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ABSTRACT

Urban infrastructure is especially vulnerable to increasing climate-related hazards. In anticipation of this societal threat, the U.S. Government, under Executive Order 13514, is developing an interagency U.S. strategy for climate change adaptation. For urban areas, the envisioned federal role includes scientific assessments (with locally actionable outputs) and technical coordination to promote best practices for improving resiliency through coordinated planning from the federal to local level. This talk addresses climate-related natural hazards risks unique to urban environments and infrastructure and suggests approaches to enhance adaptive capacity and build resilience in urban areas.

1. INTRODUCTION

While there is uncertainty in the scope, severity, and rapidity of future climate change impacts, observations and long-term trends suggest that they will be potentially large and predominantly negative. Projected impacts include more frequent heat waves and high-intensity precipitation events, rising sea levels, ocean acidification, and more prolonged droughts. The annual average air temperature in the United States has already risen by more than 2°F over the past 50 years and is projected to increase further in the future (Karl *et al.*, 2009). These changes will intersect with a myriad of local vulnerabilities, especially in urban areas with their fixed physical infrastructure, yielding difficult societal decisions on adaptation (harden, relocate, abandon?) in the near to long term. Executive Order 13541 explicitly calls for agencies to “evaluate climate-change risks and vulnerabilities to manage the effects of climate change on the agency’s operations and mission in both the short and long term” (White House, 2009). This evaluation has significant implications for the nation’s urban areas.

The prescriptions for addressing climate impacts on society are well understood. The contributors to climate change (yielding deleterious impacts) can be **mitigated** through agreement at the national and international level (e.g., greenhouse gas reduction frameworks). The impacts of climate change can also be reduced through local to national strategies to **adapt** infrastructure to both increase resilience and reduce vulnerability to climate impacts. Table 1 outlines the distinction between mitigation and adaptation, as well as resilience and vulnerability – all critical to understanding and responding to climate change impacts.

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Table 1. Definitions of Key Terms (NRC, 2010)

Adaptation: Adjustment in natural or human systems to a new or changing environment that exploits beneficial opportunities or moderates negative effects.
Resilience: A capability to anticipate, prepare for, respond to, and recover from significant multi-hazard threats with minimum damage to social well-being, the economy, and the environment.
Vulnerability: The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes.
Mitigation: An intervention to reduce the causes of changes in climate, such as through reducing emissions of greenhouse gases to the atmosphere.

While top-down approaches are often attributed to the federal government, it has a much more meaningful role to play in leveraging its resources to support bottom-up adaptation efforts throughout the United States. To be successful, however, end-to-end approaches that combine research understanding of causes and processes must be translated into supporting and multi-disciplinary actions needed to cope with the societal consequences of climate change. NRC (2008) notes that such end-to-end approaches are especially important in response to extreme weather and climate events and disasters, sea-level rise and melting ice, reduced freshwater availability, endangered agriculture and food security, stressed ecosystems, strains on human health, and negative impacts on the U.S. economy generally. The October 2010 *Progress Report of the Interagency Climate Change Adaptation Task Force* (CEQ, 2010) considers these challenges and outlines some of the key recommendations relevant for the *urban* environment in the United States.

2. THE FEDERAL ADAPTATION TASK FORCE

The *Interagency Climate Change Adaptation Task Force* began meeting in Spring 2009. Co-chaired by the Council on Environmental Quality (CEQ), the National Oceanic and Atmospheric Administration (NOAA), and the Office of Science and Technology Policy (OSTP), the task force was guided by a strategic vision of a resilient, healthy, and prosperous Nation in the face of a changing climate. President Obama signed Executive Order 13514 on October 5, 2009, calling on the Task Force to recommend how the policies and practices of Federal agencies can be made compatible with and reinforce a national climate change adaptation strategy. The Executive Order charged the Task Force with delivering a report through the Chair of CEQ to the President within one year. The report was completed in September 2010.

The Task Force, comprised of more than 20 federal agencies and Executive branch offices, formed workgroups to consider the capabilities of the federal government to respond to the impacts of climate change on select sectors, institutions, and agencies. The Task Force conducted numerous listening sessions and public outreach events with a wide range of stakeholders, including those at the state, Tribal, regional, and local government levels, as well as non-governmental organizations (NGOs), scientists, academia, industry, and others. From these events and workgroup deliberations, the Task Force identified a set of guiding principles in designing and implementing adaptation strategies (Table 2).

Table 2. Guiding Principles for Adaptation

Integration / Prioritization	<ul style="list-style-type: none"> • Adopt Integrated Approaches • Prioritize the Most Vulnerable • Apply Risk-Management Methods
Science Collaboration	<ul style="list-style-type: none"> • Use Best-Available Science • Build Strong Partnerships • Apply Ecosystem-based Approaches
Evaluation	<ul style="list-style-type: none"> • Maximize Mutual Benefits • Continuously Evaluate Performance

3. URBAN ADAPTATION

The urban environment is especially vulnerable to climate change, given its concentrated infrastructure (e.g., 160 million people in coastal counties), complex regional interactions and dependencies, and patterns of migration and large clusters of vulnerable populations that have limited capacity to respond to climate change (Gamble, 2008). While urban settings are concentrated, the impacts of climate change are unevenly distributed and interact and exacerbate non-climatic stressors (Karl *et al.*, 2009). Clearly, the impacts of climate change disproportionately and negatively fall upon urban areas in the United States and most of the world, currently and in the future.

