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Local Government Responses to Climate Change in the United States

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EXECUTIVE SUMMARY

Climate change has emerged as an important issue for society and government, with recent recognition and focus on the need for adaptation to respond to past and existing emissions that will continue to have profound effects on the planet and on communities. Local governments have a strong role to play in adaptation planning and implementation, and this paper examines in particular the response of local governments in the United States to this issue. The paper sets out to provide a snapshot of adaptation activities and attempts to address the questions of what actions would give the greatest return on investment and what actions are showing the most promise.

Research has indicated that in North America, an overall northern shift in climate conditions is expected. An increase in the frequency and severity of extreme weather events is predicted, and some regions will become wetter while others will become drier. Sea-level rise is a major concern for low-lying coastal areas and tropical islands. Negative impacts are expected on water supply, quality, and temperature, which affect both people and natural ecosystems. These predicted impacts have significant implications for local governments, affecting a wide range of services, functions, and infrastructure, and budgets.

In the United States, the majority of cities have been slow to incorporate adaptation into policy; however, there a number of positive examples of where cities have incorporated climate change factors into the planning and implementation of specific projects. A number of tools exist to undertake adaptation, and often a mix of actions and policies is needed to achieve the desired outcome. There is a definite need for more coordinated efforts and strategies, and this will involve reforming institutions and structures. Sometimes existing institutions, such as the U.S. - Canada Great Lakes Commission, can provide the necessary framework, while at other times, new institutions will need to be formed. Experience thus far indicates that these institutional mechanisms should involve multiple stakeholders and be supported by senior staff, funding, and linkages with climate change research organizations.

Other important tools for adaptation include land use planning, expenditures, incentives, regulation and design, and outreach and communications. Land use planning is a preventative approach to siting of buildings and infrastructure, and often changes in infrastructure design and building codes can be achieved relatively inexpensively. Some costly expenditures may be required such as protection measures, land purchases, and damage claims from extreme weather events. Preventative programs such as offering grants and incentives, planting trees, conducting public outreach, and purchasing beneficial products may help to buffer the costly expenditures.

Very little research has been completed on the effectiveness of various adaptation options. This is mostly because the efforts of local governments to incorporate climate change adaptation into policies is new and at the draft stage. Thus, it was not possible to provide an evaluation of alternative approaches for efficiency or for being the most promising. However, some preliminary considerations in examining adaptation options and assessing resiliency are provided in the appendices. Overall, the literature indicated

that the most suitable adaptive strategies are those that also provide benefits in the present ("no regrets actions"). There is a strong argument for proactive strategies as being the most cost-effective. Finally, more understanding is needed on risks, local effects, and when impacts will actually occur, and more extensive adaptation than is currently occurring is required to reduce vulnerability to climate change.

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1. INTRODUCTION

Climate Change has become an emerging priority for society and communities, and all levels of governments, including local, are forming responses to this issue. However, in the United States, this effort is just beginning. The majority of states and cities have focused on creating Climate Change Action Plans dealing with mitigation, and very few have addressed the issue of adaptation. Many of the adaptation plans and actions that are in progress by state and local governments are in their earliest stages. Adaptation planning is now gaining greater attention and resources from states and localities, and there are several leading case studies to learn from. (Pew Centre on Global Climate Change, 2007)

This paper is meant to address the following three research questions:

1. What are local governments doing in anticipation of climate change, i.e. planning for its impact by lessening the negative consequences?
2. Of all possible actions a local government could take, which set would give the greatest return on investment?
3. What actions have already made a difference or are most promising independent of efficiency considerations?

To explore these research questions, the remainder of the paper covers the background on the issue of climate change and local government responsibility, the key findings and case studies of local government adaptation in the United States, and issues around evaluating policy options.

This research paper has a practical focus, thus secondary research was undertaken from references such as Internet sources, planning documents, academic publications, newspapers, magazines, and government publications to assess the status of climate change preparation in the United States. Specific examples were drawn from local government and regional websites as well as climate change research centres.

2. BACKGROUND

Climate Change resulting from increased greenhouse gas emissions has the potential to harm societies and ecosystems. Vulnerable sectors include but are not limited to human health, coastal settlements, water resources, forestry, and agriculture. It has become a major issue for all levels of government. The majority of local authorities' responses to climate change have tended to concentrate on their role in reducing greenhouse gas emissions (Easterling et al., 2004). According to editorials in the Boston Globe and in Nature, the lack of discussion on climate change adaptation in the United States has been attributed to the federal government's reluctance to acknowledge manmade warming, and environmental groups' concern that talking about adaptation would weaken the focus on the need to reduce greenhouse gas emissions (Daley, 2007; Funkhouser, 2007).

However, recognition is increasing that despite the best mitigation efforts, there will be a lag effect on the climate system from past emissions that have long lifetimes in the

atmosphere[1]. The IPCC states that, "past emissions are estimated to involve some unavoidable warming (about a further 0.6°C by the end of the century) even if atmospheric greenhouse gas concentrations remain at 2000 levels". Vulnerable sectors and communities will need to adapt to a changing climate or face diminished functions. Adaptation has emerged as a future necessity and as a risk-management strategy; it represents a complementary approach to mitigation.

Specific impacts such as droughts and increased flooding often occur at a community and regional level, thus local governments have a responsibility to prepare and will play an especially crucial role (Kirshen et al., 2005). Many areas under local government jurisdiction such as emergency preparedness and response, community facilities, water management (drinking, storm, waste), land-use planning, building regulation, economic development, and natural areas management will be impacted by climate change. The focus of this paper is on the local government response, as it is the area where direct decisions and actions affecting communities can be made; however, each level of government has an important role in any adaptation strategy (Pew Centre on Global Climate Change, 2007).

3. FINDINGS

3.1 Climate Change Impacts

3.1.1 General Impacts in the United States

The United States has undergone a national assessment to develop an initial understanding of the potential impacts of climate change in the 21st century. In addition, individual states, such as California and Washington, have begun to conduct similar assessments. The scientific community is uncertain about the extent of future global warming, thus they have projected a range of scenarios depending on future greenhouse gas emissions. The mid-range of projected warming is often used in assessments, which predicts a global average warming of about 3 to 5 degrees Celsius by the end of the century (U.S. Department of State, 2002).

