¹⁹⁸

Get regional.

Climate risks are not local. Watersheds are shared, rivers are shared, and climate impacts do not contain themselves nicely within City walls. Regional coordination allows for knowledge sharing, networking, and pooling of resources.

- Chicago's regional efforts: The Department of Environment regional watershed planning, regional wilderness response, regional energy efficiency programs and regional transportation solutions to reduce GHG emissions.
- Toronto is focused on regional participation: regional precipitation events have led to collaboration with Environment Canada, Conservation Ontario, Toronto and Region

¹⁹⁴ The Mayor's Office of Long-Term Planning and Sustainability, City of New York and ICLEI USA. *The Process Behind PlaNYC*. 2010.

http://nytelecom.vo.llnwd.net/o15/agencies/planyc2030/pdf/iclei_planyc_case_study_201004.pdf

¹⁹⁵ Climate Action Leadership Committee and Community Advisory Committee, *Sparking Boston's Climate Revolution*. 2010. http://www.cityofboston.gov/Images_Documents/BCA_full_rprt_r5_tcm3-19558.pdf (Boston Plan)

¹⁹⁶ King County, *2007 Climate Plan*. 2007. <http://your.kingcounty.gov/exec/news/2007/pdf/climateplan.pdf>

¹⁹⁷ King County, *2007 Climate Plan*. 2007. <http://your.kingcounty.gov/exec/news/2007/pdf/climateplan.pdf>

¹⁹⁸ King County, *2007 Climate Plan*. 2007. <http://your.kingcounty.gov/exec/news/2007/pdf/climateplan.pdf>

Conservation Authority, and other municipalities to design drainage infrastructure and identify future policy requirements for flood protection in the shared watershed. The city also joined Alliance for Resilient Cities and Urban Leaders Initiative, to obtain new knowledge and potentially access funds.¹⁹⁹

- Oakland and San Francisco participate in the Bay Conservation and Development Commission (BCDC). The BCDC has funded and implemented many projects related to Bay Area sea-level rise and flooding.²⁰⁰

Host educational conferences and workshops to engage a variety of civic and scientific organizations.

- Boston's MassDOT held a three-day climate academy for all employees.²⁰¹
- King County has led a climate consortium inviting multiple stakeholders to learn more about climate plans.²⁰²
- Oakland's mayor has presented at numerous community events.²⁰³

Create resilient jobs.

- Several cities, including Boston, Chicago, Seattle, and Denver, have created Green Job programs, designed to develop workforce skills that take advantage of climate change opportunities.

Sometimes it takes an iron fist.

Collaboration is an important part of the adaptation process; however executive orders have been used in several key cities to drive adaptation planning forward.

- King County Council passed a directive requiring county departments to develop both a mitigation and preparedness plan and provide annual progress reports.²⁰⁴
- Mayor Bloomberg created the Office of Long-Term Planning and Sustainability and created PlaNYC without getting official City approval first.²⁰⁵

¹⁹⁹ Toronto Environmental Office, Toronto Climate Adaptation Steering Group, and the Clean Air Partnership. *Ahead of the Storm. Preparing Toronto for Climate Change: Development of a climate Change Adaptation Strategy*. 2008. http://www.toronto.ca/teo/pdf/ahead_of_the_storm.pdf

²⁰⁰ City of Oakland, *Draft Energy and Climate Action Plan*. 2011. <http://www2.oaklandnet.com/oakca/groups/pwa/documents/policy/oak024383.pdf>

²⁰¹ Climate Action Leadership Committee and Community Advisory Committee, *Sparking Boston's Climate Revolution*. 2010. http://www.cityofboston.gov/Images_Documents/BCA_full_rprt_r5_tcm3-19558.pdf (Boston Plan)

²⁰² King County, *2007 Climate Plan*. 2007. <http://your.kingcounty.gov/exec/news/2007/pdf/climateplan.pdf>

²⁰³ City of Oakland, *Draft Energy and Climate Action Plan*. 2011.

