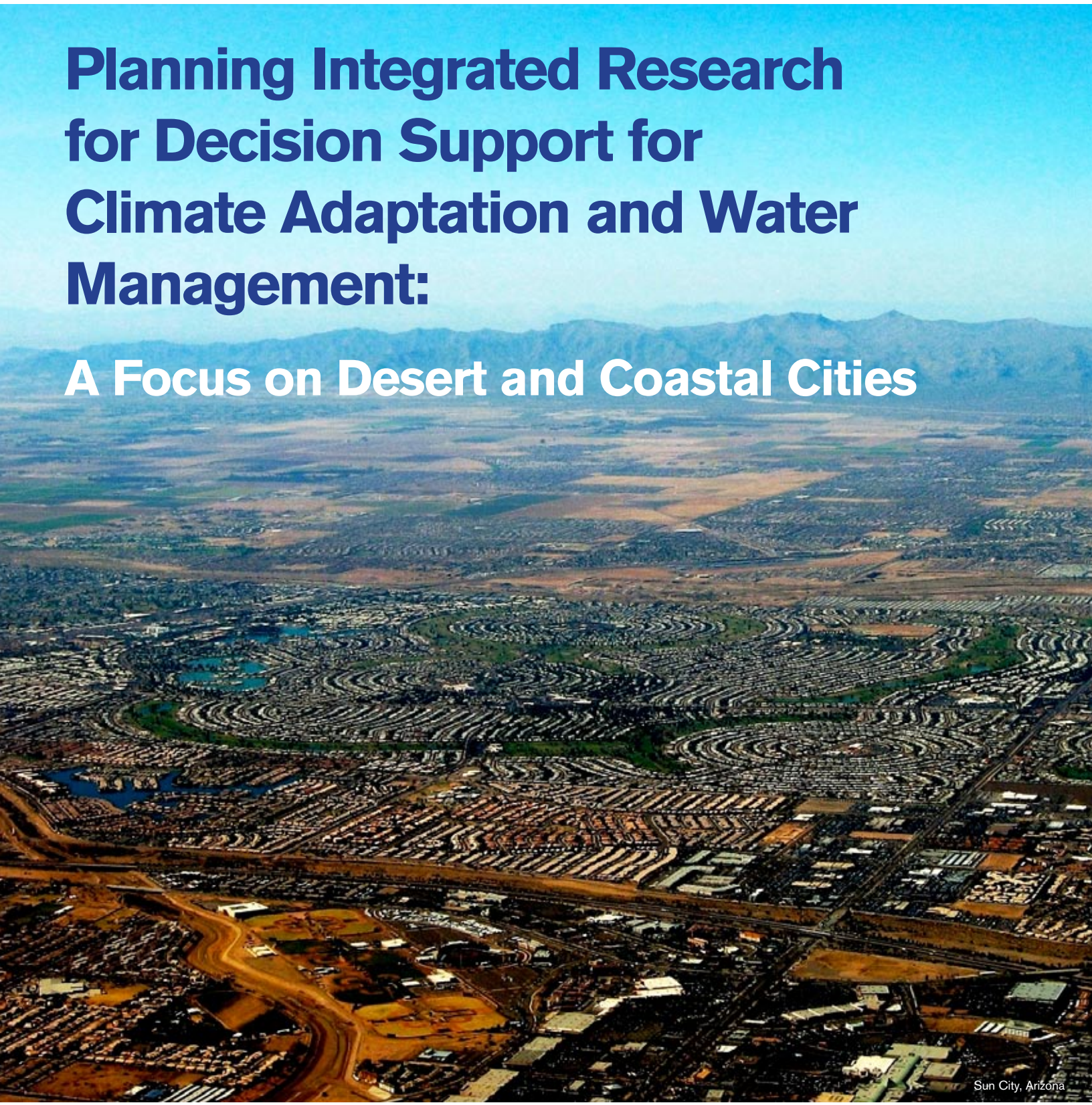
Planning Integrated Research for Decision Support for Climate Adaptation and Water Management:

A Focus on Desert and Coastal Cities



Sun City, Arizona

Arizona State University
Tempe, Arizona
January 8-10, 2009

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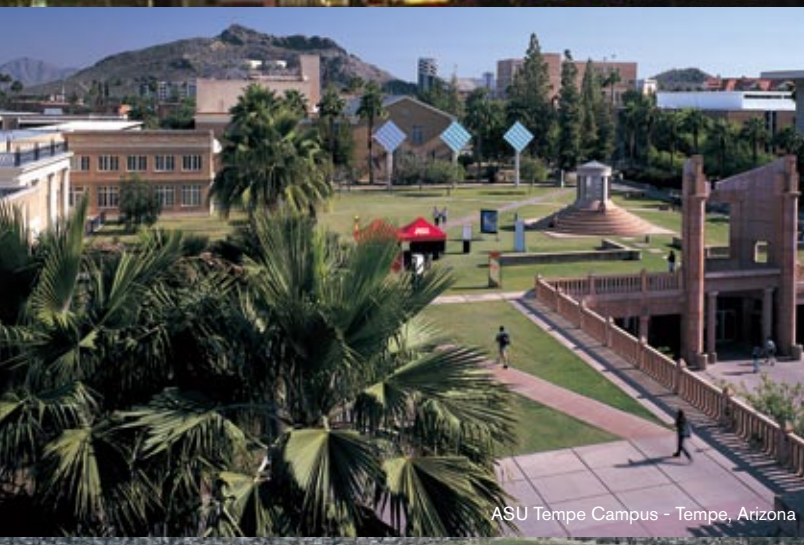

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Planning Integrated Research for Decision Support for Climate Adaptation and Water Management: A Focus on Desert and Coastal Cities

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Conference Organizers:
James Buizer, Nancy Beller-Simms,
Katharine Jacobs, Bonny Bentzin, Eileen Shea
Richard Anderson, Michele Roy

The challenges of city management and infrastructure planning are many, requiring the provision of water, flood control, waste disposal, transportation and power services and ensuring the protection of health, air and water quality. Climate change and weather extremes make these challenges increasingly complex but, in some cases, also present opportunities to contribute to a climate solution. The government sector in cooperation with academia and the private sector will play an increasingly critical role in meeting these challenges.

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Acknowledgements

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In addition, we are indebted to George Basile, Executive Director of the Arizona State University Decision Theater and Patricia Gober, Co-Director of the Decision Center for a Desert City, for hosting the conference at their facility and for George's humorous keynote talk at our conference dinner. We acknowledge the contributions of our scribes Jessica Corman, Libby Larson and Michelle McCrackin.

Finally, we thank all who attended the workshop, contributed as reviewers of this document and provided valuable input as presenters, discussion leaders and contributors to the success of this workshop. We look forward to working with you in the future to implement the recommendations we provide in this document.

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San Diego, California

The Vision

The purpose for this workshop was to identify the necessary components of a collaborative climate science, information delivery and decision support program to meet the needs of cities for freshwater management in a changing climate. Further, the workshop was aimed at identifying remaining knowledge gaps that must be filled in order to implement an effective system. The effort began as a scoping exercise to be used for planning program direction for the NOAA Climate Program Office, Sectoral Applications Research Program (SARP). As planning efforts evolved, it became evident that this workshop could provide input to a variety of offices within NOAA (including the Coastal Services Center, National Climatic Data Center and the Education Council).

Workshop discussions addressed the potential to build a climate program focused on the needs of urban decision-makers, with particular focus on cities with high vulnerability — those in coastal areas, where natural hazards related to flooding and inundation are of particular concern, and those in arid regions, where water supply issues are of increasing importance. Underlying this vision is the need to build a community that can support urban areas in their attempts to build robust responses to sustainability challenges. Appendix A contains the workshop agenda; Appendix B includes a list of participants.

Why Now, Why Cities?