The United States is a geographically diverse country with a wide variety of climate conditions and ecosystems. Thus the impacts of climate change will be felt differently in each region. However, an overall northern shift in weather systems and climate conditions is expected. Some of the most dramatic climate change impacts will be experienced as increased frequency and severity of extreme weather events, such as heat waves, wildfires, flooding, hurricanes, major drought, and storms. In some regions precipitation will increase along with heavier rain events, while other regions will become drier and face drought. Sea-level rise is a major concern for low-lying coastal areas and tropical islands (Easterling et al., 2004). Changes in surface water and groundwater temperature, quantity, and quality will impact fish and wildlife, and challenge water managers. Natural ecosystems are the most vulnerable, because it will be difficult for many species to change behaviour or migrate in response to climate change. Minor changes will affect many ecosystems, many of which are already threatened, and

[1]Easterling et al., 2004; U.S. EPA, 2006; U.S. Department of State, 2002; IPCC, 2007.

some of the goods and services lost through the disappearance or fragmentation of natural ecosystems will be costly or impossible to replace. At this point, significant uncertainties remain in the science underlying regional changes in climate and their impacts, as complex systems will respond to ongoing climate change in unexpected ways (U.S. Department of State, 2002).

3.1.2 Specific Impacts on Local Government

The general impacts of climate change have significant implications for local governments. There could be large financial ramifications, affecting a wide range of municipal services, functions, and infrastructure. Asset and infrastructure management, water management, growth management and land use planning, public and environmental health, and emergency management are examples of areas of work that will be affected.

Infrastructure and asset management is an obvious and substantial area of activity for local governments where anticipating impacts is required. Infrastructure that can be affected includes roads, bridges, stormwater systems, sewage treatment plants and distribution systems, water supply, levees and dams, buildings, and local power supplies (Funkhouser, 2007). Flooding is of particular concern with major implications for infrastructure and emergency management, as it can cause overloading of storm-water and wastewater systems, damage water and sewage treatment facilities, inundate landfills, cause property damage, and stop traffic flow (Easterling et al., 2004). For example, the intense rainfall (100-year storm event) that occurred over Seattle on December 14, 2006 flooded streets and stopped traffic for hours. The downpour flooded basements, felled thousands of trees, knocked out power to over a million homes and businesses, opened up a 15 by 20 foot sinkhole, and caused a sewage treatment plant to dump tens of millions of raw sewage into Puget Sound. More than 1500 emergencies were called in, and by January of 2007, more than 200 people had filed damage claims with the City of Seattle (Funkhouser, 2007).

Water management is already a significant challenge for regional and urban governments. Many U.S. rivers and streams currently do not have enough water to satisfy existing water rights and claims and parts of the United States such as California and the Great Plains are dependent on declining ground-water supplies. Coastal aquifers will be affected by seawater intrusion, which will place additional pressure on surface water. Climate change will increase competition for water supplies, and the nation's water resources will have to be managed very carefully (U.S. Department of State, 2002).

Growth management and planning is often thought of when proposing solutions to reducing greenhouse gas emissions. Smart growth planning such as redevelopment, infill and people-scaled communities is advocated as a way to reduce traffic congestion and carbon emissions (Funkhouser, 2007). However, land use planning also has a strong role in adaptation efforts such as with coastal zoning, anticipating flood risk, planning for protected areas, and managing water resources (Wilson, 2006). The way smart growth planning is implemented may have unintended consequences for urban infrastructure. Small development projects and infills that add just 10% in imperviousness to a watershed can greatly impact urban hydrologic systems and increase flooding. Some cities have loosened requirements for mitigation of runoff to encourage redevelopment or

based runoff scenarios on pre-climate change conditions (Funkhouser, 2007). This indicates that all unintended consequences of policy need to be considered in decision-making, and that it is important how policy is implemented.

Human health impacts may increase in the United States from climate change in many ways. Examples include dehydration, fatigue, inability to leave home during extreme weather events, damage to lungs from forest fires, and increases in vector-born diseases. Those living in remote areas, in poverty, and the sick and elderly are most vulnerable to events such as power shortages and extreme weather, which could lead to food and medicine spoilage, inability to pump water, and lack of supplies being available (Drechsler et al., 2006; Natural Capital Solutions, 2007; Burton et al., 2004). Managing all these potential health impacts will challenge city governments, along with county, state and federal agencies. The impact from heat waves has already been felt in many parts of the U.S. and Europe. For example, over 100 people died in California during July 2006 from heat-related causes, which was a large increase from the year before (Natural Capital Solutions, 2007).

The impact on environmental health is expected to be significant. Increased contamination and pollution of freshwater systems, increased air pollution, decreased biodiversity, and the disappearance of vulnerable ecosystems such as barrier reefs and alpine meadows are expected to occur in some areas. One benefit is that the productivity of agriculture and forest ecosystems may actually increase, allowing for a stronger carbon sink (U.S. Department of State, 2002). The interactions of the natural environment are complex and dynamic, and these wider implications will need to be incorporated into local government activities and planning (Wilson, 2006). For example, stormwater management and protected area planning can contribute to environmental health through techniques such as green roofs, urban forestry and natural ponds, and density bonusing to increase green space (Funkhouser, 2007).

Emergency and disaster management crosscuts the work of many local government departments. Through anticipating backup power for critical urban infrastructure systems, planning for flooding and storms, participating in flood-risk mapping, and setting up emergency procedures and centers and response plans for times of disaster such as heat waves and hurricanes, emergency management has an important role in adaptation. For example, the city of Philadelphia has a response plan that includes a Heat Health Watch-Warning System (HHWWS), and the City of Chicago has an Action Plan for Extreme Weather Conditions during a heat wave or severe cold (Natural Capital Solutions, 2007).

3.2 General Findings about Adaptation

There has been limited applied research thus far on adaptation, due in part to the uncertainties associated with the complexity and scale of adaptation processes and limited experience with regards to anthropogenic climate change. However, the literature thus far indicates that US society can adapt with either net gains or some costs if warming occurs at the lower end of projections, and this assumes no change in climate variability and optimistic assumptions about mitigation and adaptation efforts. However, a much larger magnitude of warming could impact many sectors with net losses and higher costs.

It is uncertain how much of an increase in frequency or intensity of extreme weather events the United States can handle (Easterling et al., 2004).

A positive factor is that the United States has shown a great capacity for applying technological and geographical knowledge to enhance resilience and reduce vulnerability to fluctuating climate conditions. For example, buildings have been designed and constructed better over the last fifty years and better warning systems about extreme events have been developed (U.S. Department of State, 2002). There is a need to continue this learning and to use adaptive management in preparing for climate change and to minimize future impacts. Research and information sharing should occur at a greater scale to transfer knowledge about successful adaptation strategies (Thompson et al., 2006).

It has been found that many of the most suitable adaptive strategies are "win-win" or "no regrets" in that they improve today's conditions such as public health, resource planning and economic efficiency. A "no regrets" action provides benefits in current and future climate conditions even if no climate change occurs (Luers and Moser, 2006). For example, improved disease surveillance and prevention programs, improved sanitation programs, and education of health professionals and the public are beneficial activities to carry out to improve public health regardless of climate change (U.S. Department of State, 2002). Allowing markets to signal whether water supplies are limited enables consumers to react quickly to changes in supply, which is a technique that has been advocated for some time to improve water use efficiency and will help mitigate the adverse impacts of climate change (Luers and Moser, 2006). Often, proactive steps in one sector will benefit other sectors, particularly in the case of flood management, even with less severe climate change scenarios. For example, land use policies that limit development in flood-prone areas also improve water quality and overall environmental quality (Kirshen et al., 2005).

