DRAFT

SUSTAINABLE COMMUNITIES CLIMATE ADAPTATION GUIDEBOOK

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INTRODUCTION

OVERVIEW

Climate changes are expected to have an impact on economic, environmental and social aspects of communities. Local governments recognize the need to begin planning now for long-term solutions to address the local impacts of climate change, such as sea level rise. But what approaches have the best potential to reduce those vulnerabilities? How do communities balance the need to address climate impacts across multiple sectors (e.g., land use, transportation, water, and buildings)?

This guidebook helps local governments make sense of the complexities of preparing for climate change by presenting a set of sustainable community approaches local governments can take to most effectively prepare for future climate vulnerabilities. Using the metropolitan Washington, D.C., area as a case study, the guidebook includes regional and local government-level approaches, which are applicable to all community contexts (rural, suburban, and urban).

BACKGROUND AND PURPOSE

Local governments, which bear the primary responsibility for land use planning, have long balanced demand for development with protection of fragile environmental and cultural resources. This challenge is growing in many communities with the long-term risks associated with climate change looming on the horizon.

Climate change refers to any significant change in measures of climate, such as temperature, precipitation, or wind, lasting for an extended period (i.e., decades or longer). Climate change may result from natural factors, natural processes within the climate system, or human activities that change the atmosphere's composition.[1] Recognizing that some degree of climate change will occur regardless of future greenhouse gas emissions,[2] local governments are implementing ***climate change adaptation*** approaches, or approaches that allow communities to adapt and/or become more resilient to unavoidable impacts from climate change. Local governments are seeking effective techniques to respond to estimated changes in precipitation, temperature, sea level, and severity of storm events, which all pose risks to people, infrastructure, buildings, transportation, and food production.

An increasing number of states (e.g., Alaska, California, Florida, Maryland, and Washington) and local governments (e.g., Boston; New York City; Fort Collins, Colorado; Los Angeles; Portland, Oregon; San Francisco; Miami; and King County, Washington) are actively planning and implementing approaches to climate change adaptation. The pace by which states and local governments are embracing climate adaptation policies and techniques is encouraging, but much of this effort is *ad hoc* based on perceived priorities. One jurisdiction may be focusing on how to deal with sea level rise or the urban heat island effect while another nearby jurisdiction is more focused on drought and wildfires. Overall, the approach to climate adaptation in most communities is neither complete nor methodical.

A reactive and uncoordinated approach to climate change can make it more costly and difficult for local jurisdictions to implement needed climate adaptation programs. In contrast, an anticipatory response involves advance planning to implement regulatory and policy changes that preemptively mitigate and/or identify methods to avoid the negative consequences from natural hazards.[3] For example, land use approaches that support resilient development are generally less expensive than implementing retreat strategies in direct response to a climate threats, such as sea walls or relocating critical infrastructure. However, such forward-thinking approaches require significant advance planning.

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[1] U.S. Environmental Protection Agency. Climate Change: Basic Information, http://www.epa.gov/climatechange/basicinfo.html. Accessed August 12, 2011.
[2] IPCC (Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)). *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, 2007.
[3] http://www.georgetownclimate.org/sites/default/files/Adaptation_Tool_Kit_SLR.pdf page 6

The purpose of this guidebook is to identify climate adaptation approaches to allow local jurisdictions to go beyond an issue-by-issue approach and deal with climate adaptation in a more anticipatory and comprehensive fashion. To do so, this guidebook focuses on sustainable community approaches, with a focus on smart growth and green building approaches.

Smart growth promotes development patterns that accommodate population growth, while balancing long-term economic, environmental, and social impacts.[4] The ten basic principles of smart growth include: 1) mix land uses; 2) take advantage of compact building design; 3) create a range of housing opportunities and choices; 4) create walkable neighborhoods; 5) foster distinctive, attractive communities with a strong sense of place; 6) preserve open space, farmland, natural beauty, and critical environmental areas; 7) strengthen and direct development towards existing communities; 8) provide a variety of transportation choices; 9) make development decisions predictable, fair, and cost effective; and 10) encourage community and stakeholder collaboration in development decisions.

Complementing smart growth approaches are ***green building*** techniques, which seek to reduce the direct environmental impact of buildings through the use of more sustainable materials, improved energy efficiency, and reduced water consumption and runoff.[5]

The sustainable community approaches included in this guidebook have the greatest potential to be used by local governments to conduct advance planning for and adapt to climate changes. At its core, planning for climate change is a natural extension of the standard planning processes used in the land use, transportation, water, and building sectors. This guidebook does not suggest that climate adaptation planning be conducted as a separate exercise from the existing planning processes, but instead, that emerging information related to projected climate changes be included in existing processes.

The approaches presented in this guidebook are already being used by communities across the country to improve sustainability (encouraging compact development patterns; improving stormwater management; implementing green building design standards; regional transportation planning). This guidebook suggests how these common approaches can be effective tools for climate adaptation planning, and is unique in that it describes the ability of each traditional approach to improve resiliency to climate change, through slight modifications in how each approach is implemented.

WHO SHOULD USE THIS GUIDEBOOK?

This guidebook is designed to provide a starting point for local governments in identifying and developing policies and programs that improve community resiliency to climate change through sustainable community approaches. It was developed by the U.S. Environmental Protection Agency to assist the Metropolitan Washington Council of Governments (MWCOG) in its regional climate adaptation planning efforts related to the land use, transportation, buildings, and water sector.

The MWCOG region is fairly advanced in its approach to regional planning and includes a number of jurisdictions that are recognized for their sophistication in sustainable community planning. In addition, the region includes rural, suburban, and urban areas, making it an excellent case study for other communities and regions across the country. Finally, it is projected to experience a variety of climate impacts that other communities will likely experience (e.g., sea level rise, temperature increase or decrease, increase in precipitation, and an increase in severe storm events).

The guidebook is designed to be used by the following individuals within the MWCOG region and nationwide:

- Directors and staff of local transportation, land use planning and zoning departments
- Directors and staff of local environmental departments responsible for water infrastructure

[4] Learn more at www.epa.gov/smartgrowth
[5] Learn more at www.epa.gov/greenbuilding

ORGANIZATION AND USE OF THIS DOCUMENT

This guidebook is organized into five sections. The first, *Plan for Climate Change*, explains the process by which communities can conduct climate change planning and/or develop a vulnerability assessment to identify vulnerable areas, risk, and priority planning areas. The second section provides a high level summary of land use, transportation, and water approaches that are best conducted at the regional level to sustainably adapt to climate change.

Sections 3-5 present sustainable climate adaptation approaches that can be conducted by local governments, and include approaches that:

- Protect vulnerable areas from development (Section 3)
- Protect people and assets in vulnerable areas (Section 4)
- Encourage sustainable development in appropriate, less-vulnerable areas (Section 5)

The following table summarizes the local government approaches presented in this guidebook.