This is a unique point in history, with the climate science community ready to build on the efforts of the past several decades and provide real-time, use-inspired information and solutions to decision makers; new leadership in Washington D.C. that has committed to making climate policy a central part of the administration's agenda; and enhanced public awareness of the potential impacts of climate change that is bringing this pressing issue to the forefront. These factors together with the large proportion of the world's population living in cities that are vulnerable to the effects of climate change make this an opportune time to reevaluate the role of federal agencies in relation to urban development.

Population growth in cities is already a serious challenge. In the context of climate change and other stresses, urban issues rise in priority among multiple other concerns. Urbanization is expected to continue for the foreseeable future (UNFP 2007). Globally, 50% of the population lives in urban areas, and the Earth's population recently became more urban than rural for the first time (UNFPA 2007). In the next half-century, we will build as much urban habitat as now exists (Lee 2009) with an unprecedented increase in megacities (those with populations of greater than 10 million).

In the U.S., 80% of the population lives in urban areas (U.S. Bureau of the Census 2000). Current migration trends suggest urban areas that are at greatest risk from the impacts of climate change will continue to see the greatest increases in population. For example,

approximately 53% of the nation's population lives in the 673 U.S. coastal counties (NOAA 2008) with the Gulf and Florida coasts seeing rapid growth. Meanwhile, western states, including the arid Southwest, are experiencing the most rapid population growth in the country (Anderson 2005).

Rapid growth in the face of climate change is therefore becoming increasingly important to policy and decision makers in these growing municipalities. Despite this, these areas have received little attention from the community of scientists and policy analysts focused on responding to climate change to date. Furthermore, because many of these cities are located in areas that are especially vulnerable to climate impacts, there is a pressing need to be proactive in making these areas more resilient and adaptable. Today's changing political environment provides opportunities to meet this need.

Political focus has been primarily on long-term mitigation of greenhouse gas emissions in recent years. However, growing concerns about existing and near-term climate impacts has resulted in a greater focus on adaptation. Combined with maturing investments in new data and tools by federal science agencies, this new focus is expected to find a receptive audience with national and local policy and decision makers and stakeholders alike.

This "pull" for information is steadily increasing; city and community leaders, professional associations, non-governmental organizations (NGOs) and the design community all seek advice from federal agencies on how to integrate adaptation into urban planning, systems and services. Current decisions made in these areas— the height of levies, the location of new developments and the size of new reservoirs for example— have long-lasting impacts and suffer from relative irreversibility, underscoring the urgent need to incorporate resiliency and adaptive measures early in the planning process. A national climate service could help address these emerging needs at local and regional levels.

Currently a growing community of science and practice is emerging in cities and states. This community is looking at local and regional impacts of climate change. Its focus is on accelerating the use of climate science for decision-making and enhancing adaptive capacity in regions and sectors. The collaborative nature and established partnerships of these communities make them an essential resource for federal agencies in designing and implementing a national climate service.

An illustration of this community in action is the work being done at Arizona State University's Decision Theater. City managers, planners, policy and decision makers from the Phoenix metro area and around the globe are using this space to meet with ASU scientists and researchers to inform decisions ranging from water use to zoning regulations. Using tools such as WaterSim (a water-planning model designed by ASU's Decision Center for a Desert City and available online at http://watersim.asu.edu/) and urban growth models, these stakeholders are creating adaptive solutions to the challenges they face. This interaction has also allowed model developers, particularly in the case of WaterSim, to address practitioner concerns related to scale of analysis and representation, evolution and time depth thus making the model more relevant to end-users.

End-users and community members involved in this workshop agreed that resilience, adaptation and sustainability are important frameworks and conceptual foundations for building a climate service. Approaching adaptation as a process and incorporating resilience and sustainability into urban planning, forecasting models and decision-making is important to the success of such a venture. Participants emphasized that this broad agenda and the magnitude of potential climatic impacts on urban environments and vulnerable populations warranted an in-depth exploration of new roles for federal agencies, as well as new partnerships with state and local entities, the private sector, and non-governmental entities.

Adaptation is not just a product.

It is a process; some components include:

1. Laying the foundation (education)
2. Designing integrative processes (engagement)
3. Articulating regional strategies
4. Coordinating and providing planning tools
5. Identification, selection and implementation of adaptation options
6. Monitoring and assessment

The Urban Environment

Three factors that differentiate urban and rural environments are crucial to this conversation. First, the physical and social landscapes of cities are different from those of rural areas. Therefore, any discussion regarding urban environments and climate change must be framed in the unique context of urban societal, economic and cultural influences. Physical differences include a greater density of buildings, roads and sidewalks and a reduction in the proportion of natural environments, which result in an increase in temperatures particularly at night. These increases are known as the urban heat island effect. Urban social patterns and their impacts on urban climate are different from rural social landscapes due to larger and more diverse populations. These differences manifest themselves in many different ways, for example—workweek cycles of commuting correspond to urban cycles of pollutants, which may in turn modify local weather.

While much of the current urban meteorology research concentrates on urban heat island effects, a myriad of other urban climatic conditions are not being well documented. Collaborative, inclusive dialogue between different disciplines and sectors is needed. Meteorologists and others studying urban microclimates will also require new tools and methods, including assessing social impacts and designing downscaled projections, to identify and address these unique climatic conditions.

Second, economics plays a key role in urban climatic policy- and decision-making. Expenditures needed for key infrastructure development and improvements are of particular concern, as is the importance of aligning incentives with the full social cost of providing services. According to a recent study by the U.S. Conference of Mayors (Anderson 2007), water- and sewer-related expenditures are the third highest annual expenditures of local governments, with $82 billion spent to provide sewer and water services and infrastructure in FY2005 alone. This figure is up from $45 billion in FY1992. The trend for increased spending is likely to continue as urban populations grow and demands increase.

As stakeholders obtain a better understanding of and appreciation for how climate can and does affect their cities, they realize that integrating climate information and forecasts into today's decisions will yield future fiscal and social dividends. Given the current economic crisis, these stakeholders are looking for creative solutions to both current and future needs that they can implement now.


Phoenix, Arizona

Finally, city managers control an important socio-economic network of infrastructure and delivery institutions, policies, and mechanisms (e.g., land use decisions, water regulations, etc.). This network and the decisions made by the entities within this network ultimately affect large numbers of people. City managers are finding that climate change can wreak havoc on decisions implemented within a 20-year master plan or compacts and treaties made decades ago. They are also discovering that over time, incremental day-to-day decisions such as maintenance improvements may have significant long-term impacts of the same magnitude as one long-term investment decision, for example, to build a levy to protect against sea level rise that could inundate a coastal subway system.

As a result, city managers and planners are potentially powerful conduits for the dissemination of climate information and understanding as they have the potential to influence and affect the lives of many others by integrating climate solutions into their planning activities (Glackin 2009). Therefore, it is important to not only address the concerns of these stakeholders, but also to engage them in the conversation, help them understand climate change and provide them with solutions designed to improve the resilience and adaptability of the urban environments in which they work.

Urban Water Systems and Climate Change: The New York City Experience

The New York City Department of Environmental Protection (NYCDEP) is the agency responsible for delivering water to approximately 9 million people in the metropolitan region. In 2004, the NYCDEP created their own Climate Change Task Force, with the mission to include climate change in "all short-term and long-term infrastructure and policy planning initiatives" (NYCDEP, 2008). This mission encompasses both mitigation of greenhouse gas emissions and adaptation to the potential risks of climate change on the City's water supply, drainage and wastewater management systems.

With representation from each of the operating and planning bureaus within NYCDEP as well as experts from Columbia University's Center for Climate Systems Research, other area universities, and engineering firms, the Task Force not only allowed for the development of an integrated climate change program across the entire agency but also facilitated a more collaborative approach that helped foster mutual respect and understanding among researchers and policy-makers. This went a long way in instilling relevance and credibility into the Task Force products.