Other times simply changing operations can have a positive effect. Seattle Public Utilities (responsible for supplying drinking water to more than 1.45 million people from the Cascade Mountains) has developed and applied a number of adaptation strategies to enhance the water supply system while also meeting stream flow requirements for fish. In 2005, the record low winter snowpack created deep concern for water supply availability in the summer, thus Seattle Public Utilities captured more water in storage than during a normal year. This provided enough water to return to normal by the early summer (City of Seattle, 2006).

Two types of adaptation measures are being undertaken in the US – most are reactive, and some are proactive. However, there is a strong argument in the literature that the most cost-effective solution is to be proactive (plan for 50-100 years) (U.S. Department of State, 2002). This can be difficult for local governments with the short-term horizons of local plans and budgets, which are at odds with the long-term implications of climate change (Wilson, 2006). By taking climate change into account for long-term decision making, removing disincentives and introducing incentives to modify behaviour, the capacity to cope will improve. This approach makes sense for long-term investments and the design and organization of institutions, and calls for the better design, reform, and

coordination of government policies and programs. Measures taken now can minimize property damage, reduce eventual costs, maximize the ecological health of ecosystems and are generally of lower cost (Luers and Moser, 2006).

Being proactive about anticipating future change can add value to infrastructure investments at low additional cost. For example, adding a reclaimed water system onto a planned wastewater treatment system expansion reduces the marginal cost of adding a reclaimed water system in the future while providing a buffer for projected reductions in water supply (The Climate Impacts Group, 2007).

Proactive adaptation can be facilitated through a variety of mechanisms including infrastructure planning and development, knowledge and learning, institutional design and reform, avoidance of maladaptation, technological innovation, and risk and disaster management and response. The adequacy and preparedness of relief systems and programs is particularly important, such as fire mitigation programs that include prescribed burns and land use controls to reduce risk. All of these mechanisms are governed or influenced by public policy, showing the important role that government has in proactive adaptation (U.S. Department of State, 2002).

3.3 Climate Change Policy Toolbox

The range of potential adaptive responses available is large, from technological solutions such as sea defences to policy such as planning regulations (Intergovernmental Panel on Climate Change, 2007). Just as the impacts of climate change will vary from area to area, the combination of institutions and legal and political tools available to elected decision-makers are unique from region to region. Preparedness actions will need to be tailored to the circumstances of different communities, and often can be merged with existing planning efforts, such as when updates to community water supply plans or development master plans are occurring (The Climate Impacts Group, 2007). The majority of cities have been slow to incorporate adaptation into policy, and what has occurred has been piecemeal and unsystematic. However, there are a number of positive examples where cities have incorporated climate change factors into the planning and implementation of specific projects (Ligeti et al., 2007). Appendix A provides a more detailed list of tools and actions that some urban regions are considering by sector (Ligeti et al., 2007).

This section covers examples of institutional arrangements and comprehensive planning, regulation and design, expenditures, and information and incentives. All of these responses form a toolbox of strategies for local governments to respond to climate change. Often a mix of actions and policies help achieve the desired outcome (Natural Capital Solutions, 2007). The following case study from Goleta, California[2] indicates how policies, information and incentives, regulation and design, and government expenditures came together to achieve water conservation and avoidance of a large capital cost.

[2] Source: [Natural Capital Solutions, 2007. Climate Protection Manual for Cities.]

CASE STUDY

In 1989, Goleta was facing drought and a possible multi-million dollar expenditure to meet the Environmental Protection Agency's (EPA) sewage treatment standards. The town decided to spend $1.5 million on a variety of activities such as: providing incentives to buy ultra low-flow toilets, changing tariff structures and implementing universal metering, giving away high-performance showerheads, developing water restrictions, and offering information and surveys of outdoor water-efficiency opportunities. These actions resulted in a 30% reduction in water consumption, which was twice the target. The existing sewage treatment plant met the EPA standards as a result of a 40% reduction in sewage flow, and the plant expansion was deferred indefinitely. Goleta was then prepared for the drought of 1990, avoiding the disruption and difficulties that nearby communities faced.

3.3.1 Institutional Arrangements and Comprehensive Planning

Much of the literature points to the need to have institutional design and structure be reformed to have more coordinated efforts to deal with climate change adaptation (Terhune, 2007; Intergovernmental Panel on Climate Change, 2007, Thompson et al., 2006; U.S. EPA, 2006; Kirshen et al., 2005). Institutions need to be flexible, coordinated, and open to partnerships in order to respond, learn, conduct research, monitor outcomes, and provide reliable information. For example, there is a need to create new authorities to manage water in watershed basins and to confer property rights to water. This would encourage conservation, recycling, and reuse of water by all users, and to manage the resource for multiple stakeholders such as industry and natural resource management agencies (U.S. Department of State, 2002).

Along with a shift to more coordinated actions, there is a need to undertake adaptive plans on a broad scale. The United Nations has an Adaptation Policy Framework (APF) that can be used to implement responsive adaptation strategies, policies and measures. The APF begins with scoping and designing an adaptation project, assessing current vulnerability, assessing future climate risks (building awareness of the threat), formulating an adaptation strategy, and continuing the adaptation process (Burton et al., 2004).

Leaders in the field at the local government level in the United States include King County, Washington; Boston; and ICLEI (Local Governments for Sustainability). In King County, which is a large area that includes Seattle, an inter-departmental climate change adaptation team was formed in 2006. The purpose of the team is to build scientific expertise within county departments to ensure that climate change issues are considered in all policy, planning and capital investment decisions. The County has partnered with the Climate Impacts Group out of the University of Washington to develop adaptation actions, such as developing water quality and quantity models and monitoring programs. King County has a Climate Plan with a detailed adaptation section outlining goals in six strategic focus areas: climate science; public health; safety and emergency preparedness; surface water management, freshwater quality, and water supply; land use, building, and transportation; financial and economic impacts; and biodiversity and ecosystems. The proposed actions in these strategic areas include research, outreach to the public, updating

plans, technical analysis, reviewing policies and investments, and collaborate with other organizations (Easterling et al., 2004; King County, 2007).

King County has also produced a guidebook to help local governments across the country prepare for climate change (Daley, 2007). The guidebook leads local, regional, and state governments through a multi-step process to become better prepared. The first step is to undertake a climate resiliency study and to scope climate change impacts in major sectors and in planning areas. Part of this step includes building a climate change preparedness team and garnering stakeholder and political support. The second step is to identify priority-planning areas for action and to undertake vulnerability and risk assessments. The third step is to develop a climate change plan for the priority areas including establishing a vision, setting preparedness goals, and developing and selecting preparedness actions. The fourth step is to develop an implementation plan including identifying important implementation tools, and ways to manage risk and uncertainty. The last step is to set up a monitoring system to measure progress and results through measures of resilience, to review assumptions, and update plans regularly (The Climate Impacts Group, 2007).