		Adaptation Planning Stage			Most Relevant Sector	Relevant Vulnerabilities			
		Beginner	Inter-mediate	Advanced		Temper-ature	Precip-itation	Severe Storms	Sea Level Rise
3	Protect Vulnerable Areas from Development								
3-A	Evaluate Development Incentives Provided in Vulnerable Areas	●			Land Use		●	●	●
3-B	Adopt Protective Regulations for Vulnerable Areas	●					●	●	●
3-C	Direct Development Away from Vulnerable Areas on Large Development Sites		●				●	●	
3-D	Enhance or Restore Wetlands		●		Water		●	●	●
3-E	Purchase and Transfer of Development Rights			●			●	●	●
3-F	Establish Fund to Purchase/Acquire Land in Vulnerable Areas			●			●	●	●
4	Protect People and Assets in Vulnerable Areas								
4-A	Develop a Climate Readiness Plan for Local Government Facilities	●			Buildings	●	●	●	●
4-B	Improve Stormwater Management Approaches	●					●	●	●
4-C	Adapt Zoning and Building Codes to Evolving Risks		●			●	●	●	●
4-D	Create Special Taxing and Assessment Districts to Fund the Protection of Buildings and Infrastructure		●			●	●	●	●
4	Protect People and Assets in Vulnerable Areas (continued)								

		Adaptation Planning Stage			Most Relevant Sector	Relevant Vulnerabilities			
		Beginner	Inter-mediate	Advanced		Temper-ature	Precip-itation	Severe Storms	Sea Level Rise
4-E	Amend Non-Conforming Use Provisions to Allow Safer, Sustainable Redevelopment in Vulnerable Areas		●				●	●	●
4-F	Identify Transportation System Vulnerabilities		●		Transportation	●	●	●	●
4-G	Implement Integrated Heat Island and Stormwater Reduction Strategies		●			●	●	●	
4-H	Use Non-Structural Flood Mitigation Measures for Buildings in Floodprone Sites		●				●	●	●
4-I	Streamline the Relocation Process			●			●	●	●
4-J	Establish Fund to Relocate People and Assets from Vulnerable Areas			●			●	●	●
5	Encourage Sustainable Development in Appropriate, Less-vulnerable Areas								
5-A	Promote Smart Growth	●					●	●	●
5-B	Promote Infill Development		●				●	●	●
5-C	Remove Roadblocks to Development in Appropriate Areas		●				●	●	●
5-D	Adopt Complete Streets Design Standards		●			●	●	●	●
5-E	Upgrade Building Code Requirements			●		●	●	●	●
5-F	Incorporate Passive Survivability Into New and Existing Projects			●		●	●	●	●

Each approach captured in Sections 3-5 includes:

- A definition
- An explanation of how the approach can be used to enhance climate adaptation planning, referred to as the "climate connection"
- Examples of where the approach is being used in the Washington, D.C., metro region
- Benefits of using the approach
- Implementation considerations
- References and links to find more information

1 PLAN FOR CLIMATE CHANGE

BACKGROUND

Local governments are at the forefront of climate change planning. Not only will they be among the first responders to climate changes, they are best positioned to develop tailored climate change strategies that react directly to expected local impacts.

However, local governments often face challenges in understanding the full scope of expected climate change impacts due to a lack of capacity, access to data, or lack of resources. In addition, many local government staff feel ill-equipped to make long-term planning and capital improvement decisions based on imperfect data, preferring instead to make decisions based on more precise information. These challenges pose a significant hurdle for communities seeking to begin the climate adaptation planning process now.

Yet climate change is a dynamic, long-term process that will continually result in changing local condition. Local governments should not expect climate models to be refined and produce a projected "new normal" set of conditions. More realistically, governments need to expect to plan for a range of conditions, that may change over the course of a decade or a century. Waiting for more certain data does not guarantee that communities will be better prepared for climate changes, but instead may lead to higher social and financial costs once climate adaption approaches are implemented.

For example, a low-cost strategy for managing the risk of more frequent or intense floods might be to leave a floodplain undeveloped. If however, a local government waits until it has perfect information about increased flood risk and in the meantime allows development to continue in the floodplain, it may need to take a more costly approach later, such as installing dikes or other infrastructure to protect property in the most vulnerable areas of the floodplain.

To truly be prepared, local governments must make decisions based on imperfect information. In other words, the perfect should not be the enemy of the good.

That said, local governments do need to have a reasonable understanding of the expected range of climate change impacts. Likewise, the more detailed and localized information that can be collected and analyzed, the better prepared local governments will be to make long-term decisions.

This remainder of this section describes the basic steps local governments can take to gather data and develop a reasonable understanding of what climate impacts to which they should be prepared to respond as a part of their existing planning processes. The basic steps provided here are derived from the ICLEI - Local Governments for Sustainability *Climate Adaptation Guidebook*. More detailed information on each step, as well as templates that can be used to collect information and examples of completed templates can also be found in the ICELI Guidebook.

SCOPING CLIMATE CHANGE IMPACTS TO MAJOR SECTORS

As a first step to understanding projected climate impacts, communities should collect and analyze basic published research on expected climate impacts in the region. The types of information a local government should try to obtain include:

- Projected changes in key climate variables within a specified timeframe (e.g., sea level may rise 1-3 feet by 2040); variables may include temperature, precipitation, sea level, extreme weather, and wind.
- Information on seasonal variation in the key climate variables (e.g., is the variation expected to be greater or smaller than what the region experiences now, or will there be changes to seasonal weather patterns?)
- A range of projected impacts instead of a single number; often this information is available in worst-case, mid-range, and best-case scenarios
- The degree of uncertainty of the projections
- How the projections compare to current conditions

One source of this data is the U.S. Global Change Research Program's *Global Climate Impacts in the US* (2009). Other data sources include local universities, state environmental agencies, the National Oceanic and Atmospheric Administration (NOAA) (including their Regional Climate Centers), and the U.S. Environmental Protection Agency (EPA).

The next step is to qualitatively analyze this information to understand how these projected impacts may affect natural sectors in your community, such as water resources, nature resources, energy, coastal resources, or agriculture, and manmade sectors such as transportation and water infrastructure, emergency response, and buildings.

In doing so, local governments should keep in mind that projections may differ based on the use of different methodologies and models and different levels of uncertainty in the underlying assumptions. By carefully comparing different data sources, their projections, and expected impact to local sectors, local governments can gain a fairly clear understanding of expected climate impacts.

SCOPING CLIMATE CHANGE IMPACTS IN THE WASHINGTON, D.C., REGION

Of all major metropolitan areas, the Washington, D.C., region faces a unique challenge in that it straddles two of the country's Regional Climate Centers (the Northeast and Southeast). Being on the edge of two primary research areas makes it more difficult to project expected climate impacts, particularly when such impacts are contradictory in the two regions.

To help communities overcome this barrier, for the last two years, MWCOG has partnered with NOAA and EPA to better understand projected climate impacts in the Washington, D.C., region. Federal support for climate adaptation planning has included a climate adaptation workshop series with NOAA and technical assistance provided by NOAA and EPA. In summer 2011, MWCOG completed its first effort to scope climate change impacts in the Washington, D.C., region, largely following the process described in this guidebook.