<http://www2.oaklandnet.com/oakca/groups/pwa/documents/policy/oak024383.pdf>

²⁰⁴ King County, *2007 Climate Plan*. 2007. <http://your.kingcounty.gov/exec/news/2007/pdf/climateplan.pdf>

²⁰⁵ The Mayor's Office of Long-Term Planning and Sustainability, City of New York and ICLEI USA. *The Process Behind PlaNYC*. 2010.

http://nytelecom.vo.llnwd.net/o15/agencies/planyc2030/pdf/iclei_planyc_case_study_201004.pdf

As urban centers and communities advance adaptation planning efforts and move toward implementing adaptation strategies, it will be important to establish key performance indicators that inform stakeholders about the effectiveness of adaptation strategies. Without understanding the effectiveness of chosen strategies, it will be difficult to know how to adjust or change approaches over time. Stakeholders needing to understand this information include city officials, the private sector, and the community at large. Performance metrics can be a method of communication, but also provide a mechanism to understand what adaptation strategies are working well, and what strategies are not providing the increase in resilience that was intended. It is important to note that because adaptation is still an emerging field, there is not a common set of adaptation metrics. However, metrics are being used by some communities to gauge the performance of mitigation programs that overlap with adaptation, such as energy efficiency and stormwater management. In addition, there are metrics being used to measure the success of programs implemented by emergency management, such as extreme heat and weather events, which can also have ties to adaptation.

Identifying performance metrics up front for any adaptation strategy that will be implemented ensures the proper data can be collected and analyzed in order to understand what is working well and what is not. This provides a feedback loop into the adaptation planning process, and will allow the responsible agency to make necessary adjustments to the implementation of a given strategy.

Guidance to help identify key performance indicators:

In an Expert Consultation on Adaptation Metrics conducted by the Institute for Global Environmental Strategies (IGES), and funded by the World Bank, three overarching questions were outlined, aimed at helping the development of adaptation metrics, and emphasizing the need for them:

- How effective is the adaptation strategy in reducing community risks from climate hazards?²⁰⁶
- How sustainable is the strategy itself? Can the strategy continue to reduce risks after the project period?²⁰⁷

²⁰⁶ Srinivasan, Ancha PhD., Expert Consultation on Adaptation Metrics: Scope and Objectives. Climate Policy Project – Institute for Global Environmental Strategies (IGES). Tokyo 17-18 April, 2009. Available at: http://www.iges.or.jp/en/cp/pdf/activity20/1_Ancha.pdf

- Can the strategy improve the ability of communities to cope with increasing hazards after this project is completed?²⁰⁸

While the overall goal of the IGES project was to improve adaptation planning efforts in the most vulnerable parts of developing countries, the questions above are relevant to any community who wants to evaluate the effectiveness of their adaptation strategies.

Some cities have recognized the need for effectiveness measures as part of their adaptation planning process. For example, the final step in Toronto’s long-term strategy for comprehensive adaptation planning states:

*Monitor climate change, evaluate the effectiveness of adaptation initiatives in protecting the city from continuing changes, and adjust strategies when necessary.*²⁰⁹

For Toronto, this last step creates the feedback loop that allows ongoing adjustment to adaptation planning as new climate data is reported, and as more is understood about the strengths and weaknesses of current programs, initiatives, and investments.

Define leading and lagging indicators to measure outcomes

Metrics can be put in place to measure various aspects of climate change effects on a city and the success of a city’s response. In Toronto’s report “Ahead of the Storm...Preparing Toronto for Climate Change”, metrics were incorporated into the discussion about specific climate issues. Indicators are classified as lagging or leading, and both play a role informing trends and performance of adaptation strategies.²¹⁰ As an example of how metrics can be identified and incorporated into adaptation strategies, we have used Toronto as a model.

²⁰⁷ Srinivasan, Ancha PhD., Expert Consultation on Adaptation Metrics: Scope and Objectives. Climate Policy Project – Institute for Global Environmental Strategies (IGES). Tokyo 17-18 April, 2009. Available at: http://www.iges.or.jp/en/cp/pdf/activity20/1_Ancha.pdf

²⁰⁸ *Ibid*

²⁰⁹ *Ibid*

²¹⁰ Toronto Environmental Office, Toronto Climate Adaptation Steering Group, and the Clean Air Partnership. *Ahead of the Storm. Preparing Toronto for Climate Change: Development of a climate Change Adaptation Strategy*. 2008. http://www.toronto.ca/teo/pdf/ahead_of_the_storm.pdf

Metrics Related to Extreme Heat²¹¹

Lagging Indicators:

- Number of air pollution related deaths
- Number of heat related deaths
- Number of 9-1-1 calls for heat related illness

Leading indicators:

- Number of smog advisories
- Number of heat alerts issued
- Number of pools, cooling and misting stations
 - Note: Toronto's plan calls for expanding the number of cooling centers for the City, and so a leading indicator such as the one above can easily be deduced from this action.