Working together, the NYCDEP Task Force members and climate scientists developed an adaptation assessment framework. Using observed data, scaled-down global climate models, and regional climate models the Task Force were able to create a framework that enables NYCDEP decision makers to:

1) Increase their understanding of current climate risks
2) Project future climate change risks
3) Determine climate protection levels
4) Evaluate flexible adaptation pathways
5) Utilize insurance and policy strategies
6) Monitor and reassess

In 2008, DEP released its Climate Change Assessment and Action Plan. The Task Force concluded that the climate change risks to New York City's water supply, sewer, and wastewater treatment systems will be many and that managing those risks will be vital to DEP's ability to continue supplying New York City's water for the next hundred years.

Key Issues/Problems

Conference participants identified a broad range of issues that should be addressed by a national climate network, including flood protection, sea level rise, extreme events, infrastructure investment decisions, water supply, storm-water and wastewater management, public education and outreach. There was also significant discussion regarding water quality issues, both in regards to the challenges to providing quality water in the context of extreme events and the consequent implications for infrastructure and public health. Participants feel that many of these challenges require novel approaches to strategic planning while others require the establishment of new engineering and other standards. The difficulties presented in meeting these challenges demand a more resilient and flexible approach overall, which participants believe warrant robust engagement with all stakeholders, including the public.

Background considerations discussed during the workshop:

Climate Change Impacts on the Water Sector — Scientific consensus regarding the impacts of climate change on water supply is that they will vary by region. Generally, they include changes in the nature of precipitation— more rain and less snow; changes in the seasonality of precipitation— an earlier peak in the hydrograph; an increase in drought stress associated with higher temperatures— reduction of soil moisture and increase in the rate of evapotranspiration; and a likelihood of increased intensity of precipitation and runoff (CCSP 2008a)[1]. Many of these events negatively affect water supply through reduced surface runoff, groundwater recharge and reservoir storage. As a result, scientists are predicting reduced water supply, along with increases in demand, for water in portions of the U.S., including the Southwest and a significant portion of the Midwest.

In many regions, it is not clear from current model projections whether total precipitation will increase or decrease. Several of the participants' expressed concern about the level of uncertainty in these models. While they realize there will always be a degree of uncertainty, they feel that addressing this issue will help end-users make better decisions.

Participants were also concerned with the significant challenges associated with higher temperatures and an increase in extreme events. In coastal regions, critical water-related impacts are associated with sea level rise, salt-water intrusion, coastal erosion and flooding in coastal rivers and estuaries, particularly in low-lying areas. Storm surges and hurricanes are likely to increase their impact on vulnerable populations and ecosystems. In arid regions, critical water-related concerns include longer and more intense droughts and increased storm intensity. A decrease in supply coupled with increased demand for water due to continued population growth is expected to continue to be a pressing problem in these areas.

Underlying Stresses in the Urban Sector — Climate change compounds a series of existing stresses, which include growth, energy availability, lack of financial resources, waste management issues and rapid changes in land use and vegetation. These stresses change patterns of supply and demand against a backdrop of changing values related to environmental flows, demographic shifts, and the economy. Some of these stresses result from migration patterns and socio-economic influences. Others result from failed policies and misleading incentives, including subsidies for behaviors that should be discouraged rather than encouraged, such as development in highly vulnerable areas.

Several recently released reports (CCSP 2008a; National Intelligence Report 2008; IPPC 2007a and b) document the increase in number and intensity of heavy downpours over most of North America. This same report suggests that there have been regional changes in weather patterns. For example, there have been fewer snowstorms in the South and lower Midwestern United States in recent years and more snowstorms in the upper Midwest and Northeast. At the same time, in the western north Pacific, hurricane intensity appears to have increased. North America, as a whole, has witnessed a shift towards a warmer climate that includes an increase in high temperatures with an accompanying reduction in extreme low temperatures. The Arctic region is warming about twice as fast as the rest of the planet. In the future, droughts are likely to become more frequent and severe in some regions, precipitation is likely to be less frequent but more intense, and precipitation extremes are very likely to increase.

Low-lying coastal areas and inland arid areas with growing populations and attractive year-round climates will continue to see stresses related to increases in population over the coming years and decades. This would lead to an increase in vulnerability to environmental stresses even if they were not subject to impacts of climate changes, which many are already experiencing. Although there is some certainty among experts about the direction of change of the climate system, there is little consensus about the potential for rapid shifts in key climate processes. Rapid shifts would likely have dramatic impacts on cities whose infrastructure is already stressed.

Participants reasoned that a national climate service focused on providing urban climate tools and products would be an excellent resource for urban decision makers to access up-to-date, relevant climate information as well as for the exchange of real-world experiences related to climate impacts in the urban setting.

The Context for Water Managers — Local water managers work within a variety of time and administrative constraints. They are subject to legal and policy requirements, political agendas, and required planning and policy activities. In addition, jurisdictional oversight and planning horizons for most utilities span a range of temporal and geographic spaces. For example, many cities have long-range (e.g., 20 years) master plans that direct future development and land-use strategies. They also often have Capital Improvement Plans for the nearer term (e.g., 5-7 years), which prioritize major capital investments (a partial listing of urban-related plans and legal mandates are enumerated in Appendix C).

Water resources are subject to a variety of layers of legal relationships and regulations with differing geographic jurisdictions (e.g., river compacts, river basin agreements, state agencies, etc.). There are multiple decision makers whose interests should be considered, including utility companies, flood control districts and irrigation management districts among many others. As a result, there is considerable complexity in increasing the use and utility of climate information for decision support in water resources management (CCSP, 2008b).


Glen Canyon Dam, Arizona

It is important to note that many water management systems in place today were not designed to address changing climate conditions. For example, water planning is often performed on a city scale, when regional or even global dimensions are required. Overlapping jurisdictions and layers of authority make adaptive management much more complicated.

Workshop participants advanced the idea that a national climate service could enable local water managers and decision makers to connect to other stakeholders using the same resources. This would allow them to make better-informed decisions regarding climate impacts and shared resource use.

Aging and Inadequate Infrastructure — A critical cause for concern in cities is aging and inadequate infrastructure. Water and wastewater facilities, flood control structures, highways, bridges and levees are not being maintained properly in many regions despite nearing the end of their useful life. Availability of funds to pay for infrastructure improvements is extremely inadequate. A 2007 estimate by Booz, Allen and Hamilton of the total investment that will be required simply to bring existing water supply infrastructure in the U.S. and Canada up to existing standards over the next 25 years is $6.5 trillion; while worldwide, it would be close to $23 trillion. It has been estimated that a 15-30% increase in local investments may be required to address climate change challenges (Anderson 2007). Meanwhile, capital expenditures are actually decreasing in many localities due to economic conditions, while maintenance costs are increasing, leaving a significant backlog of deferred maintenance.

Urban planners, city managers and policy and decision makers are looking at planning and managing greater risks with less money in the next generation of infrastructure decisions. Furthermore, infrastructure design has in many cases not kept pace with the demands of today's larger and more resource-intensive cities.

A New Planning Paradigm — Across a wide spectrum of personal and professional contexts, many decisions are made without certainty. However, climate-related impacts raise a host of new concerns regarding use of uncertain science in decision-making. In some ways, it appears that there is a lower tolerance for uncertainty in this arena than in other decision processes. There is a need for managers to move away from an expectation of a perfect or near-perfect forecast. There will be no crystal ball. Helping managers set boundaries on expectations, and learn how to incorporate different kinds of uncertainty in decision processes will be critical to maximizing effective planning and minimizing "stranded assets", or investments in adaptations that turn out not to be needed.

Other key elements will include increasing understanding of the sources of uncertainty and helping both scientists and decision makers learn how to manage risk more effectively in the context of climate change. These appear to be important in improving the resilience of urban environments while minimizing sunken capital investments.

This new stressor requires a "climate change lens" on decision making, which would inject a multitude of new considerations into management decisions. Climate-change stressors and the related considerations seem to suggest that a new planning paradigm is needed. Included among the elements of a new planning paradigm should be the concept of design and management with ecological principles in mind. These ecological principles include protecting the services that are provided by ecosystems that are of value to humans: flood management, water quality improvements, aesthetics, biodiversity, etc. and the spatial relationships between urban and natural environments.