IDENTIFYING PLANNING AREAS RELEVANT TO CLIMATE CHANGE

After scoping climate change impacts, the next step is to assess which planning areas—the areas in which a government or community manages, plans, or makes policy affecting the services and activities associated with built, natural and human systems—will be most directly affected or stressed by the projected climate impacts. For example, an expected increase in storm severity may lead to an increased number of combined sewer overflows (stressor) affecting stormwater management (planning area).

By aligning projected impacts with a local government's planning areas, communities can identify and begin to prioritize climate changes requiring a direct response.

CONDUCTING A VULNERABILITY ASSESSMENT

The vulnerability assessment is typically the most difficult and data-driven element of the climate planning process. However, the scope and scale can be limited to align with the resources and capacity of each community. While many local governments would prefer to have access to detailed geographic information system (GIS) data layers to create climate scenario maps and evaluate potential impacts to local populations and key assets, a more qualitative assessment can also be an effective means of identifying key vulnerabilities. Local governments may also find value in pooling resources with other nearby jurisdictions to collect data or conduct the vulnerability assessment. For example, many coastal states have assembled sea level rise data that can be used by multiple communities.

Sensitivity Analysis

Building from the list of planning areas and expected stresses on the systems within those planning areas (i.e., developed in the preceding step), local governments can complete a sensitivity analysis to understand the degree to which a system (built, natural, or human) is affected by changing climate conditions. For each planning area, the following questions should be answered:

- What are the specific climate conditions causing stresses on the systems in the planning area?

- How do the climate conditions affect those systems?
- What is the projected change in climate condition (including time period)?
- What is the projected climate change impact to the systems associated with this planning area if no climate adaptation approaches are enacted?
- To what degree is the system sensitive to changes in climate (high, medium, low)?6
- What are the projected changes in stresses on a system as a result of the projected climate change impacts? Are they likely to get worse, stay the same, or improve as a result of climate change impacts? Do new system stresses emerge?

To assess how sensitive the systems are to climate change, local governments may use GIS mapping systems and other common planning tools to evaluate climate impacts on local assets such as the impact of sea level rise. The Federal Emergency Management Administration (FEMA) also makes updated floodplain data available through its Map Service Center. In addition, local governments can consider how these systems are currently stressed during extreme weather events similar to those projected to occur under future climate scenarios.

Adaptive Capacity

The ability of systems associated within a planning area to absorb climate changes with minimal cost and disruption is referred to as adaptive capacity. Local governments should consider how flexible each system is to respond to climate changes and whether there are barriers to a system's ability to accommodate climate change. In addition, they should consider whether the rate of climate change may exceed the capacity of the system to adapt.

Vulnerability Assessment

The final step in the vulnerability assessment process is to conduct the vulnerability assessment itself, either qualitatively (assigning high, medium, or low values) or quantitatively, depending on resource and data availability. Reflecting on the analysis conducted up to this point, planning areas with systems that are sensitive to climate change and less able to adapt to those changes are generally considered to be vulnerable to climate change impacts.

As shown in the table below, a qualitative vulnerability assessment will provide a relative prioritization of planning areas, system stresses, and the vulnerability of those systems.

2. Planning Area	3. Current and Expected Stresses to Systems in This Planning Area	7. Projected Climate Change Impacts to Systems in This Planning Area	Vulnerability Assessment		
			8. Degree of Sensitivity of Systems in This Planning Area	10&11. Adaptive Capacity of Systems in This Planning Area	12. Vulnerability of Systems in this Planning Area
Storm-water manage-ment	Combined sewer overflows (CSOs) during heavy rainstorms (current and expected)	More localized flooding, water quality problems possible if precipitation becomes more intense, frequent.	High – CSO events are sensitive to changes in the intensity and frequency of rain events.	Medium – can upgrade the system but costly; some upgrades already underway.	Medium
Road operations and mainten-ance	Pavement buckling on asphalt roads during extreme heat events	More required asphalt maintenance likely.	High – pavement buckling an existing problem on many roads.	Medium – can replace asphalt more frequently but costly; dependent on industry-wide changes in asphalt for improved asphalt mixes.	Medium

CONDUCTING A RISK ASSESSMENT

Assessing climate change risk requires and understanding of the *probability* of an impact occurring and the *consequence* of that impact. Staff associated with each planning area should help assess the risk associated with each climate impact on the local systems.

Some considerations that can affect risk are the planning time frame (20 years versus 50 years), geographic scale, and attitudes towards risk. Risk can be assigned as high, medium, or low, or as a number (e.g., 1-5).

In order to assess the risk associated with projected climate changes, communities should consider using GIS mapping tools to model and estimate the extent of potential impacts and to identify key assets that may be at risk. For example, updated floodplain and sea level

[6] The degree of sensitivity can be analyzed by using the questions provided in the ICLEI - Local Governments for Sustainability *Climate Adaptation Guidebook*.

rise data can most easily be obtained and mapped against community assets to determine potential risk.

Some questions to consider when assessing risk include:

- How important is the potential impact related to other issues you are currently managing?
- If the probability of the impact is unknown, how problematic would an increase be for systems in your planning areas?
- How effectively are you handling stresses on the systems today?
- What is the adaptive capacity associated with systems?

The results of the risk analysis should be used to directly inform revisions to local capital improvement plans, comprehensive plans, and zoning by restricting or limiting development in areas with the greatest risk and vulnerability.

PRIORITIZING PLANNING AREAS

The climate planning process provides a foundation on which long-term climate adaptation approaches can be developed. To identify which planning areas should be prioritized for climate adaptation planning within a community, a simple graph can be used to compare vulnerability against risk.

Planning Areas with Systems that are…

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

Planning areas that are estimated to have high risk and high vulnerability should be priority planning areas. Those that are high risk and low vulnerability, or low risk and high vulnerability should also be considered candidates to be priority planning areas for climate adaptation planning.

Using the information generated through the Plan for Climate Change process, land use planners, transportation planners, water engineers, and building code specialists—among other local government staff—can to begin to identify the most appropriate approaches to respond to projected climate vulnerabilities and risks in the priority planning areas.

The approaches presented in Sections 2-5 of this guidebook represent some of the techniques that communities may choose to use. The approaches are written assuming that communities have completed the Plan for Climate Change process and have a solid understanding of their unique risks and vulnerabilities. This information should inform the selection of the most appropriate sustainable community climate adaptation approaches. In addition, the approaches are written assuming that there will be close coordination with or updates made to existing local capital improvement plans, comprehensive plans, and zoning.

All decisions on how to respond to the projected vulnerabilities and risks will be based on unique locally-derived factors including existing priorities, unique planning opportunities, and funding availability.

REMAINING FLEXIBLE

Projected climate change impacts, vulnerabilities, and risk will all change over time. It is therefore important for local governments to revisit the climate planning process on a regular basis. Once the climate planning process has been completed and climate impacts are considered in a community's regular planning processes, future updates or enhancements to the climate planning may be conducted by individual planning staff, or on a more periodic basis (once every 5-10 years), reviewed and revised in its entirety.