Boston participated in a multi-year CLIMB project (Climate's Long-term Impacts on Metro Boston), which was a large scale integrated urban study with the aim to produce a replicable set of processes and principles for analyzing, modeling, and developing a consensus for climate change adaptation strategies. The study was funded by the U.S. Environmental Protection Agency, took four years and covered 100 municipalities in six counties. The project documented and analyzed Boston's infrastructure systems, the forces behind infrastructure change, effects of climate change on that infrastructure, and identified research and policy needs to prepare for impacts. From a practical standpoint, the project tied the impacts of climate change on urban infrastructure and on urban socioeconomics together. In terms of process, the CLIMB project was a good example of stakeholder and public consultation (in the first part of the study). Stakeholders were involved through a transparent modeling process and through consensus building, and the public was put at the centre of the process in building the adaptation plan. A good infrastructure design process includes giving stakeholders a choice of their preferred applications from a range of options and including people from all stakeholder groups in the decision-making (Funkhouser, 2007).

On the other hand, a review of how Boston was progressing after the study was completed revealed that climate change adaptation was no longer on the radar of municipalities in the greater region, and no institutional mechanism had been created to take the project forward. Reasons given for this failure included the technical nature of the study, lack of stakeholder participation in the last two years of the study, the large number of jurisdictions within the region who are territorial, and lack of authority given to the Metropolitan Area Planning Council (the regional body). (Ligeti et al., 2007)

The ICLEI has a Climate Resilient Communities Program, begun in late 2005. The purpose is to help local governments prepare for global warming impacts and to establish a nationwide network of Climate Resilient Communities that would be able to share learning and resources. The initial participants include Miami-Dade County, Keene in

New Hampshire, Ft. Collins in Colorado, and Homer in Alaska. The ICLEI also has a California-based arm to help local governments assess their adaptation needs and prepare for the effects of climate change. The program works with participants to develop a five-step process similar to what the ICLEI/ King County Guidebook suggests. Participants also learn to use tools and develop strategies that reduce hazards and manage risks related to regulations, planning, urban design, and investments, reduce costs associated with disaster relief, and prioritize vulnerabilities such as infrastructure, zoning, and water capacity (Pew Centre on Global Climate Change, 2007; Miller, 2007).

Miami-Dade County has responded by forming a Climate Change Advisory Task Force which consists of expert stakeholders and a committee structure in various areas such as natural systems adaptations; economic, health and social issues; and intergovernmental affairs to communicate with other local governments and state and federal governments. They are currently beginning to conduct a comprehensive review of capital and financial planning, and analysis of natural systems and infrastructure to identify vulnerabilities. They have found, for example, that in southern Florida, the drinking water supplies from groundwater could end up being contaminated by salt intrusions from rising sea levels (Miller, 2007).

Existing institutions designed to address common water issues such as the U.S.- Canada Great Lakes Commission and joint commissions and agreements cover the Colorado and Rio Grande rivers could provide the framework for designing adaptive measures for responding to the effects of climate change. The U.S. - Canada Great Lakes Commission has already conducted studies to evaluate options for dealing with the potential increased evaporation, shorter duration of lake ice, and other changes projected to affect the Great Lakes – St. Lawrence River basin. Close coordination is especially needed with water resources to efficiently manage levels of water supply and to maintain water quality (U.S. Department of State, 2002).

Two comprehensive plans that address mitigation and adaptation *include PLANYC: A Greener, Greater New York* and *Seattle's Climate Action Plan* which both call for inter-governmental and inter-departmental task forces to prioritize climate change related issues and make recommendations on adaptive measures and timing. Efforts in comprehensive adaptation planning are underway, with the plans due at the end of 2007. Seattle will examine water supply, hydroelectricity, stormwater management, urban forestry, building codes, emergency planning, and transportation, among other issues (City of Seattle, 2006). The New York Climate Change Task Force expects to release a report on its work in the near future. The report will include an analysis of likely climate impacts on New York's water system, an outline of issues for decision-makers to consider and a planning checklist. It is unclear whether the Task Force will continue its work when this report is concluded (Ligeti et al., 2007).

Another example of a comprehensive study is the Gulf Coast Study being conducted by the U.S. Department of Transportation. The central gulf coast was selected as it has unique transportation modes and a geographic location making it particularly vulnerable to sea level rise and the threat of severe weather events. The study is to be conducted in three phases with completion at the end of 2007. Phase 1 is an integrated geospatial

overview of climate and weather trends and projections, overlaid with economic, environmental, and geographic data. This will include an assessment of relative risks and vulnerability to transportation infrastructure and facilities. Phase 2 will be to identify adaptation strategies and develop analytical tools that stakeholders can use to assess adaptation options (U.S. EPA, 2006).

While comprehensive planning is a key tool, as the Boston example indicates, a critical stage in the development of adaptation processes in cities is to establish effective institutional mechanisms for moving the process forward. Lessons learned thus far indicate that this should include an ongoing forum to bring stakeholders in city government and other relevant organizations together to stay updated on climate impacts and to discuss adaptation options and strategies. In addition, local governments should create guidelines to integrate climate concerns and adaptation into decision-making and policy, dedicated staff needs to be assigned that report to the executive level, and funds should be allocated for staff time and research, analysis, workshops, conferences, and other activities. Preferably local governments should create linkages with climate research institutions to assist with the in-depth analysis that some adaptation decisions require (Ligeti et al., 2007).

3.3.2 Land Use Planning

Land use planning at a local level has a critical role in promoting preventative adaptation (Wilson, 2006). Present and future land use can greatly affect the magnitude of climate change impacts. The distribution of the population affects the location of infrastructure, and land use affects flood magnitude and losses, water quality, water availability, and local heat island effects (Kirshen et al., 2005).

Local power to regulate land use comes from a state's power to enact legislation to promote the health, safety, and welfare of its citizens. This control can take the form of having the authority to adopt comprehensive land-use plans and community plans and their associated zoning ordinances and subdivision regulations. This allows local governments the ability to restrict shoreline, floodplain, or wetland developments, and to conserve migration corridors that could improve the likelihood that some species survive as climate change impacts are felt (Pew Centre on Global Climate Change, 2007).