According to participants, this shift in approach presents new opportunities. A national climate service that understands and responds to the needs of urban decision makers could present a change in the capacity to adapt to a changing climate. For example, a planning paradigm that uses climate as a means to be "climate smart and resilient" could mean generating new planning models and new technologies that are more adaptable, modular and flexible and that could have other benefits such as financial and energy savings.

Building people *and* ecosystem services — The climate service will have multiple audiences and will need to provide services that support both people and ecosystems, even in urban environments. The broad range of stakeholders expected to use this service includes citizens, decision-makers from multiple layers of government agencies, utility managers, businesses and resource managers. These stakeholders make decisions at different time and space scales. Decisions range from answering routine daily questions, to long-term planning, to disaster management. These decisions require different levels of decision support and are often made without critical climate information. Information needs to address long-term gradual changes that are considered low-impact but appear highly probable differ from those for threshold events that may be high impact and low probability. Both types require information and tools that are scaled to the nature of the problem, and that integrate social and physical science solutions.

By default, planners, resource managers and politicians are currently being asked to take the lead in integrating climate considerations into the urban fabric. However, they lack explicit tools, metrics and strategic methods to do so effectively. Formalizing the ongoing but ad-hoc dialogue that is taking place between the science community, planners and the public would help fill this acute need. This would also build an understanding in the planning community of the larger ecosystem service perspective and may provide a pathway to address many of the new challenges presented by global climate change.

Equity — Working with urban populations raises a number of issues, including how to handle an even wider array of potential stakeholders. Participation of and support for vulnerable and underrepresented populations raises communication and education concerns. Most users are likely to require additional technical support in order to benefit fully from the tools provided by a national climate service. It is likely that they will require additional education and instruction on the use and interpretation of the data as well.

To meet these needs, information will have to be presented in such a way that it can be generally understood, meaning that the modes of information delivery as well as its applications will have to be reexamined. At the same time, information needs of sophisticated users, such as scientists and practitioners, cannot be ignored or overly simplified. Thus, it will be important that the development of a national climate service reflect the sophisticated, complex and multi-layered systems of the urban structure and its stakeholders.

Data limitations and gaps in understanding — Urban managers participating in the workshop voiced their concerns regarding inadequate climate data resolution relative to the scale of decisions they must make. Much of the data available are formulated at the national or occasionally at the regional level, while most decisions are made at the local level. In addition, attendees report critical data gaps relative to urban regions. These gaps exist because urban areas have not historically been a priority from an observation perspective. Scientists often prefer to study "natural" systems because they are not as complicated as linked human-natural environments.

In order to fill these gaps, there may need to be new approaches to data gathering, including linking together existing non-federal sources of information in a "network of networks" approach. The matching of scales— geographic, political and temporal— in analysis to the various scales of decisions represents a key research need. Engagement of local partners in development of data and tools can lead to a higher level of trust in the data quality, tools and human resources. Participants believe that inclusion of these stakeholders from early in the development process will make a national climate service relevant to local as well as regional and national end users.

Adaptation Options/Solutions

Discussions at the workshop revealed a wide range of potential adaptation approaches that urban planners and managers could take, ranging from the more conventional— reinforcing existing infrastructure and demand management to the unconventional— desalination, eco-sanitation (e.g., waste separation and recycling), redefinition of flood management objectives and techniques and redefinition of drought in terms of changes in expectation and risk. In addition, attendees discussed adaptation approaches that people and firms might not have been willing to consider previously such as contracts for interruptible voluntary or compulsory water or conservation policies. This type of "policy adaptation" has received far less attention than other adaptation options such as those that focus on "hard" infrastructure, although there are examples emerging.

New York City, because of its low elevation and location along the coast, is becoming increasingly cognizant of

Impairment and Flood Damage from Extreme Events and Sea Level Rise

Mayor Bloomberg of New York City has convened a team of representatives from city and state agencies, public authorities and companies that operate and maintain the transit, water, sanitation, energy and telecommunications systems to develop a long-term sustainability plan. A subset of this group is the city's Climate Change Adaptation Task Force whose primary mission is to develop adaptation strategies to secure the City's infrastructure from the effects of climate change. This task force has identified a five-step process for their mission:

1. Lay the Foundation (by way of a series of key assessment reports and studies).
2. Design Integrative Process (including soliciting input from public and private decision makers and buy-in from high level city officials)
3. Articulate Regional Strategy (through flexible adaptation pathways)
4. Provide Planning Tools (including tools to assess climate risk, adaptation assessment and climate protection)
5. Monitor and Reassess Program Accomplishments

One example of a decision that allowed NYC planners the opportunity to address a problem with a climate adaptation overlay occurred during a March 2001 storm when treatment tanks overflowed at a Bronx Water Pollution Control Plant as a combined result of flood damage from treatment systems following heavy rainfall and sea level rise. An unusually high tide blocked discharge of treated sewage into the East River and caused a back up. Planners were challenged with fixing the plant, but with the additional cost of anticipating future climate-induced problems. They considered several adaptation options including building floodwalls and relocating critical control systems to higher floors.

Source: Treated sewage backup at a Bronx Water Pollution Control Plant during a March 2001 storm (NYC DEP)

the potential risks of climate change and is among the country's leaders in formulating a strategy for adaptation (see Text Box). Workshop participants discussed a variety of adaptation options and solutions that could be led by the Federal government, intermediary organizations (such as non-governmental organizations, the NOAA Regional Integrated Science Assessments, and Regional Climate Centers), and local decision makers; below are their suggestions.

Uncertainty: Providing information on a range of possibilities, building useful scenarios — One way to address uncertainty is to plan for multiple possible futures by building or modifying scenarios to include a number of plausible outcomes. These scenarios should include a combination of climate science and social science variables. They must also be flexible and adaptable enough to accommodate a wide array of local needs and issues in order to be relevant to end users. The climate service can support the development of data used for urban planning purposes, including the NYC example above, as well as support the appropriate design of scenarios to focus on critical management issues. Scenarios are a powerful tool for decision-making if developed in a rigorous, internally consistent way.

Partnership: Bringing Federal assets to bear on local problems, matching assets to needs via a collaborative approach — The demand for information from cities, regions and sectors is overwhelming; therefore, a key part of providing decision support will be matching science to information needs. This requires long-term relationship building, a continuous dialogue between scientists and managers, a supportive learning environment, and a robust system for prioritization and management of science support activities. The urban climate program will need to be evolutionary and adaptive — from both the science and decision-making perspective. Developing specialized communicators and trusted information brokers who can connect federal science agencies to local decision makers will help build


Phoenix, Arizona

the adaptation capacity. Because the challenge is so daunting, a collaborative venture is highly recommended. NOAA cannot address this issue alone; other science agencies as well as private and public sector partners will need to engage. Though this approach increases the resources available, it also increases the magnitude of the coordination effort dramatically. The support network will need to be strategically deployed, probably in phases, in order to maximize impact in the context of very constrained resources. It was noted by participants that institutions are the mechanisms to implement new policies. One participant noted, "Institution building in the face of climate change is at least as important as infrastructure building."

Systems: Integrated land use policies, urban planning and landscape design — A critical component of urban climate vulnerability is land use. In general, land-use decisions are federally directed but locally implemented and there are inadequate incentives to limit bad decisions. In fact, FEMA and insurance companies actually encourage risky behavior by protecting people from the consequences of these decisions. For example, the potential of rising sea levels has extreme future possibilities that could affect hundreds of thousand of square miles and millions of people in the United States, yet increased funding for mitigation programs and flood insurance have done little to discourage people from building in these areas.