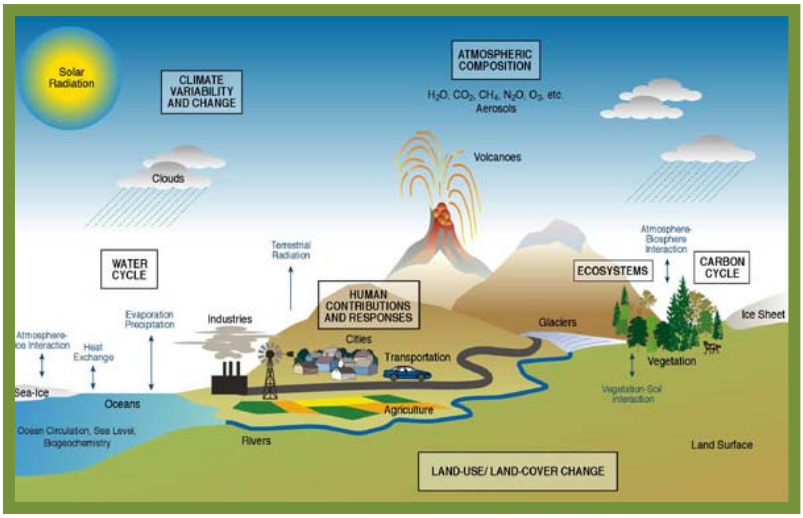
2 CONSIDER REGIONAL APPROACHES

The day-to-day impacts from climate change, such as flooding or changes in temperature, will directly affect communities. Local governments need to identify and implement a variety of community-specific approaches to protect their residents, buildings, infrastructure, and natural features (described in Sections 3-5).

However, in some cases, the most effective way to effectively respond to climate changes is for local governments to work cooperatively with other nearby jurisdictions on regional approaches to climate change. Regional approaches provide an opportunity for local governments to think beyond their borders in terms of projected climate impacts (e.g., localized flooding may be caused by conditions downstream in another community) and regional systems (e.g., sustainable land use, transportation).

The remainder of this section highlights regional approaches that address climate impacts in the land use, transportation, and water sectors. These approaches could be used by jurisdictions working together or by existing regional or state organizations (e.g., MWCOG).

Image source: http://solarb.msfc.nasa.gov/images/science/impacts/climate_big.jpg



Climate changes affect natural and built systems region-wide, requiring cooperative regional approaches.

2-A LAND USE

REGIONAL LAND USE PLANNING FOR CLIMATE CHANGE

One of the goals of climate adaptation planning is to encourage the movement of people, structures, and infrastructure away from vulnerable areas (i.e., areas with higher vulnerability and/or higher risk) and into less-vulnerable areas that are projected to be more suitable for development long-term. Many of the land use approaches described in Sections 3-5 of this guidebook focus on the distinction between vulnerable areas and less-vulnerable, or buildable, areas. Regional cooperation has the macro view necessary to provide guidance about making the most sustainable development decisions region-wide.

Approaches to regional land use planning vary from state-to-state and region-to-region. Regional planning can range from a county that participates in joint planning with its constituent jurisdictions to a regional council of governments such as the MWCOG. Land use planning at the regional level also ranges greatly, from very general policy planning and goal setting; to a more hands-on land use planning and mapping approach, such as that provided by the Maryland – National Capital Park and Planning Commission; to very specific issue-oriented planning and implementation, such as that provided by the Metropolitan Washington Air Quality Committee of MWCOG. Any, or all, of these approaches, however, can be helpful in planning to protect vulnerable areas.

At a policy level, regional organizations can be an educational clearinghouse for local governments and agencies, providing reports and links to climate adaptation information. Regional governments can develop and adopt climate adaptation policies and priorities that both start the conversation about climate adaption and guide similar efforts by local government. Regional governments can also lead the adaptation effort through the creation of model regulations and

instructions for the establishment of project funding that guide local governments.

At the land use planning level, regional planning that identifies and maps the extent and boundaries of the vulnerable area(s), quantifies the impacts anticipated from climate change, and coordinates responses across local governments can provide a greater level of protection than single-jurisdiction planning where the vulnerable area crosses local boundaries. Regional planning organizations have opportunities to suggest and guide implementation solutions that might be rejected at a local level because of cost or administrative difficulty but where a shared approach makes implementation easier and more effective. Regional organizations may also have access to state or federal funding that is unavailable to local governments. These funds can be allocated to technical mapping and planning efforts and the creation of model adaptation regulations in support of local climate adaptation efforts.

And at an issue-oriented level, regional organizations can advocate for, fund the protection of, and potentially regulate the impacts to a specific type of vulnerable area, such as a watershed, a river, or a forest.

There are numerous examples of regional coordination related to climate adaptation:

- The Chesapeake and Coastal Program, administered by the Maryland Department of Natural Resources, is a local, regional, and state partnership that provides assistance in coastal planning and resource protection.
- The City of Portland and Multnomah County, Oregon, look at the entire range of climate adaption issues and approaches in the Climate Action Plan 2009. The plan addresses topics such as buildings and energy, urban form and mobility, food and agriculture, and climate change preparedness.
- The Southeastern Wisconsin Regional Planning Commission has prepared a 2035 regional land use plan to help communities: 1) abate and contain urban sprawl; protect and preserve the natural resource base; and protect and preserve prime agricultural lands. According to SEWRPC, regional planning started in 1966, and even with imperfect implementation in the intervening years, the approach has served the region well.
- Sustainability is the foundation of the Atlanta Regional Commission's (ARC) Plan 2040. The plan explores "fifty forward findings" that look to future growth and change. In the environmental category, Plan 2040 states: "climate change has moved to the forefront of the global consciousness, and governments at all levels are assessing their impact on it." To understand and account for regional impacts, Plan 2040 links the identification of regionally important resources with a regional development guide. Together, these plan elements promote compact development in growth areas as well as the preservation of resource areas.
- St. Louis County, Missouri, is undertaking a sustainable code project similar to the CRCOG project described above as part of the St. Louis County, Green and Growing program. Through the Green and Growing process, the county has identified key sustainability goals and is reviewing plans and regulations for alignment with those goals. Updating the zoning and subdivision regulations to reflect sustainable development priorities is underway and should be completed in 2012.
- The Maryland Commission on Climate Change developed a Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change, which has a section focused on Population Growth and Infrastructure.
- Washington D.C.'s Region Forward is the outgrowth of the Greater Washington 2050 Coalition's work to provide a vision for a more accessible, sustainable, prosperous, and livable National Capital Region. Region Forward has established goals for land use, transportation, environmental, climate and energy, economic, housing, health and human services, education, and public safety that is uses to help guide local government decision-making and funding requests.

DATA CONSOLIDATION AND DISTRIBUTION

Regional government organizations can also be a primary source of information and mapping data related to specific, local climate adaptation issues.

Regional organizations are particularly well-equipped to serve this function because they can function as data aggregators from local governments. Once the information is collected and mapped or analyzed, regional climate vulnerabilities can be identified and shared back to local government. Where regional governments do not serve this function, institutional participants such as universities or state agencies/ commissions frequently provide assistance with addressing regional issues.

Information collected and created by regional or institutional agencies is related back to local governments and decision makers through reports, meetings, maps, plans, portals, and websites.