Areas most at risk include coastal areas and areas prone to flooding. In the United States, there has been aggressive building along coastlines in the last fifteen years. More than 86 million people live in communities along the hurricane-prone Atlantic and Gulf coasts. By 2004, there was more than $7.2 trillion in insured property in these at-risk communities. The insurance industry is an advocate of proactive land use planning to prevent weakening of natural defences against storms and to consider the risk of natural disasters in zoning decisions (Racicot, 2006). Insurers are encouraging policymakers to make hard decisions around development in fragile areas such as coastal areas and forest fringes. Some companies are even refusing to insure property located in such areas. Others are contributing to programs for the conservation of mangroves and wetlands, which sequester carbon while providing a natural buffer from storms, surges, and waves (Anderson et al., 2006).

In the case of sea-level rise, development will need to be limited in low-lying coastal areas. However, sea-level rise is not an easy process to predict because of the rate of change and shifts in wave activity and because storm surges are not well understood. The first step to take is to gather data about shorelines and develop geographic information systems (GIS) models to measure and model the possible effects on natural resources and human habitat on the coast. Cities need to work with major coastal conservancies, counties, states, and federal agencies to develop a baseline of land-use data (Natural Capital Solutions, 2007). Examples of policies and activities to deal with sea level rise include land acquisition programs, comprehensive planning for investments and protection in coastal areas, prohibition of shoreline armoring, setbacks, and acknowledgement of storm evacuation potential in land use plans. An innovative example from Texas, which is now being used in Maine, Rhode Island, South Carolina, and Massachusetts is the establishment of rolling easements, which is an entitlement to public ownership of property that rolls inland with the coastline as the sea rises. Coastal landowners and conservation agencies are able to purchase the required easements. Setbacks are considered a less desirable measure, because once the development line becomes fixed, there is no accommodation for sea level rise, and expensive fortifications against the ocean will have to be installed (Easterling et al., 2004).

3.3.3 Regulation and Design

The infrastructure systems that support society are vulnerable to climate change, and in many cases changes to infrastructure design characteristics and building codes done relatively inexpensively can increase resilience to climate change, such as the approach taken in earthquake-prone areas (Easterling et al., 2004). Building codes could be adopted that require energy-efficient construction materials and designs to reduce heat build-up in dense urban areas. A requirement for the construction of thermal shells around buildings to insulate them from extreme temperatures may be needed (Kirshen et al., 2005). Design models for infrastructure using 50-year old rainfall data or the 100-year storm as the norm may have to be changed to using information from the last decade, where the 100-year storm is the new 10-year storm, and urban infrastructure will have to be increased to handle more intense storms (Funkhouser, 2007). Cities could include the expected impact of climate change in environmental reviews of new construction and building codes (Daley, 2007).

A shift to developing sustainable infrastructure needs to occur, including a set of planning processes, design principles, regulations and sustainable applications. For example, in stormwater management, sustainable applications include rainwater harvesting and porous pavements and natural swales to deal with flooding and drought. Regulations have the power to control runoff from new developments. In Lacey, Washington (not far from Seattle), the city has developed a zero effect drainage discharge ordinance, and in Santa Monica, California, the city requires all new homes and redevelopments to include designs to offset runoff from increased imperviousness through capture and reuse or infiltration. An outside of the box idea may be to retrofit culverts and curb and gutter systems with micro hydropower systems to create power from rain in order to provide emergency backup during heavy storms (Funkhouser, 2007).

CASE STUDIES

BOSTON

An interesting example of changing infrastructure design comes from Boston, where the Massachusetts Water Resource Authority (MWRA) designed a sewage treatment plan for the greater Boston metropolitan area with regard to sea-level rise. Raw sewage collected from communities on shore is pumped under Boston Harbour and up to the treatment plant on Deer Island. After the wastes are treated, the effluent is discharged into the harbor through a downhill pipe. The MWRA originally planned to lower the level of Deer Island about half a metre to be closer to sea level. This would reduce the costs of pumping untreated sewage from the shore up to the treatment plant. However, design engineers were concerned that sea-level rise would necessitate construction of a wall around the treatment plant to keep the sea out. The effluent would then need to be pumped up over the wall and into the harbour. Such a pump would cost several hundred million dollars. To avoid such a cost, even though it might be decades before it would need to be installed, the designers decided to leave the island at a higher elevation.
Source: Coping with Global Climate Change Pew Report

SEATTLE

The Office of the City Auditor in Seattle has initiated a series of reviews on how changes in climate could impact various city departments. The first review focused on the Department of Transportation's operations, services, and infrastructure. In the report, the City recognized that the sea- level rise figure used in design standards for the Alaskan Way Seawall replacement was too small (0.9 feet over 75 years). New information from the Climate Impacts Group predicts a sea level rise of up to 2.8 feet over the same period. Thus, the City Auditor recommended that the Department obtain a comprehensive, independent analysis that considers all available scientific sources to estimate the probabilities of the increase and rate of increase in sea-level. Department planners and engineers agreed that newly constructed seawalls would need to be stronger, higher, or both, to accommodate higher water levels and stronger tide forces in the future.
Source: Cohen et al., 2005 (Report of Office of the City Auditor)

An important lobby for the promotion of appropriate building materials and improved building codes comes from the insurance industry. The industry is funding research and is advocating effective building codes that mandate standards for survivable construction and durable materials that can withstand severe storms and flooding (Racicot, 2006). For example, in North Carolina, the American Insurance Association is urging the North Carolina Building Code Council to have provisions for wind load design and wind borne debris protections in all residential properties in areas subject to wind speeds of more than 110 mph. The code council has been reluctant to do so, while other states have adopted the full provisions. This will affect insurance rates in the future, as the U.S. Federal Emergency Management Agency (FEMA) has considered adoption of building codes and mitigation in setting flood insurance rates and discounts and they may reduce relief programs in areas that have not set adequate standards. In addition, the Insurance Services Office has a program called the Building Code Grading Enforcement System (BCEGS) that rates the adoption of proper codes and enforcement in local municipalities. If counties and communities receive downgraded BCEGS ratings, insurers will increase their rates (Unnewehr, 2007).

The insurance industry is also researching win-win approaches for climate change with highly energy efficient buildings that incorporate protection against wind, fire and water damage. They are also beginning to provide discounts and credits to encourage property owners to use mitigating and green building in repairs to encourage the reduction of greenhouse gas emissions (Anderson et al., 2006).

3.3.4 Expenditures

Some of the tools in the climate change policy toolbox can be implemented at little cost, and as the previous case study from Goleta, California demonstrates some expenditures are worthwhile as they create savings in the long run. Some of the most expensive expenditures for climate change adaptation are capital and physical investments such as shoreline protection measures (e.g. dikes, bulkheads, beach nourishment). Other costly expenditures include compensation for inland retreat, land purchases, and damage claims from extreme weather events. For example, New Jersey spends $15 million a year for shore protection (U.S. Department of State, 2002). King County has a flood buyout and home elevation program that purchases homes in areas prone to floods or serious erosion, or that assists homeowners with the costs of raising the finished floor of the home above the 100-year flood level (Ligeti et al., 2007).