Climate change impacts, such as the example above, will significantly challenge current land-use management practices. These challenges will be so great they will transcend all geo-political and federal organizational boundaries. Measures should be taken now to integrate federal decision making with local implementation. These measures should include urban managers sharing observations and learning from each other's experiences and federal agencies, such as FEMA and NOAA, sharing observations and engaging in joint strategy development with urban managers. The climate program could support the context for this learning and joint strategy development.

In addition, rather than treating urban systems as built environments where natural processes are deliberately constrained, managers, planners and policy and decision makers need to incorporate ecosystem services and functions into urban design. A new focus on lower carbon, high-efficiency development practices, including more walkable cities and higher densities, needs to work in tandem with the idea of urban form as linked to natural systems. This will increase resilience, quality of life and aesthetics, in addition to potentially reducing heat island effects, minimizing shared resource conflicts and increasing recreation opportunities.

This is a significant challenge for the planning, architecture and landscape architecture communities. Due to this challenge, incorporating climate issues in urban design is an emerging priority in some parts of the industry. However, they need support from climate science in ways that are not yet well articulated to build these more resilient urban environments. This represents opportunities for integration of communities that do not traditionally work together. Ideally, this will become incorporated into institutional learning about climate resilience. Continuous assessment of newly implemented designs through monitoring must be a priority to allow for informed future planning options.

Adaptability: Modularized capital improvement options — Because of the uncertainty associated with future climate conditions, it would be advantageous to be able to build urban infrastructure such as water treatment, flood control, wastewater management and storage facilities in a more flexible mode than is done today. One suggestion was to incorporate modular options when designing and building infrastructure. This would limit the potential for stranded assets, and provide less upfront investment to offset uncertain future risks. In addition, modular, flexible infrastructure will increase resilience in the face of unknown future climate impacts. This is a research area that requires more support.

Other solution ideas (not necessarily limited to urban applications) include:

- **Develop LEED-like certification for infrastructure** relative to climate change resilience (e.g., adaptation benefits, such as design to withstand extreme events) and low emissions impacts (e.g., mitigation benefits).
- **Benchmark best practices** by learning from the experiences of large utilities and early adopters, and providing easily accessible information based on their lessons learned — both successes and the failures.
- **Create a Climate Change "Boot Camp"** by developing training programs that are focused on the needs of critical decision makers, such as utility staff, city managers, etc. and that increase climate literacy, helping to build the climate community and providing "Outside the Office" experiences.
- **Increase Climate Science Literacy** for an increasingly involved and knowledgeable public by making information more easily accessible and understandable.
- **Train and Support the Translators** by providing accreditation for climate service providers that will allow them to do a better job of evaluating tools and techniques. A critical part of this training should be in managing expectations. One suggestion was to work with state climatologists to train planners about climate and cities.
- **Expand and Support the network of boundary organizations and information brokers** by working to build a network of service providers based on the RISA concept and potentially to include universities, professional organizations, extension services, school systems, science museums, free choice centers and local climate task forces that are organized around providing basic climate service support. Expand this network to engage disciplines not normally involved, particularly social and natural sciences.
- **Document and develop methodologies for sustainability-based decision-making**, such as cost-benefit analysis that takes the "triple bottom-line approach" (e.g., taking into account social, economic and environmental impacts over the long term) and other "product stewardship" policies currently being undertaken in other countries.
- **Investigate incentives** for local and Federal investments in adaptation and elimination of current dis-incentives for adaptation, e.g., tax credits for providing employee parking, subsidized energy used to reduce water prices for low-value crops, etc. This may also include the structuring of new policy instruments (or contracts) that alter incentives and constructing instruments that are agreed to in advance and come into play when events warrant; these will create new types of incentives to adapt to uncertainty that have not previously existed.
- **Evaluate institutional decision-making in the context of adaptation and sustainability**.

"institution building in the face of climate change is at least as important as infrastructure building."

Guiding Principles/Criteria for Success

Clear articulation of the issues — A climate information service should begin by clearly defining issues faced by resource managers and determining how decisions might benefit from the incorporation of climate information products. Asking and answering the right questions can substantially increase the effectiveness of investments in this program.

Recognize that decisions are local — While there are sets of climate products that are general in nature and should be part of any information system, it cannot be forgotten that decisions and implementation occur at the local level. That is, the information must fit within the social, economic and political context of the place where the decision is being made, at decision-relevant scales, and with the recognition that each place has its own unique decision-making system and processes. The production of usable or "actionable" science-based information is a priority.

Develop services on a foundation of open, collaborative, information sharing — The process should be sustained and iterative, with continued progress monitoring, evaluation and revision of the tools, services and approaches. That is, there should be flexibility in both the production of the information products and the associated management systems.

Build trust amongst the actors — The value of information (perceived and real) increases dramatically when co-produced by scientists and practitioners. This increases the likelihood that the information products address the most salient issues, that the information is deemed as credible, and that the purveyors are seen as legitimate in the process.

Leverage past experience — An efficient means of leveraging experience is to build on institutional knowledge. It is critical that the process expand the capacity to exchange ideas, discoveries, methods, and approaches between scientists and managers and between communities in one city or region and another. It is also important that this exchange engage actors in the U.S. and other nations. This exchange need not be limited to research results, technologies or new solution options, but can also include exchange of policy and market mechanisms that have worked in one place or another. It is important that case studies and best practices be documented, and standards for adaptation performance be shared across communities.

Create problem/solution-focused, user-relevant information — Climate services need to be ***place-based***, with a special focus on defining problems relative to urban areas that have significant vulnerability, including those in arid regions and low-lying coastal areas with growing populations. Such areas have numerous sources of vulnerability such as rapid influx of population, interruptions of environmental services, loss of habitat, and land subsidence. In coastal areas seawater intrusion, water quality impacts on biodiversity and productivity in estuaries and flooding are concerns for vulnerable populations. Inland areas with growing populations also share unique vulnerabilities, including the availability of water resources, increasing heat stress, energy-water issues, inadequate infrastructure, increased or decreased flooding, and shifts in the range of habitats. In all communities growth itself is a major driver of vulnerability because of the difficulty to ensure that services keep pace with demand. Because of these factors, the issues associated with global climate change will be unique for each community. Therefore, climate services must be flexible enough to focus on each community's unique circumstance.

For information to be relevant and useful, it should be produced within the context of decisions. Cities have complex decision-making systems, which are often multi-layered and multi-institutional. This complexity should be taken into account in designing support systems. Much more needs to be known about who makes what decisions, at what scales, and in what time frames. "Actionable science" should be provided in a way that it is useful in a given place and context.

Insure broad engagement — A robust urban information system should engage people from multiple cultures, perspectives and disciplines, including scientists and decision-makers, from the initial problem statement through evaluation of options and development of collaborative solutions. Players need to include government, private sector, academia, NGOs, public sector and boundary organizations. A more inclusive concept such as a "network of networks" is required to support data collection, decision support and project implementation.

Raise public climate literacy — This effort will require a robust communications strategy that is flexible enough to allow decision makers to interact with climate scientists and the data and information they produce in forums and formats that are accessible. Communication and education programs should not focus on telling decision makers what to think. Rather, communications should assist them in how to think by providing context and insight into the processes that led to particular scientific conclusions. In this way, non-scientists are better able to understand the science and to decide for themselves whether it has validity and relevance to their lives, and whether and how it is a sufficient basis for public policy.

Identify and nurture leaders at all levels — It is rare for significant change to occur without identifiable leaders who have vision and the capacity to communicate a vision to others. Early adopters of innovation are critical to progress, especially where changes in lifestyle or individual sacrifices are required for collective benefit. Climate adaptation for urban regions will require a cadre of talented people who are trained to lead the initiative.

Improve communications between scientists and decision makers — While it is of primary importance that decision-makers' needs, goals, and local realities are taken into account at each level of engagement, the science community must be trusted and have pathways to share information that may be challenged. Clear explanations of science and consistent representations of uncertainty are needed to limit confusion and increase the capacity for science-based decisions.