Metrics Related to Drought²¹²

Lagging Indicators:

- Number of consecutive days without significant rain
- Number of trees that died or became stressed from drought (this can result in vulnerability to pests and disease)

Leading Indicators:

- Percentage of trees covered by tree pruning services
 - Note: Toronto's plan calls for increasing systematic tree pruning services to promote tree strengthening as protection from stressors such as drought. A leading indicator such as the one above can easily be deduced from this action.

Metrics Related to Extreme Weather Events²¹³

Lagging Indicators:

- Number of natural disasters

²¹¹ Toronto Environmental Office, Toronto Climate Adaptation Steering Group, and the Clean Air Partnership. *Ahead of the Storm. Preparing Toronto for Climate Change: Development of a climate Change Adaptation Strategy*. 2008. http://www.toronto.ca/teo/pdf/ahead_of_the_storm.pdf

²¹² *Ibid*

²¹³ *Ibid*

- Amount of weather-related insurance loss
- Amount of damage to public property
- Amount of damage to private property
- Number of basements flooded

Leading Indicators:

- Percentage of private residences abiding by mandatory downspout disconnection
 - Note: Toronto’s plan calls for this measure as a short-term action. Measuring the compliance with this can be easily deduced as a leading indicator from this action.
- Number of new trees planted (can alleviate flooding issues)

It is important to note that lagging indicators measure outcomes after the event has occurred, while leading indicators measure an activity meant to prevent an event from occurring. In the case of the heat-related metrics above, a decrease in lagging indicators would show that the measures put in place have successfully improved the city’s resilience to heat.

Ultimately, a mix of leading and lagging indicators is ideal for understanding the effectiveness of adaptation strategies. Typically, leading indicators increase over time, resulting in a decrease of negative aspects associated with lagging indicators.

Align metrics with the structure of your adaptation planning process

While the examples from Toronto show how metrics can be grouped by issue, there are other ways of grouping metrics within adaptation planning. Chicago’s Climate Action Plan sets out adaptation performance indicators to complement the scorecard it has for progress on mitigation actions. These adaptation indicators aim to measure progress on adaptation for purposes of internal decision-making and illustrating progress to the public.²¹⁴ Chicago groups adaptation metrics in a way that mirrors their adaptation planning process.

Climate Change Measures²¹⁵

- Increased annual average Chicago temperatures
- Number of days over 95 °F per year
- Number of seasonal precipitation events per year

²¹⁴ Chicago Climate Action Plan, Climate Adaptation Overview presentation. City of Chicago, 2011.

²¹⁵ *Ibid*

Climate Readiness Measures²¹⁶

- Stormwater catch-basin restrictors in place (built environment)
- Permeable pavement built (built environment)
- Water control structures sized for extreme precipitation (natural environment)
- Urban Heat Island area planted with climate ready trees (natural environment)

Surveillance Measures²¹⁷

- Heat-related fatalities per year (people)
- Street closure hours per year due to flooding (people, built environment)
- Power shut down hours per year (people, built environment)
- Heat-related school and labor absences per year (people)
- Beach swim ban and advisory days per year (natural environment)

Chicago's Climate action plan is built on three pillars: Built Environment, Natural Environment, and People. When establishing the metrics, they also selected measures that related back to each of the three focus areas. Although Chicago organized their metrics differently, it was done to align with the Climate Action Plan, and contain both leading and lagging indicators. The metrics on readiness are primarily leading indicators that measure preventative activities, with the other sections containing lagging indicators.

In summary, establishing a set of performance metrics as part of adaptation planning is a critical factor in setting up a feedback loop for continuous improvement and ensuring the most effective use of operational and capital investments.

²¹⁶Chicago Climate Action Plan, Climate Adaptation Overview presentation. City of Chicago, 2011.

²¹⁷ *Ibid*

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