In comparison, preventative programs such as public outreach, offering grants and other incentives, and purchase of beneficial products and items are a cost-effective strategy. For example, in Chicago, the city has installed waterless urinals, planted thousands of trees around patches of heavy asphalt and black roofs that exacerbate the heat island effect, and distributed more than 500,000 compact fluorescent bulbs (Washington Post, 2007). In Florida, there is a new state-funded program that provides free inspections of eligible homes and business to help them comply with the latest building codes (Racicot, 2006). Other areas of expenditure include technology (such as desalinization plants and using reclaimed wastewater), developing monitoring programs, contributing to environmental restoration activities, improving disaster management programs, and moving or changing infrastructure.

3.3.5 Information and Incentives

Outreach and education are key components in improving community awareness of climate impacts and garnering support for adaptation within government and among the public. Communications can be used to effect voluntary change at the individual household level, such as with water conservation or with the risks of building homes in vulnerable coastal zones (The Climate Impacts Group, 2007). Local governments can also provide guidance for developers in incorporating climate change into planning and development decisions. Outreach strategies can include maps of vulnerable areas, newsletters, public presentations, workshops, dedicated websites and factsheets, brown bag lunches, home visits, and conferences. The media can be alley in these efforts -- Seattle and King County have been successful in using the media to draw attention to climate change impacts (Ligeti et al., 2007). Box 1 provides a listing of specific examples of information tools helpful in climate change preparation.

BOX 1: Specific information tools for climate change preparedness

- Offering free public courses on xeriscape gardening techniques
- Providing education about vector-borne diseases to counteract outbreaks
- Developing forecasting and public communications systems for extreme weather
- Telephone hotlines with up to date and accurate information on heat resources and medical advice, reverse 911 calls to seniors and those at risk
- Contacting the media with tips on how vulnerable individuals can protect themselves from the heat, and where to go to cool off
- Leading cities, counties, states and organizations providing best practices on adaptation
- Making information from state and federal agencies accessible, e.g. the U.S. Geological Survey has relevant coastal information, the National Oceanic and Atmospheric Administration provides weather forecasts and remotely sensed environmental data, and FEMA prepares Flood Insurance Rate Maps

Adapting to and integrating climate change risks will require more flexible, innovative, and forward-looking approaches. Policy and legal changes and incentives are powerful instruments in the climate change adaptation toolbox. For an individual or business to act, they often need to perceive or receive rewards and benefits (OECD, 2006). In addition, local governments need to ensure that their regulations, economic instruments and policies do not provide perverse incentives (causing maladaptations) such as encouraging building in sensitive areas. Incentives can be in the form of tariff/fee structures, grants, changes to property taxes, pricing, and financing. Box 2 provides a listing of specific examples of incentive-related tools helpful in climate change preparation.

BOX 2: Specific incentive tools for climate change preparedness

- Incentives for purchase and use of high-efficiency appliances and irrigation systems
- Use of market-based instruments such as efficient water pricing and water markets -- this reduces demand during critical periods. (e.g., demand response incentives to pay people to not use water during shortages or increase the cost of water during shortages)
- Grants to purchase solar panels and other alternative energy technology
- Privatize the risk of insuring and financing coastal development (risk-based insurance for properties, floods and droughts)
- Voluntary and incentive programs that encourage energy efficiency and conservation
- Incentives to move people and structures away from floodplains
- Incentives for the installation of high efficiency air-conditioners and furnaces to reduce energy demand during heat
- Incentives for developers to construct green roofs and to climate-proof new buildings

4. EVALUATING POLICY OPTIONS

It is recognized that adaptation will be messy, possibly expensive, and not guaranteed to work. Thus, the literature emphasizes that the worthiness of adaptation strategies and actions need to be carefully weighed. The expected value of the avoided damages should be compared against the costs of implementing the action or strategy. Successful adaptation strategies should be designed to be flexible and effective under a wide variety of potential climate conditions and greenhouse gas emission scenarios, be economically

efficient (benefits exceed costs), and increase overall adaptive capacity (Easterling et al., 2004).

However, at the present there are more questions than answers. There is no clear picture of the limits to adaptation, or the cost, because effective adaptation measures are dependent on specific geographical risk factors and key vulnerabilities such as magnitude, timing, and persistence/ reversibility and on institutional, political, and financial constraints. The barriers, limits and costs are not fully understood. Some barriers include environmental, economic, informational, social (such as values), and behavioural. The assessed literature does not indicate how effective various adaptation options are to fully reduce risks, particularly at the higher levels of projects warming, and for vulnerable groups (Intergovernmental Panel on Climate Change, 2007).

It is also important to consider the interactions of various stresses when developing effective responses. Climate variability and change will interact with existing environmental stressors such as habitat fragmentation, wetland loss, deforestation, air and water pollution, coastal erosion, and reductions in fisheries. These factors increase the sensitivity of the environment to climate change, as does an aging population and rapidly growing populations in cities and coastal areas (where more and more vulnerable structures are being built) (U.S. Department of State, 2002).

The questions that remain in the minds of researchers include: “What specific measures of responses to climate change exist, are comparable, globally implementable, and most appropriate? And what specific conditions produce and reproduce the social and political capital necessary for such responses? “ (Thompson et al., 2006).

In leading cities that are beginning to plan for adaptation options, efforts to assess whether existing or proposed measures are adequate have not been completed, and preferences for specific types of adaptation options have not been expressed. A more systematic approach to the identification and review of adaptation measures remains to be accomplished. This is mostly because the efforts of local governments to incorporate climate change adaptation into policies is new and at the draft stage. Thus, it is not possible to provide an evaluation of alternative approaches for efficiency or for being the most promising. However, Appendix B provides some preliminary questions to consider when identifying adaptation options, and some background on measures of resiliency which can be used to inform the development of implementation options.

An exception is the CLIMB project that included a comprehensive evaluation study of options for adaptation. The study examined overall monetary and environmental costs for three adaptive strategies: 1.”Ride-it-Out” which is focused on rebuilding after being damaged by climate-related impacts; 2.”Build-Your-Way-Out” which uses limited pre-emptive actions such as coastal protection by “hardening” shorelines with sea walls and bulkheads; and 3. The ”Green” scenario that looks at pre-emptive actions such as new building codes for greater energy efficiency, early warning systems, and revising standards and upgrading. The study revealed that doing nothing to prepare for climate change would result in the greatest amount of damage and the highest possible costs to governments and residents in the Boston region. Scenario two was the second most costly

option in most locations, and Scenario three had the lowest costs in most locations with the greatest environmental benefits (three times less than Scenario one). However, the study also found that infrastructure requirements such as realignment of roadways, many of which run through river valleys, could not be justified on a cost-benefit basis. Thus, increased delays during large storms are a nuisance that motorists will likely endure as the frequency of extreme rain increases (Kirshen et al., 2005).