Some examples include:

- Sea-Level Rise: The Tampa Bay Regional Planning Council has prepared a report that maps potential areas of sea-level rise and identifies potential adaptation approaches to development in those areas.
- Drought: Collecting information from a number of regional water management districts, the Florida Drought Action Plan looks at areas that have been subject to water shortages in recent years and identifies a number of short and long-term to coordinate regional and state response as well as mitigate drought issues. The National Drought Information Center at the University of Nebraska tracks the status of drought planning across the country.
- Wildfire: The Tahoe Regional Planning Agency (TRPA) addresses wildfire issues in both Nevada and California through regional planning and permitting, coordination with local fire protection agencies, and education about defensible spaces and wildfire safety. The Western Forestry Leadership Coalition's 2011 Strategic Plan identifies five strategic issues that guide the coalition's work. The first three issues are climate, wildfire, and water.
- Flooding: Following Hurricane Katrina, Louisiana reorganized its approach to coastal planning and created the Coastal Protection and Restoration Agency (CRPA). In 2007 the CRPA prepared a Comprehensive Master Plan for a Sustainable Coast that is in the process of a 2012 update. The master plan update, to be completed in March 2012, focuses on preventing flooding and wetland loss through a range of approaches including levees, landscape features, floodproofing, and elevating structures. The Southern Nevada Regional Policy Plan links the conservation of open space to regional flood control approaches.
- Storm Intensity: The San Diego Integrated Regional Water Management Plan identifies potential changes in the region, state, and Colorado River Basin resulting from climate change. The Wisconsin Initiative on Climate Change Impacts has prepared a Coastal Communities Working Group Report that explores the impact of lake water level rise combined with changes in storm intensity and frequency.

CLIMATE ADAPTATION EDUCATION

One of the most important roles for regional government, universities, or other regional organizations in planning for climate adaptation is providing educational resources. Regional government organizations are often looked to by their constituent jurisdictions for model regulations, supporting policies, and issue research.

These policies and regulations can be used to advocate climate adaptation approaches that cross jurisdictional boundaries to provide a move comprehensive method of protecting vulnerable areas. Access to educational information, such as studies, reports, and the climate adaptation approaches of other communities can also provide support to local elected-officials who want to be more responsive to climate adaptation issues at both the local and regional levels but who need to develop a better understanding about where to start.

The following are examples of effective information sharing at the regional government level:

- The National Association of Regional Councils (NARC) has a Climate Change Adaptation webpage that details its work, in conjunction with NOAA, to survey member organization about planning for climate adaptation. NARC is now reviewing this information to determine how best to facilitate the information needs of elected officials and planners.
- The San Francisco Bay Conservation and Development Commission is an excellent example

of a regional organization providing informational and educational services. The SFBCDC has a web page titled "Planning for Climate Change: Resources for Bay Area Local Government" that includes links to climate change primers; scientific studies on sea-level rise; state, federal, and international climate change websites; and a long list of tools, data sources, and example adaptation actions.

- Columbia University, funded by a grant from NOAA and in collaboration with the Goddard Institute for Space Studies and Hunter College, hosts the Climate Change Information Resources website. The purpose of the site is to provide information to the public and decision-makers in the tri-state New York metropolitan area. The site provides issue briefs that explain the various aspects of climate change and multiple links to articles, reports, data, and organizations that address climate issues.
- The Capitol Region Council of Governments in Hartford, Connecticut, provides links to a number of sustainable reports and publications, including the Governor's Steering Committee on Climate Change. The Committee is currently developing strategies for climate adaptation in the state. The CRCOG is in the process of taking education to the next step – implementation - by assessing how local codes need to be updated to advance sustainability. The sustainable code project will include the preparation of model ordinances to be adopted by local jurisdictions.

2-B TRANSPORTATION

INCREASE REGIONAL TRANSPORTATION RESILIENCY THROUGH RENEWED COMMITMENT TO SMART GROWTH

Sprawling development patterns require more infrastructure compared with more compact, infill-based alternatives. One of the best ways to prepare transportation networks to function within a climate-impacted future is to implement smart growth on a regional scale.

Because inefficient development patterns require more infrastructure (e.g., miles of highway and rail networks, number of bridges and tunnels), in a climate affected future, sprawling infrastructure has a greater potential to be exposed to temperature and precipitation extremes, sea level rise, wildfires, and more frequent and intense flooding. These vulnerabilities can dramatically increase the cost of adaptation investments necessary to preserve access and mobility in a climate affected future.

Modern communities have also grown increasingly dependent on regional travel to access jobs and basic goods and services. More and more, commutes and errands are completed on grade-separated highways, rather than local roads, avenues, and boulevards. The increased use of high-volume highways increases the

REGIONAL TRANSPORTATION PLANNING CONSIDERATIONS IN THE WASHINGTON, D.C., REGION

In a typical MPO, the planning region is contained entirely within one state and state transportation dollars are sub-allocated to urbanized areas to develop and fund regional plans. The Washington Metropolitan Region presents an atypical, but not entirely unique, challenge to true regional planning and project prioritization. The Washington Region is comprised of two states and the District of Columbia, which for the purposes of federal transportation funding is treated as a full state.

While many regions have an adopted practice of how the region's dollars are further distributed, there is usually not specific predetermined amounts that each jurisdiction is to receive. In the Washington region, however, the distribution of federal aid channeled through the states to the urbanized region are typically already determined by the states themselves and simply coordinated by the MPO. The money does not co-mingle, which can pose challenges for climate adaptation planning.

For example, a project in the District of Columbia may be a very high priority to the State of Virginia but a low priority to the District. While the region may advocate for the advancement of such a project, there are but a few rare occasions where states have contributed dollars across jurisdictional lines. While this arrangement is logical and expected, it nonetheless poses certain limitations for climate change adaptation planning.

potential economic and social costs of any single climate-event impact on transportation infrastructure by:

- Increasing the number of people dependent upon each segment of the network, and the number of travelers potentially affected by a single event.
- Reducing options for re-routing trips in response to compromised network segments.
- Reducing access to multi-modal options to meet basic daily travel needs. Beyond the broader sustainability impacts of automobile dependent neighborhoods, climate resiliency is limited (e.g., the ability to walk to a quality grocery during an intense snowstorm or take light rail to work following the collapse of a highway bridge is limited).

Regional adoption of smart growth reduces the amount of infrastructure required to sustain growth; promotes densities to support interconnected, multimodal networks; and reduces dependence upon regional infrastructure to meet basic access and mobility needs by bringing people, goods, and services closer together. As described by the Urban Land Institute: "compact development provides an insurance policy against the worst effects of climate change…in the worst case, current or future residents of compact development will have a variety of viable transportation options, while the residents of sprawl will not."[7]

Some approaches that can be used at the regional level to promote smart growth to improve the resiliency of the transportation sector include:

- Coordinate across counties and municipalities to develop consistent strategies for increasing roadway connectivity, such as connectivity-scoring measures for approving new roadway proposals (as recently adopted by Virginia DOT) or minimum requirements for through streets (required every 600 feet in Portland, Oregon, for example).
- Metropolitan planning organizations (MPOs) can develop a transit hierarchy to help guide local and regional investments to complete transit networks. The hierarchy would identify ideal modal choices/service types for different levels and types of transportation service required (e.g., neighborhood, local, regional, long-distance) to provide a complete transit network. Complete transit networks that allow door-to-door transit access across the network, long the ideal for regional transit planners, will become a higher priority within climate impacted regions when personal auto mobility will become less reliable.