Flood Warnings

The warning sign in this Volusia County neighborhood applies to boats as well as vehicles, following the flooding from Tropical Storm Fay. (Deltona, FL, August 24, 2008).

Priorities

There are short-term priorities that would have an immediate payoff for a climate program focused on urban needs; many of these priorities would serve other constituencies as well.

Improving the content of data: moving from data to information to knowledge — Urban decision makers require information in a variety of formats to respond to constituent needs. While there are a number of reasons they might not currently be using climate information in decision making (see for example CCSP 2008b), key among them is that the information is not in a usable format for decision-making. Among the most immediate needs for making climate information usable would be:

- ***Increasing resolution (time and space) of data, predictions and projections*** — decision makers in every region and sector would like data tailored to their own geography and scaled to the level

of their watershed or community. Because the global circulation models are at such a large scale, and because they do not consider land surface elevation, it is not possible to get small-scale resolution without downscaling into regional climate models. Supporting the regional downscaling efforts, evaluating the utility of the data produced and translating lessons learned would be important climate services.

- ***Enhancing computing capabilities*** — it will be important for a climate service to support finer scale modeling and applications at the level of utilities and regional resource managers.
- ***Overcoming model bias concerns*** — many managers express concern about whether it is necessary to invest in one "best" model or whether supporting an ensemble of models to create meaningful scenarios and a range of possible futures is more likely to provide accurate information. It would be useful to help answer this question, through a conversation between modelers and managers.

Improving the understanding of information and potential applications — Decision and policy makers from federal government through local levels need more information about ways to insert climate information into the decision process. Some fundamental questions that need to be addressed in the short term include:

- ***Improving the understanding of the links between climate and urban design*** — What are the ingredients of settlement efficiency? How can a better understanding of climate and its effects support sustainable design?
- ***Enhancing decision scenarios and decision trees***— Decision-making can be better supported if social and physical scientists work together to help develop plausible alternative future scenarios that are internally consistent. This will help in identifying no risk or low-risk alternatives that have positive outcomes under multiple scenarios. How well can these ideas translate to new applications for urban areas? Is it possible to integrate climate scenarios with decision scenarios more effectively?
- ***Performing a socio-economic-environmental vulnerability assessment*** — It is important to focus resources on vulnerable communities. There is a need to enhance tools for vulnerability assessment and test them in multiple regions and sectors to establish clear priorities for investment of limited resources.

Data interpretation and translation for specific users and applications — Data integration and visualization tools will become increasingly important modes of accessing information and supporting decisions. NOAA and its partners need to stay abreast of new research on informatics and design of information access, retrieval, manipulation, and dissemination systems intended for use by end-users and decision makers. These systems can have multiple applications, including mobilizing multiple communities, sharing insights and creative exploration of options.

Supporting climate adaptation efforts in a locally meaningful context — It is important to understand the social, economic and institutional context for adaptation, especially in urban areas that are or have been historically underserved. Significantly more research is required to properly understand urban decision contexts and help managers frame research questions that address equity issues.

Mobilizing the required "knowledge network(s)" Knowledge networks need to be managed to ensure that there are coordinated outputs that accomplish climate program goals within cities (as well as in other applications). Supporting the following activities can maximize outputs:

- Enhancing communications skills by training science translators who can serve specific audiences (such agriculture, energy, forestry, coastal management or water specialists)
- Engaging trained scientists, decision-makers, educators, and consultants who can become trusted information brokers, educational partners and capacity builders, and who can help build local and regional teams that can address the growing demand for relevant and technical support
- Providing more resources to enhancing the network of boundary organizations available as part of the decision support system creating partnerships with professional and industry associations to enhance outreach capacity without sacrificing efficiency
- Supporting education and outreach programs in both formal and informal venues to increase the awareness and knowledge of students and citizens

- Documenting the experiences of early adopters and assessing and evaluating the effectiveness of alternative solutions
- Exploring the success of options selected by decision makers in other countries
- Engaging with existing agricultural and coastal extension programs and other pre-existing outreach organizations and networks
- Certifying reliable information brokers/partners

Exploration of adaptation options — the range of options available for adaptation needs to be expanded significantly, including methods for incorporating ecological principles in urban design, economic assessment of "green" infrastructure and policy options relating to water management among others. This will increase the size of the toolbox available to urban managers. Methods for integration of climate — and sustainability — into utilities management, policy and regulation also need to be developed.

Fort Lauderdale, Florida

Near-Term Opportunities

Taking advantage of near-term opportunities is crucial for both a national climate service and Federal agencies. Listed below are some near term opportunities and activities for providing services to urban water resource managers for their decision making.

A rationale for — why now? — Current trends include opportunities espoused by a new federal administration, an economy where decision makers are looking for cost savings, and a public more primed than it has been to respond to the climate challenge. Within the urban realm, there is also the ability to engage an entire community of decision makers whose decisions impact millions of citizens and incur costs in the billions.

Informing decisions *today* while planning for the future — There is a sense of urgency vis-à-vis infrastructure investments being made today, particularly those made in the context of the federal stimulus package. Discussion of shovel-ready projects in light of new standards to reduce vulnerability should be explored (quickly).

Developing integrated and up-to-date flood risk management mapping — This is a high priority. NOAA should reach out to FEMA in the short term to enhance the capacity to do floodplain mapping in the context of larger flooding risk and the "end of stationarity" in the climate system.

Enhancing access to existing data — live Adaptation "Information Portal" for Cities and Water — in the near term, it is possible to support the development of a virtual, digital warehouse for communities based on the latest informatics techniques. The portal should include:

- data integration and visualization tools;
- translation/interpretation of changing climate conditions in the context of cities and water management;
- historic records, monitoring networks and research results;
- lists of adaptation options; and
- access to science translators who can answer questions.

This urban portal could be housed within a larger climate portal.

Improving communication, education and outreach — There is a need for increasing climate awareness and understanding for the U.S. population as a whole— not just for decision makers. There needs to be a broader understanding of the scientific underpinnings of the climate issue (e.g., global circulation patterns, ocean-atmosphere interactions, etc). Existing educational networks such as those recently established through the multi-agency and organization Climate Literacy campaign can be mobilized as part of this process. There also needs to be an increased social science awareness of adapting to climate change. Among the suggestions made were:

- an inventory of critical infrastructure at risk;
- a clarification of the risks to sectors and regions, health implications, economic costs, etc;
- setting design standards for infrastructure, operations and management; and
- infrastructure sharing and working within a regional framework.

A special edition of a journal highlighting these types of topics as well as near-term expectations in the field could also be pursued.

Informing the research agenda — Clearly, research needs related to climate and water in urban areas need to be better defined. This should happen in partnership with city managers, urban planners and

water managers who serve metropolitan regions and cities, particularly those that are in areas where coastal issues and water supply are already known to be critical concerns. One suggestion was to take advantage of the background and institutional ties of those in attendance at this workshop to hold a national meeting regarding the state of the climate for urban water decision makers; attendees could include representatives from various level of government along with intermediary organizations, non-governmental organizations and representatives from the private sector.

Sustaining the Process

It is clear that if a climate program is initiated, there should be a plan to sustain it. Significant damage has been done in the past (with other audiences) through lack of follow through within programs that engage stakeholders, set up expectations, then fail to deliver. There are multiple opportunities to build momentum using existing networks of "climate-savvy" people familiar with the science/society interface. Modes for building the outreach program for urban issues can include professional associations like those represented at the workshop (United States Conference of Mayors, American Water Works Association, Water Utility Climate Alliance, Association of Metropolitan Water Agencies) as well as NOAA staff, other USGCRP agencies, universities, extension services, and various public, private and NGO partners throughout urban areas.

NOAA representatives will have an opportunity to respond to workshop findings and suggestions, and to build the adaptation network, including urban observatories and climate adaptation centers. It was noted that the number of staff people dedicated to this sort of work has actually been diminishing within the NOAA climate office, in part due to funding issues. This trend will need to be reversed.