In addition, as mentioned in Section 3.2, the case has been made that in general, more preventative adaptation options (such as programs to reduce the urban heat island effect) are more cost-effective than reactive options (such as heat alert and response systems). This has been documented in the case of changing building standards to account for major hurricanes. The 2004-2005 hurricanes in Florida provide evidence of reduced frequency of hurricane claims and a much lower amount of damage per home in homes built to modern wind standards. A study by the Institute for Business and Home Safety on hurricane damage caused from Hurricane Charley, showed the dramatic differences in homes built before 1996 (when modern wind standards were adopted), and those built in 1996 or later. The average amount of damage was twice as high for homes built before 1996, and about 40% of newer homes did not need roof covering replacements, garage door replacements, and did not have window glass and/or frame damage (Unnewehr, 2007).

However, there may also be situations where postponing adaptive responses is justified. Uncertainty, cost considerations and additional time needed to gather more information through research and monitoring are valid reasons (Paavola and Adger, 2006). Even in these cases, there may be "no-regrets" strategies that can be implemented in the meantime. Sometimes proactive and reactive responses can complement each other as in the building of additional water storage capacity (*proactive*) used to complement and facilitate water rationing (*reactive*) (The Climate Impacts Group, 2007).

5. CONCLUSION

This research paper set out to address three questions. The first was to identify what local governments in the United States are doing in anticipation of climate change; the second was to indicate what set of actions would give the greatest return on investment; and the third was to examine what actions have already made a difference or are most promising independent of efficiency considerations. The key findings indicated that climate change will pose significant challenges for cities in the future, and that overall, few local governments have begun to prepare for climate change. However, there are some leading examples of projects, planning activities, and a mixture of tools that cities are using to combat existing problems and to begin to prepare for climate change. The literature seemed to concur that proactive strategies are generally more effective cost-wise and operationally than reactive approaches. There was also consensus on the need to change institutional mechanisms and to have more coordinated efforts in dealing with climate change. In addition, many adaptation options that are worth doing anyway ("no regrets") can be implemented immediately.

More understanding is required on risks, local effects, and when impacts will occur. Very few local governments and states have moved passed examining impacts and assessing risk and vulnerabilities to implementing concrete actions. Thus, it was very difficult to answer the second and third research questions about specific actions or sets of actions. In order to do so, increased monitoring of local climate systems is required and pilots of specific adaptation options need to be implemented for evaluation purposes.

In sum, the International Panel on Climate Change recognizes that more extensive adaptation than is currently occurring is required to reduce vulnerability to climate change (Intergovernmental Panel on Climate Change, 2007). Or put more directly, the Pew Centre on Global Climate Change stated that, "in reality, we are more likely to muddle through, taking adaptive actions as necessary, but often not doing what may be needed for optimal or ideal adaptation" (Easterling et al., 2004). The experiences of leading cities indicate that adaptation will require leadership, persistence, and knowledge to establish a culture of climate change preparedness. Further learning on urban systems and how they interact with climate and each other is needed.

To that end, it is recommended that an in-depth analysis of local governments around the world about lessons learned including opportunities and constraints in developing and adopting adaptation strategies be undertaken to further the research efforts in this report. It will continue to be important for cities and states/ provinces to share and learn from each other as the road to adaptation continues.

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APPENDIX A: List of Possible Adaptation Options

SECTOR or SYSTEM	ADAPTATION OPTIONS
Water Supply	• Conduct baseline monitoring and inventories for: o Water resources o Condition & capacity of water distribution and treatment systems o Number, size & location of businesses with high water demand • Implement enhanced conservation & demand management programs to counteract increased water demand and potential decrease in supply, e.g. o Leak identification & repair o Metering and increased water prices o Efficiency standards for appliances o Xeriscaping o Restrictions in periods of drought, etc. • Develop additional reservoir capacity • Capture and reuse rainwater for irrigation and other uses • Reclaim and reuse grey water or water from sewage treatment (in place in King County) • Prepare plans to balance the needs of competing users when water availability is reduced
Stormwater/ Flooding	• Prepare high resolution topographic mapping to identify high risk areas • Implement sustainable urban drainage systems including: o Permeable pavements o Green roofs to increase on-site retention of stormwater o Increased use of stormwater retention ponds, constructed wetlands • Create natural eco-system buffers for vulnerable water bodies, low-lying areas • Expand capacity of storm sewers to manage extreme weather events • Institute land-use planning and zoning to avoid buildings and infrastructure in flood or landslide prone areas • Flood-proof buildings in vulnerable locations
Energy	• Expand conservation, energy efficiency and demand side management strategies to reduce demand on hydropower systems dependent on snowpack or vulnerable to drought, and to reduce peak loads during heat waves that make transmission systems vulnerable to blackouts • Increase street tree planning and maintenance, green roofs and high-albedo surfaces to reduce urban heat and unsustainable energy demand for air conditioning • Amend building codes to decrease energy needs for cooling • Implement weatherization programs to reduce building loads, especially for low-income people • Invest in distributed energy systems such as cogeneration, and local renewable energy systems to reduce vulnerability to transmission interruptions from storms and high winds • Invest in increased power generation to meet peak demands
Transportation	• Assess opportunities to extend the winter shipping season • Evaluate the vulnerability of port facilities and associated infrastructure due to changes in water level, increased wave activity, storm surges and ice pile-up • Raise levels of dykes in areas vulnerable to flooding • Relocate coastal roads, rail lines and other infrastructure subject to sea-level rise • Assess and retrofit vulnerable transportation infrastructure systems such as culverts, tunnels, bridges, subway entrances, etc. • Ensure critical components such as switch gear or substations are above flood levels • Investigate transportation modal shifts (from subways to private cars, for example) in response to high heat • Ensure alternative routes are available in case of disruption and/or need for evacuation
Buildings	• Take account of the increased risks of flooding, heat waves, intense storms, windspeed and other climate change effects on building developments • Strengthen building code requirements to reduce heat gain in summer • Design drainage systems and entrance thresholds to cope with more intense rainfall