WASHINGTON, D.C., TRANSIT HIERARCHY

In the Washington, D.C., region, the Washington Metropolitan Area Transit Authority developed a Station Site and Access Planning Manual (2008) Access Hierarchy which prioritizes station access by mode for daily trip patterns. In addition, Arlington, Virginia's Primary Transit Network which establishes corridors where transit is the focus over all other modes (except the pedestrian) to maximize person trips. These two existing concepts can be further applied across the D.C. region with the MWCOG organizing the municipalities and transit operators to agree on the routes and right-of-way treatments. The result will be a hierarchy system that can be implemented to encourage smart growth today and be ready for future climate changes.

- Coordinate efforts between municipalities and transit operators to create regional plans to link and prioritize non-motorized and high-capacity mobility at key transportation nodes and along critical access routes. Two Washington, D.C., region examples of individual plans which could then be combined for regional implementation include: 1) the Washington Metropolitan Area Transit Authority's Station Site and Access Planning Manual (2008) Access Hierarchy which prioritizes station access by mode for daily trip patterns; and 2) Arlington, Virginia's Primary Transit Network, which establishes corridors where transit is the focus over all other modes (except the pedestrian) to maximize person trips.
- Coordinate local agencies and advocates in the planning, development, and identification of bike and trail networks and complete streets across the region to complete a regional non-motorized network plan.
- Institutionalize consideration of climate change impacts in all levels of planning. The Maryland Commission on Climate Change developed the

[7] Urban Land Institute, *Growing Cooler,* Ewing, R. et al. Page 137 (PDF version).

Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change, which provides guidance on incorporating climate adaptation considerations in all aspects of planning, including "the integration of land use, infrastructure planning, and climate change adaptation strategies."

Two Washington, D.C., region examples of individual plans which could then be combined for regional implementation include:

- The Washington Metropolitan Area Transit Authority's Station Site and Access Planning Manual (2008) Access Hierarchy which prioritizes station access by mode for daily trip patterns.
- Arlington, Virginia's Primary Transit Network, which establishes corridors where transit is the focus over all other modes (except the pedestrian) to maximize person trips.

DEVELOP A REGIONAL RISK-BASED APPROACH TO IDENTIFY TRANSPORTATION INVESTMENTS

MPOs typically help communities identify priority transportation projects for funding in their Transportation Improvement Program and Air Quality Conformity Determination (TIP). The TIP serves as the implementation arm of the MPO's long-range transportation plan by incrementally programming funding for improvements. It programs federal-aid funds for transit projects, and state and federal-aid funds for roadway projects.

In the Washington, D.C., region, MWCOG manages the TIP as a 6-year financial program with a schedule for obligating federal funds to state and local projects. The TIP contains funding information for all modes of transportation including highways and HOV as well as transit capital and operating costs.

Often, a traditional cost-benefit analysis is used to weigh transportation investment options. Climate condition changes have not historically factored in these analyses. However, analyses must begin factoring the costs and benefits of the anticipated impacts of highly variable climate-related conditions and the available options for responding to them. For example, short-lived infrastructure elements such as highway surfaces can be retrofitted in accordance with regular replacement schedules — minimizing the cost of this adaptation option. By contrast, adapting long-lived infrastructure such as bridges and tunnels would be more likely to require significant investment or even replacement prior to the end of their normal life cycle.

Incorporating a risk assessment into the final investment scoring for future transportation investments can, therefore, ensure that limited investment dollars are spent where and when they can be most effective.

To develop a regional, risk-based approach to identify appropriate transportation investments in a climate impacted future, MPOs should review and rely on available transportation asset vulnerability assessments conducted by local governments (See Approach 4F). With this information, an MPO can lead a coordinated, comprehensive risk assessment of regional transportation networks and network components by incorporating the following basic steps into their TIP process:

- Develop an inventory. Identify the region's primary transportation networks, and the major components of each, such as bridges, tunnels, and highway and rail line segments. This would commence with compiling inventories from local vulnerability assessments from throughout the region.
- Assess vulnerabilities. Identify which anticipated climate impacts present potential threats to each network component (this can take advantage of the many emerging efforts to model and map anticipated impacts from climate change, as well as local vulnerability assessments).
- Calculate incident probability. Identify the likelihood of the identified threats to each network component. This should include coordination with climate scientists and other experts beyond regional and transportation planning fields. This step should complete work already begun at the local level.
- Multiply by projected incident costs (the likely economic and social costs of each potential incident) and divide by the cost of adaptation (e.g., relocating, retrofitting, replacing, or creating redundancies). This is where a regional assessment can add critical value to a simple

compilation of local vulnerability assessments. An at-risk local road within the District that is critical to Virginia commuters, for example, would not necessarily be assigned a high incident cost within a District vulnerability assessment, and would not even be a factor in a Arlington County assessment with no jurisdiction over the road. At the regional level, however, the cost of anticipated impacts to this road can be assigned an appropriate value.

- Use scores to identify adaptation investment priorities. Make the most of limited infrastructure funds to shore up the most at-risk, critical, and cost-effective options from a regional perspective.

Other options to consider when scoring transportation investments include the following.

- When scoring new transportation infrastructure/services investments, give weight to options that add redundancy to at-risk infrastructure. For example, a bus rapid transit line could reduce costs compared with a rail line expected to become vulnerable to storm surge. Weighting should be based on total existing and potential ridership (gained or lost) by the loss of an existing transportation component, compared to how much ridership would be maintained by offering the redundant service. Key data points will include ridership, potential to maintain accessibility to the first and redundant components, and population and employment densities within a 5 to 10 minute walk of the services.
- Categorize infrastructure by the number of anticipated changes to existing conditions (sea level rise, wind/storms, etc.). For example, Ronald Reagan Washington National Airport is likely to be subject to rising sea level on one side plus flooding on the George Washington Memorial Parkway side.

MPOs bring a regional focus to such efforts, while the local focus of counties and municipalities cannot address the interconnectedness of the infrastructure components within their various jurisdictions. While this could likely be done effectively at the state level, MPOs have traditionally been more active in these areas of broad transportation planning.

There are many examples of risk-based approaches to transportation investment decisions. Two of the most relevant to regional climate adaptation are:

- The State of California's *Seismic Retrofit Program*, which uses such an approach to assess the relative level of earthquake-vulnerability and systemic importance of bridges across the state to prioritize retrofit and replacement investments.[8]
- The Federal Highway Administration has developed a Conceptual Model of a risk-based, climate change vulnerability assessment that will be piloted by select State Departments of Transportation and/ or MPOs.[9] The goal of the model is "to help transportation decision makers (particularly transportation planners, asset managers, and system operators) identify which assets (a) are most exposed to the threats from climate change and/or (b) are associated with the most serious potential consequences of those climate change threat."
- The Puget Sound Regional Council's long-range transportation plan, Transportation 2040, includes a white paper on adaptation of the transportation system to potential impacts from climate change.