Even within limited funding scenarios there are likely to be ways to move forward; though there is a substantial unmet need associated with the "service" part of the climate service — the human dimensions, policy, applications, outreach and informatics pieces. Multiple professional groups and stakeholders, including the US Conference of Mayors, stand ready to support the funding requests, so long as the service is appropriately focused on the needs of urban stakeholders. Proposals for additional funding can and should be prepared as soon as possible.

If a new urban climate program is to be developed, guidance for participation should be developed that consider the needs of the climate service more generally. Intra- and inter-agency coordination will be required if this effort is to be successful. Intermediaries, including professional organizations and decision makers, should also be consulted. Their input should include specifics about their climate information needs and their resource needs for mobilizing at-risk communities to achieve actual reductions in risk.

For example, the Western Governors, faced with forecasts of continued drought, convened scientists and national resource managers from a variety of levels of government. Their meetings resulted in a plan for a national drought information service, which they published and reported on to Congress (Western Governors Association 2007). The plan proposed a strategy to assess drought risk in a timely fashion and to provide information to decision makers so that they could make time-critical decisions that would mitigate the impact of an impending drought. The resulting congressional legislation allowed the formation and funding of the National Integrated Drought Information Service (NIDIS).

Program design should articulate clear outcomes and measures of success, and identify potential sponsors and partners. Two specific suggestions for measurement of success included:

1. Vulnerable cities (e.g., New Orleans and Baton Rouge) should amend their local emergency management plans (which will in turn impact state plans and ultimately roll into the Department of Homeland Security's national plan) to include contingency planning for large population evacuations in response to climate related events. These plans would most likely be used in response to extended coastal inundation and high hazard events such as storm surges and flooding; and New Orleans in the aftermath of Hurricane Katrina Source: NOAA's National Weather Service (NWS) Collection Lieut. Commander Mark Moran, NOAA Corps, NMAO/AOC

New Orleans in the aftermath of Hurricane Katrina
Source: NOAA's National Weather Service (NWS) Collection
Lieut. Commander Mark Moran, NOAA Corps, NMAO/AOC

2. Cities should promote integrated water resource management, through a process of rationalizing water resource use by looking at the full spectrum of water supply, water treatment, wastewater reuse, flood control, etc. This would occur most efficiently if cities adapt their water management systems to use the best meteorological and hydrologic data available from the U.S. government and private sources.

Definitions of success for an urban climate service should include 1) having climate information integrated into the design and management of cities; 2) actual reductions in risk resulting from use of federal climate information; and 3) more integrated solutions for sustainable outcomes that consider outcomes that solve water, energy and social problems simultaneously. An example of the latter would be expanding availability of agricultural to urban water transfers and conservation enhancements that can be triggered by climate forecasts.

Finally, the current climate office is understaffed and underfunded in light of the enormity of this problem; a measure of success would be a long-term commitment of staff and resources to this issue.

Conclusions: Resilient and Sustainable Cities: Climate in Context

Urban areas are at the forefront of efforts to grapple with potential future changes in weather extremes and climate. A growing demand for better information and increased preparedness have led to the development of new partnerships between service providers and municipalities, but more integration is needed. The weather and climate community has a long history of cooperation from local to global scale. We need to expand on this history of cooperation within our community to encourage many institutions to work together effectively to solve the complex challenges our cities, coasts and our society face. *Mary Glackin, National Oceanic and Atmospheric Administration, Deputy Undersecretary for Oceans and Atmosphere, 2009*

Cities are the economic and social engines of the nation; a number of larger metropolitan areas have incomes greater than many countries. Urban leaders are making decisions today that have far-reaching repercussions in terms of how they prepare their populations for a changing climate. Workshop attendees concluded that these decision and policy makers need comprehensive climate and hydrologic information in order to make informed decisions.

"Urban planners and city managers need a trusted source for environmental information that is, in turn, responsive to the challenges confronting the decision maker and his or her decision process. It is important to incorporate knowledge from both the natural and social sciences, ranging from the economic impacts of decisions to the behavioral response to risk, to understand the full dimensions of these problems and to help identify viable solutions". (Glackin 2009)

This presents an important opportunity for Federal agencies. A national climate service that supports and coordinates a climate science information delivery and decision support program for cities would be a valid forum for Federal, private sector and intermediary collaboration. Workshop participants concluded that this type of institution building in the face of climate change is at least as important as science infrastructure building.

Their recommendation was that a national climate service should include programs that address the needs of urban decision makers, specifically through an applied research program that addresses the physical and social aspects of decision-making. Such a program should foster the development of research that identifies short- and long-term climate information needs of urban decision makers. It should also provide research opportunities for development of predictive and decision support tools (e.g., including risk assessment instruments, vulnerability models); develop effective education and outreach activities; and create forums to bring scientists and decision makers together to create trust and use of information, and to work with other federal partners in outreach programs.

The NOAA Sectoral Applications Research Program is a logical leader for such a program. Its close ties with programs such as the NOAA Coastal Services Center (CSC) and the National Climatic Data Center (NCDC) as well as the Education and Outreach activities within the NOAA Climate Program Office provides a logical springboard for obtaining a better understanding of the needs of cities with respect to climate services and helping to create and participate in a community in which new tools, methodologies, and strategies are developed, shared and improved. This program also is in a unique position to take a leadership role in the integration of science with social sciences, especially within the field of economics. However, this program cannot do it alone. There is ample opportunity for collaboration with other Federal partners to provide the most comprehensive and timely information and tools to urban resource managers for their use in making decisions for their constituents.

While the federal government plays a significant role in providing information, decision makers as well as professional and other intermediary organizations will have a responsibility to identify research needs and work with federal and local partners in addressing the key issues of concern. This requires federal partners and policy and decision makers to build trust both with each other and within the larger community. Trust should be built through continual, respectful and transparent interaction and timely delivery of viable products and information. It can also be built by engaging individuals/institutions who are involved and trusted in their communities and who understand the needs of that community early in the process.

The most productive approach for building an effective urban climate service is to build an integrated network that has at its core public outreach, particularly to affected decision makers (e.g., planners, city managers), in concert with science products that are focused around specific decisions. A critical component is setting achievable goals and managing expectations.

We have an opportunity at this juncture in American and scientific history to build a new community, a community intent on addressing the problems faced by urban areas and associated with a changing climate. The workshop attendees encouraged NOAA to take a leading role in coordinating a collaborative climate science information delivery and decision support program that will not only identify key issues but will put in place a mechanism to meet the future freshwater management needs of cities in the face of uncertainty.

Appendix A

Planning Integrated Research for Decision Support for Climate Adaptation and Water Management: A Focus on Desert and Coastal Cities

Agenda

Thursday, January 8, 2009

5:00 – 6:00 pm	Steering Committee Meeting Location: Club Room, University Club, Arizona State University
6:00 – 7:00 pm	Facilitators, Moderators and Scribes Meeting Location: Club Room, University Club, Arizona State University
7:00 – 9:00 pm	Dinner - *Welcome and Introductions* Location: University Club, Arizona State University

Friday, January 9, 2009

8:00 am – 8:30 am	Breakfast Location: ASU Decision Theater
8:30 am – 8:45 am	Workshop Overview *James Buizer and Nancy Beller-Simms*
8:45 am – 9:45 am	Plenary Panel - *Identifying the Problem* *Richard Anderson, Pat Gober, Margaret Davidson, David Behar* Moderator*: James Buizer* Discussion about the challenges faced by city managers and planners in relation to existing and anticipated water-related stresses in areas such as: water supply; water quality; wastewater management; infrastructure; flood control; growth; knowledge gaps; disconnect between tools and outcomes. Decisions are made in all of these areas, based on predictions.
9:45 am – 10:00 am	Break
10:00 am – 11:30 am	Breakout Session - *Exploring the Problem* Facilitators*: Kathy Jacobs, Eileen Shea, James Buizer* Discuss and prioritize key questions related to challenges identified above in the context of climate change, water, energy, and urban design.
11:30 am – 12:30 pm	Lunch served, report to Plenary
12:30 pm – 1:30 pm	Decision Theater demonstration
1:30 pm – 1:45 pm	Break