Buildings continued	• In areas with flooding potential, use ground-floor spaces for flood-compatible uses such as car parking, or raise the ground floor above likely flood levels • Design buildings for improved natural ventilation • Utilize green roofs to insulate against heat gain and reduce stormwater runoff • Ensure roof systems and cladding materials can cope with higher wind speeds • Increase use of swales and on-site water storage • Use permeable surfaces wherever possible
Urban Ecosystems	• Protect existing ecosystems (parks, tree stands, waterways, ponds, lakes, ravines, wetlands, etc.) and develop connected greenway system to allow natural species migration • Consider designation of coastal hazard zones and limits on development in high hazard areas • Adopt erosion setback requirements • Restrict new development in existing green spaces • Create and protect green spaces in low-lying areas that might serve for flood management • Increase shoreline buffers to protect against increased runoff from more intense storms • Plant diverse trees species and shrubs with a broad range of environmental tolerance • Enhance conditions for street tree survival and growth (increase space for roots, control soil compaction, increase watering and maintenance) • Monitor and control pests and invasive species that can expand with warmer winters
Health	• Conduct public education on climate-related health threats (vector-borne diseases, heat, air pollution, floods and storms) and prevention • Interventions to reduce heat island effects including: o Increased street trees and tree canopy coverage o Increased parks and green spaces o Green roofs o High albedo (reflective) building and road surfaces o Heat alert systems o Heat response systems (cooling centres, water distribution, etc.) • Interventions to reduce air pollution impacts, especially emissions reduction measures including: o Traffic restrictions o Restrictions on processes and materials releasing volatile organic compounds o Improved public transport o Pollution warning system • Interventions to prevent impacts from expansion of vector-borne diseases o Early detection and warning systems o Spraying to control infestations o Control of other factors that support the expansion of disease-carrying insects (e.g. standing water) • Interventions to reduce health and security impacts from extreme weather events o Early warning systems o Flood protection systems (see Stormwater/Flooding section above) o Emergency response systems

Excerpted from Ligeti et al., 2007

APPENDIX B: Tips for Measuring Adaptation Options and Resiliency

REVIEWING ADAPTATION OPTIONS

The United Kingdom Climate Impacts Programme suggests a number of simple questions that could guide decision-makers through a review of adaptation options, including:

1. ***What type of options should be considered?***
(Education, more research, increasing resilience, fortification, emergency response, etc.)

2. ***What generic strategies have others identified?***

3. ***What are the likely consequences of the "do nothing" option?***

4. ***Can "no regret" and "low regret" options be identified?***

5. ***Can flexible options that allow for uncertainty be identified?***
Some measures can be phased in over time in response to increasing risk, for example.

6. ***Is it urgent to make a decision now or is delay an option until further information is available?***
Consider:
Expected climate changes over the lifetime of the system or structure under consideration;
The extent of the risk; and
The value to be gained from improved monitoring or research.

Excerpted from Ligeti et al., 2007

A MEASURE OF RESILIENCE
is a quantitative or qualitative judgement that you develop and track over time to determine how well a preparedness action meets the preparedness goals you have set in a given priority planning area.

MEASURES OF RESILIENCE

Measures of resilience are tools that can be incorporated into performance measurement systems, budget processes, or community indicator reporting. The measures should be based on guiding principles used to develop the municipality's preparedness goals. These guiding principles can be reframed in the form of questions to see if they are meeting the vision that was set. The ICLEI guidebook provides an example of five questions with relevant measures of resilience based on sample guiding principles.

1. Has awareness about climate change and its projected impacts on your priority planning areas increased? Is there support among your government, your community and your stakeholders to prepare for climate change impacts?

(Guiding Principle #1: Increase public awareness of climate change and its projected impacts on your community.)

Potential ways to measure public awareness about climate change impacts:

- Community surveys tracking participation in public meetings on climate change impacts;
- Surveys tracking "hits" to community-sponsored climate change webpages;
- Surveys tracking requests for climate change-related publications (e.g., fact sheets, brochures, reports);
- Surveys evaluating trends in the number and types of questions or comments received by government agencies about climate change in your priority planning areas;
- Surveys of the number of media stories about climate change impacts in your region;
- Qualitatively, whether public officials understand 1) how climate change impacts relate to major decisions in your priority planning areas and 2) how those decisions could reduce or increase climate change vulnerabilities or risks.

2. Have you increased technical capacity in your government and community to prepare for climate change impacts in your priority planning areas? Is this technical capacity being used effectively to evaluate vulnerability and risk in your priority planning areas?

(Guiding Principle #2: Increase your technical capacity to prepare for climate change impacts.)

Potential ways to measure technical capacity to prepare for climate change impacts in your priority planning areas:

- Number of technical experts you have on staff who can advise you on the latest research about climate change impacts in your priority planning areas, and/or the existence of an ongoing relationship with outside climate science advisors;
- The existence and regular use of ongoing forums for sharing the latest information on climate change in your priority planning areas with internal and external stakeholders, including government employees, the business community, and the general public.

3. Is climate information being considered in decisions in your priority planning areas? Is there a formal mechanism in place that "mainstreams" or otherwise facilitates climate change preparedness in your priority planning areas?

(Guiding Principle #3: "Mainstream" information about climate change vulnerabilities, risks, and preparedness into planning, policy, and investment.)

Potential ways to measure the "mainstreaming" of climate change information and preparedness in your priority planning areas:

- The number of plans or other governing documents in your priority planning areas in which climate change is addressed qualitatively or quantitatively;
- Existence and thoroughness of guidelines on how to integrate new or updated information on climate change vulnerability, risk and preparedness into decision making;
- Existence and number of dedicated staff to help facilitate preparedness actions across departments and external stakeholders (or the amount of additional staff time used for implementation of climate change preparedness actions);
- Existence and amount of funds for vulnerability and risk assessments, preparedness actions, and measurement of resilience;
- Existence of forums which have been established for information sharing about vulnerabilities, risks and preparedness; information about who attends these forums, what information is shared and used, and how information is shared and used.

4. Are your actions increasing or maintaining the adaptive capacity of built, natural, and human systems in your priority planning areas?

(Guiding Principle #4: Increase the adaptive capacity of built, natural, and human systems in your community.)

Potential ways to measure the adaptive capacity of built, natural, and human systems in your priority planning areas:

- Survey or accepted media coverage of how well your community handles an extreme heat event, a drought, or 100-year rain event before and after certain preparedness actions have been implemented (with the understanding that each event is unique, such that a direct comparison is not always possible);
- Amount of money you have saved (or not) based on an implemented preparedness action, such as an improved flood hazard management plan, improved regional levee system, or other infrastructure investments made to improve adaptive capacity;
- Indication of the health of regional fish and wildlife based on observations by leading ecologists and/or monitoring.

5. Are community partnerships in place to enable the most robust decision-making possible for climate change preparedness in priority planning areas? Have you engaged community stakeholders in development and implementation of your preparedness actions in your priority planning areas?

(Guiding Principle #5: Strengthen community partnerships that reduce vulnerability and risk to climate change impacts)

Potential ways to measure community partnership and stakeholder engagement in decreasing vulnerability and risk in your priority planning areas:

- The existence and regular use of ongoing forums for sharing the latest information on climate change with internal and external stakeholders, including government employees, the business community, and the general public (also noted above as a measure of technical capacity);
- The existence of "consensus" reports on vulnerabilities and risks in your priority planning areas, developed collaboratively by a full range of stakeholders;
- The existence of a community task force or citizens' advisory panel on climate change preparedness in your priority planning areas, representing a range of different community perspectives and other specific interests.