[8] For more information: http://www.dot.ca.gov/hq/paffairs/about/retrofit.htm

[9] Federal Highway Administration. Highways and Climate Change, www.fhwa.dot.gov/hep/climate/conceptual_model62410.htm. Accessed 12/8/2011.

2-C Water

ENHANCE REGIONAL WATER RESOURCE MANAGEMENT USING A WATERSHED FRAMEWORK

The water sector is complex, as it includes the delivery, collection, and treatment of water . Management of stormwater, wastewater, water quality, water reuse, and potable water demand is often led by different departments at the local, county and state governments. Regulatory frameworks are established by individual entities to meet their requirements and the communities are often challenged with silo-based requirements. Also, the regulatory requirements can be conflicting (e.g., floodplain ordinance vs. water quality goals/standards), increasing the regional vulnerability of the water sector across to climate changes.

The infrastructure that supports the water sector is particularly vulnerable to climate changes (i.e., increases in air and water temperatures results in water quality conditions in the waterways, sea level rise can directly impact wastewater treatment facilities in some areas, and more frequent and intense flooding that causes increased public safety and health concerns). In addition, water and wastewater infrastructure can be more vulnerable in in sprawling communities, which tend to have more miles of infrastructure per capita than in more compactly developed areas.

To most effectively respond to these vulnerabilities, regions should consider adopting watershed approaches to enhance regional water resource management. Watersheds are not confined by political boundaries, therefore, issues pertinent to water quality, flooding, degradation of streams and biological integrity can be best addressed by undertaking a holistic approach. This systematic process allows quantification of component influences of various contributors and assessment of remedies that will improve the overall health of watersheds in a cost-effective manner. It also allows for integration of permit reporting and investments for municipal governments to meet the various regulatory requirements.

The following bullets summarize some watershed approaches communities can take to most sustainably and effectively plan for and adapt to climate changes in the water sector.

- Perform a region-specific assessment on the impact of climate change on the water sector. For example, similar assessments have been conducted in the New York City and the Southeastern U.S. regions. This assessment will need to be performed in three phases:
    1. A research effort that can be led by academic institution(s) or a regional government (e.g., MWCOG), for example, to quantify the variability and magnitude of climate change impacts in the region. Increases in precipitation intensity and volumes, sea level rise, increase in air and water temperatures due to urban heat will be among the key outcomes of this effort.
    2. Interpretation and integration of these outcomes at a watershed-scale (e.g., regional water supply and ecosystem vulnerability assessments). This can be performed by a regional or watershed organization, which can also coordinate with NOAA and FEMA to update the base indicators such as floodplain delineations, appropriateness of current design storms, and water supply yield
    3. Municipality-specific or infrastructure-specific (e.g., wastewater treatment plants, CSO outfalls, water supply intakes) vulnerability assessments that individual municipalities can undertake to develop adaptation strategies.
- Establish a well-coordinated water policy that takes an integrated approach to water planning instead of a piecemeal system that separately addresses drinking water, combined sewer, stormwater, and water quality of major water bodies (e.g., the Chesapeake Bay). This approach requires coordination among multiple levels of governments to develop appropriate, regional climate adaptation strategies for a watershed. For example, the Chesapeake Bay requires reductions

in: the nitrogen total maximum daily load to improve water quality, phosphorus to alleviate eutrophication in local impoundments, and pathogens to improve recreational needs. If temperatures rise due to climate change, the Bay could also expect more algal blooms and fish dead zones to occur. State governments and the EPA should work together to allow flexibility in regulatory frameworks for individual watersheds, so that the municipal governments can coordinate and integrate permit requirements and capital improvement programs across jurisdictions.

- Adopt a regional/watershed-based smart growth development plan and establish region-specific guidance on how to integrate climate change considerations into broader decision-making (e.g., enhance or restore critical wetlands to improve resiliency). As described earlier in this guidebook, regional smart growth approaches to land use can reduce water infrastructure needs and help local municipalities better manage the infrastructure with limited staff and financial resources.
- Regional governments (e.g., MWCOG) can coordinate with counties and municipalities to develop uniform codes and ordinances for new and redevelopment project approvals and for establishing new stormwater strategies to control for the remaining existing developments.
- Federal and state regulatory agencies can coordinate to streamline the various regulatory requirements for individual municipal governments, and also establish cost-sharing arrangements for projects that involve federal or state-owned sites that contribute to flooding and water quality impacts.
- Regional governments can develop a transparent and frequent communication protocol for local municipal governments in the planning, pursuance and implementation of water programs aimed at financial, regulatory and programmatic elements.

There are many examples of regions using a watershed framework to enhance water resource management, including:

- A watershed-based framework was formed by the State of Washington, subsequent to legislation introduced in 1998.
- A watershed planning framework for the Red River Basin covers drainage areas in the U.S. and Canada.

In addition, the following resources provide information on watershed planning approaches:

- A User's Guide to Watershed Planning in Maryland presents a common watershed planning framework for Maryland communities, assembles planning resources into one place, integrates regulatory drivers, and presents the methods necessary for completing a local watershed plan.
- *Managing An Uncertain Future: Climate Change Adaptation Strategies for California's Water* provides statewide and regional approaches for the water sector.

DEVELOP A REGIONAL STRATEGY TO ENHANCE STORMWATER MANAGEMENT

One of the most potentially effective approaches related to the water sector is regional cooperation on stormwater management because it is can be expensive to control stormwater and effective controls require the use of consistent practices among various jurisdictions to achieve watershed-based goals.

Stormwater causes local and widespread flooding leading to interruptions to traffic and businesses and poses risk to public safety. At the same time, it carries pollutants from urban and suburban areas to cause impairments to waterways downstream. Projected climate changes in the Northeast (based on New York City studies) indicate increases in intensity, frequency and volume of rainfall. Runoff patterns will change accordingly, thereby impacting the ability of stormwater control practices to potential impacts of climate change. For example, detention ponds originally designed for controlling a 10-year design storm will not be adequate to control peak flow from a new design storm with increased intensity and volume.

Stormwater controls need to be established on a regional/watershed basis to achieve consistent outcomes. For example, if the upstream communities simply design additional conveyance to dispose of stormwater, this will cause increased flooding in the downstream communities. In order to establish equity

in controls and also not stress one portion of the watershed versus others, distributed controls are necessary throughout the region/watershed to make differences in flooding and alleviate the associated public safety and health concerns.

In communities with combined storm and sewer systems, the capture and beneficial use of stormwater leads to reductions in treatment costs at the treatment plants and the associated energy and GHG emissions. Similarly, a reduction in peak flows/volumes in communities with separated sewers will lead to increased quality of life and reductions in potable water demand.

Also, the treatment of stormwater by best management or low impact development practices directly contributes to improvement in water quality. Pollution prevention initiatives will also help in achieving this goal. However, the life cycle costs associated with construction and operation and maintenance of these practices (stormwater controls) can be expensive, due to land costs and volume/peak flow to be controlled. Climate change impacts will likely increase these costs, however, the additional social and environmental benefits can be carefully accounted for in a triple bottom line analysis and can help justify the expense in terms of the total benefits achieved. Conducting a triple bottom line analysis on a regional/watershed-scale will increase the acceptance and enhance funding needed to establish the controls.