1:45 pm – 3:00 pm	Plenary Panel - *Identifying Potential Solutions* *Cynthia Rosenzweig, Ray Quay, Peter Rogers, Nancy Beller-Simms* Moderator*: Kathy Jacobs* Adaptation options and related research needs for coastal and desert cities to respond to coastal and desert urban issues.
3:00 pm – 3:15 pm	Break
3:15 pm – 4:15 pm	Breakout Session - *Identifying Needs and Approaches* Facilitators*: Kathy Jacobs, Josh Foster, Adrienne Antoine* Discuss needs and approaches to building adaptive capacity, incentives, roles of public and private sector, role of academia, funding options, science needs, planning tools; scenario development.
4:15 pm – 5:00 pm	Report to plenary
5:00pm - 6:00pm	Break
6:00 pm – 8:30 pm	Dinner Location: *Caffe Boa, 398 S Mill Ave, Tempe* Speaker*: George Basile*

Saturday, January 10, 2009

8:00 am – 8:30 am	Breakfast Location: ASU Decision Theater
8:30 am – 10:30 am	Plenary Panel - *Defining the Research Priorities* *Margaret Davidson, Dusty Hall, Emily Talen, James Buizer* Moderator*: Rich Anderson* Criteria for prioritizing research needs; designing an agenda at the local, regional and national scales.
10:30 am – 10:45 am	Break
10:45 am – 11:30 am	Plenary Discussion - *Group Perspective* Moderator*: Eileen Shea* Thoughts and discussion on priority research needs.
11:30 am – 12:00 pm	Next Steps
12:00 pm – 1:00 pm	Closing Remarks
1:00 pm – 2:30 pm	Steering Committee wrap-up meeting

Appendix B
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Appendix C

A Sampling of Planning Plans and other Administrative Documents that Effect Water Managers

Water Managers are subject to a variety of planning documents and agreements. Many are subject to the following:

- 20 Year Master Plans. Usually occurring over a 20-year horizon, these plans are blueprints for development and land use partitioning [save for states/areas that do not use strict zoning code].
- Capital Improvement Program (CIP). CIPs are usually a 5- to 7-year priority listing of physical infrastructure and other land use decisions that require major capital investment, often including bonds, but also using money authorized from the general fund.
- Water and Wastewater Plan. These plans may be part of the Master Plan or separate from it. Plans usually include a 20-year water supply plan on source and consumption. Most large cities have water conservation plans included. Some states require all municipal jurisdictions to authorize (through ordinances) water use restrictions. Many of the modern water plans involve provisions dealing with watershed management and source water protection.
- Comprehensive Emergency Management Plan (CEMP). Pre-9/11 era, many communities had emergency management plans addressing natural disasters that ranged from bare-bones plans to elaborate evacuation plans with practice drills. Post-9/11 era requires almost every community to have a fairly well thought-out emergency plan for natural and man-made disasters; and the plans should be synchronized with state Emergency Management Plans (this is a condition of receiving Department of Homeland Security financial assistance through the state administrations).
- Compacts, Treaties and Special Plans/Agreements. There are a number of these types of negotiated agreement. Notable examples include allocation of water from the Colorado River; water rights understandings and agreements between Maryland and Virginia concerning the Potomac River; and the Great Lakes Compact involving several states and Canada.
- State Mandates. Mandates are state specific. For example, the State of Florida requires all southern Florida communities to replenish groundwater in increasing percentages by a certain date. There has been a proliferation of plans to reuse wastewater for potable supply as well as to recharge aquifers such as that seen in Orange County, California.
- Court Orders, These directives are somewhat similar to State Mandates (above), but seldom involve entire regions. For example, Tampa, Florida is required by the Courts to lessen use of groundwater to mitigate salt-water intrusion.
- Local Permit Decisions. These decisions are made based on the master plan. In the 1980s-1990s, 50 % of local zoning permit decisions were overturned by the Courts.

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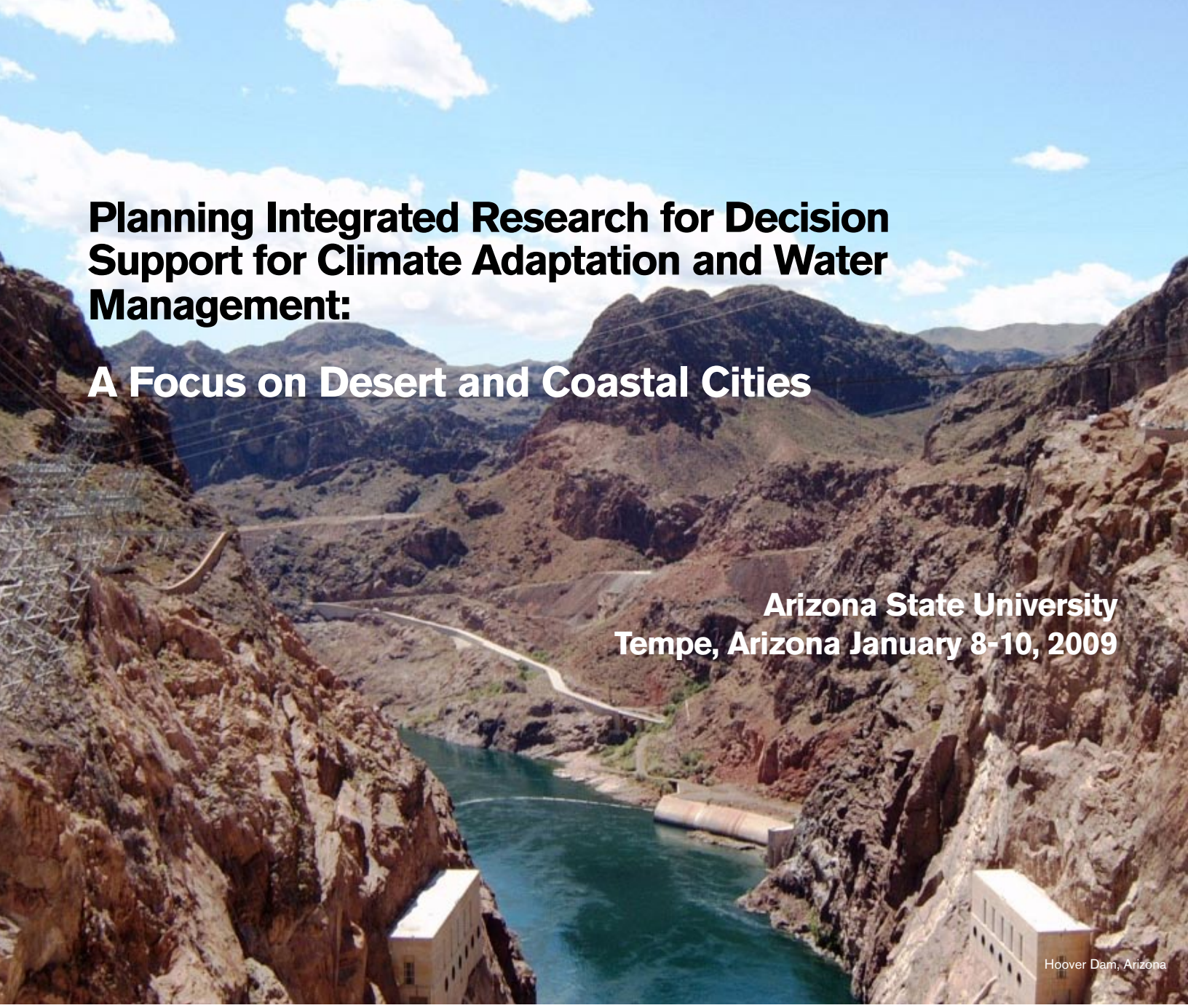

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