Among the workgroups noted in Section 2, the *urban adaptation workgroup* considered these conditions and issued the following suggestions for a constructive federal role:

1. Climate information must be properly **downscaled** for incorporation into **cost-benefit planning**.
2. Cross-agency **coordination** is needed to provide meaningful **technical assistance** that enhances both adaptive capacity and community resilience.
3. Adaptation policies and innovations need **bottom-up incubation** at the state, Tribal, regional, and local government levels through modifications to Federal laws, regulations, policies, and guidance.

4. The Federal government must demonstrate leadership in **protecting its own investments** through building adaptive capacity and resilience.
5. The Federal government should conduct **ongoing performance assessments** of adaptation efforts to gauge climate change response.

There are encouraging examples where these suggestions are being put into practice, primarily through policies that promote compact land use planning. Integration of information on climate change and regional economic growth are informing floodplain levee planning in Central California, where economic engineering optimization analyses (Zhu *et al.*, 2007) inform requirements for both levee heights and setbacks. National best practice strategies are being formalized in state climate actions plans to, among other things, encourage compact development (Ewing, 2010). The federal government's General Services Administration (GSA) is actively partnering with community planners to support compact development. With ownership of 480,000 structures valued at \$1.5 Trillion (Federal Real Property Council, 2008), the federal government has a critical obligation to 'walk the walk' on sound adaptation decisions and is taking steps to do so.

By combining granular science results with the economic and vulnerability status of a given community, decision makers can begin to take adaptation actions. The America's Climate Choices study (NRC, 2010) envisions a cyclical, iterative process to adaptation:

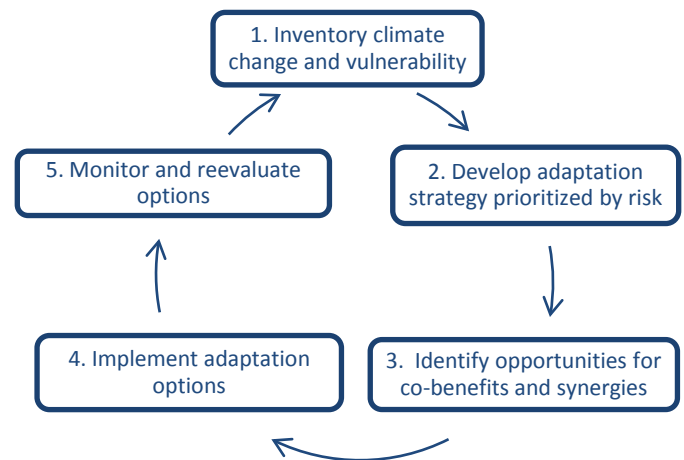


Figure 1. Adaptation planning steps (adapted from NRC, 2010)

The urban adaptation workgroup put considerable emphasis on the importance of Step 3 in this process. Community buy-in to adaptation is essential, and user engagement across sectors and regions underscores the need to highlight potential 'win-win' co-benefit approaches – effectively promoting activities that benefit a community for reasons beyond climate change adaptation alone.

4. ROADMAP FOR THE FUTURE

Planning for federal adaptation is moving forward through workshops and user engagement, with the goal of developing a baseline to measure future progress. The National Climate Adaptation Summit (NCAS), held in May 2010 (UCAR, 2010), led to recommendations to improve coordination and sustained dialogue, to enhance a clearinghouse of best practices, and to provide adequate research support for assessments (USGCRP) and economic analyses and pilot projects at regional to local levels. In considering the creation of a National Adaptation Program in the U.S. federal government, the Pew Center (Smith *et al.*, 2010) recommended a program with an adaptation strategic planning initiative, a National Climate Service, and an adaptation research program.

Whatever combination of planning, research, and service is ultimately adopted, it will likely build upon federal technical support that has already been provided for an array of state and local adaptation decisions. In coastal Alaska, six communities are now planning some type of relocation, and the U.S. Army Corps of Engineers has identified 160 villages that will likely have to be relocated due to coastal erosion (at a cost of \$30-\$50 million per village) (NRC, 2010). In New York City (City of New York, 2009), plans to harden the city from sea-level rise through sea walls are already under development. Such proposals are dramatic and well beyond the traditional scope of public policy in recent decades. The federal government has an important supporting role to play in technical coordination and bottom-up incubation, while it simultaneously provides national leadership in framing the regulatory framework and ensuring the sustainability of national resources. In essence, the federal government will likely need to establish 'rules of the road' for major infrastructure development not unlike its role in shaping 19th Century investments in waterworks and railroads.

5. CONCLUSION

The future offers both challenges and opportunities to adapt the urban environment in response to climate change. Infrastructure investments will be invariably made over the coming generation. Fully two-thirds of the 2050 urban landscape has not yet been built (Ewing 2010). With a projected population of 420 million in 2050, the United States will need 89 million new or replaced homes, 60 billion square feet of new office, institutional, and retail space, and 130 billion square feet of replaced non-residential space. Each investment to this end affords society a chance to thoughtfully adapt through individual investments that conform to climate-sensitive strategies of hardening or armoring, relocation, or even retreat or abandonment. Communities must weigh future investments in a cost-benefit context that also includes economic, social, and cultural components. The federal government must be in a position to provide support to communities to make these bottom-up decisions – through proper scaling and packaging of information, through collaboration and clear

communication of best practices, through leadership in adaptive management of national resources, and through continued dialogue with sectors, regions, and citizen groups.

6. REFERENCES

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7. ACKNOWLEDGMENTS

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