Specific guidance developed to assist local municipal governments and the implementation strategies will help in achieving the stormwater management goals. The following bullets summarize some options regions can explore to improve stormwater management:

- Develop comprehensive information on the effectiveness of stormwater controls to achieve water quality benefits for local governments that can use the information for planning, design, implementation and performance tracking of these controls to meet regulatory requirements. Construction and performance monitoring in various land uses will provide data on different practices. The research efforts pursued by University of Maryland, Virginia Tech, North Carolina State University, and University of New Hampshire, along with efforts conducted by the Center for Watershed Protection and Low Impact Development Center are valuable resources. Literature values are available from many regions, but generating data specific to a region will be more useful. A regional government (e.g., MWCOG) or a university can compile an inventory of stormwater control projects and their performance data for regional use.
- Develop regional guidance to revise plumbing code and treatment requirements for water needs for non-potable uses, so that stormwater can be put to beneficial uses (e.g., toilet flushing, cooling tower makeup and lawn irrigation), thereby reducing the amount of stormwater runoff and waste water requiring treatment. In addition to site-scale, neighborhood-scale opportunities for storage (e.g., wetponds) and beneficial use must be explored. In addition, a mix of low- (e.g., infiltration basins for groundwater recharge with no treatment) and high-technology (e.g., membrane filtration to use stormwater for lawn irrigation with potential for public contact) options should be explored. Individual local governments can collaborate with developers to explore these options.
- Develop better modeling tools for planning (e.g., vulnerability assessment tools, design criteria for stormwater management and infrastructure including site level analysis and overland relief). Pre- versus post-construction runoff calculation procedures should be modified by local municipal governments to include other design criteria such as sediment control and watershed-scale pollutant load reduction goals. This can require a significant shift away from traditional development permits to more comprehensive tools that account for both water quantity and quality. In addition, roads should be treated as overland flow pathways to convey flows in excess of the capacity of underground sewers; a hybrid tool that can characterize both sewer flows and street pathways can be more effective to understand stormwater conveyance during large storms. For example, the City of San Francisco has adopted a two-dimensional city-wide modeling approach when its original one-dimensional model was not able to accurately characterize flooding resulting from overland flow conveyance.
- Reduce impervious surface area associated with transportation (roads, alleys, and sidewalks) and

integrate stormwater improvement techniques (cisterns, bioswales, enhanced treepits, and stormwater basins/ponds), to reduce stormwater volumes and pollutant loads from transportation corridors prior to discharge into the sewer system. This also helps to reduce peak flows during rainy periods, so that the flows and pollutant loads from combined or separate sewer systems into the receiving waters are reduced. The Transportation Research Board (TRB) has developed national guidance (Evaluation of Best Management Practices for Highway Runoff Control; Stormwater Treatment with Vegetated Buffers) for regional and local governments.

- Coordinate waterfront development approaches along contiguous waterbodies, so there is a consistent approach to respond to high water levels. For example, to protect developed areas from rising water levels some areas may have sea walls, while other areas may not, which increases flooding risk increases for downstream areas that do not have hardened structures. Waterfront areas are generally in the low-lying or filled-in portions in comparison to upstream areas. If stormwater controls are not established effectively in the upstream areas, the low-lying areas can experience significantly large runoff during rainy periods, in addition to being prone to increased risk due to sea level rise and potential storm surge. Therefore, a systematic approach to reduce flow from reaching low-lying areas and enhancing resiliency to sea level rise must be undertaken collaboratively across a region. Two programs that address coastal waterfront development and mitigation strategies include: NOAA's Smart Growth in Coastal Areas report and the City of Portland, Oregon, South Waterfront Design Guidelines that cover stormwater management and other aspects pertinent to waterfront development.
- Assess the potential effects of climate change on regional groundwater conditions and water levels. High groundwater levels can increase inflow into sewer systems, which can be exacerbated by infiltration-based stormwater controls. This is particularly applicable for urban and suburban areas on a regional basis, where the original streams may have been filled and connected to sewers or where groundwater levels are high due to poor infiltration through soils. In addition, the dense urban areas can have transportation tunnels and other large underground buildings from where large quantities of groundwater may be pumped into the sewer systems. The infrastructure receives excess flows that reduces its capacity to handle stormwater flows during rainy periods. To control quantity, the strategies can be municipality-specific where codes or ordinances can be reviewed by local municipalities regarding using the pumped groundwater for beneficial uses rather than discharging into the sewers. Another stressor is the high level of dissolved nutrients in groundwater that can contribute to significant nutrient pollution in streams and large waterbodies such as Chesapeake Bay. Septic systems and infiltrating stormwater are the primary sources of this pollution. To control water quality in stream/river baseflows from upper watersheds, regional or watershed-wide controls can be explored including the adoption of process-based stormwater controls (e.g., raingardens, constructed wetlands, and bioretention) to uptake nutrients instead of infiltrating into groundwater and exploration of the need and potential costs associated with treatment technologies for removing nitrogen from groundwater (e.g., permeable reactive barrier, alternative septic systems, and sewage treatment plant expansions, and in-stream wetland in upper reaches with high septic system density).

There are many examples of regional cooperation to address stormwater management, including:

- The Maryland Commission on Climate Change developed a Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change, which has a section focused on Water Resources.
- The Northern Westchester Watershed Committee recently completed a regional study on compliance to New York State MS4 program on behalf of twelve watershed municipalities .
- The Minnesota Cities Stormwater Coalition assists municipalities in meeting federal and state stormwater regulations.
- The Toledo Metropolitan Area Council of Governments is designing and implementing regional stormwater solutions.

3 PROTECT VULNERABLE AREAS FROM DEVELOPMENT

Climate change may cause changes in precipitation, temperature, frequency of severe storm events, sea level, and wind, with the specific impacts varying region to region. And there remains significant uncertainty related to the timing and extent of impacts that can be expected from projected climate changes. However, one of the most basic long-term planning tools communities can use to prepare for these changes is to identify areas in the community that are not developed and have higher vulnerability and risk to climate change, and protect these areas from development to ensure that people, buildings, infrastructure and other assets are not inadvertently put at risk. Doing so is a conservative approach toward an uncertain future and can help avoid significant future costs (e.g., if vulnerable areas are developed, people and assets may be put at risk, requiring protection or relocation).

Using sustainable community approaches to protect vulnerable areas from development is a natural extension of using smart growth approaches for watershed protection, rural area development, natural resource protection.

For the approaches described in Section 3 of this guidebook to be effective, communities need to first complete a robust vulnerability planning process identify the highest priority planning areas (e.g., stormwater management, transportation), and within those areas, identify specific geographic areas that have the greatest vulnerabilities and risks from a changing climate. Once the "vulnerable areas" are identified, communities can review and select from the following approaches to identify those that are most appropriate for their community.

Image Source: Google Earth

Low-lying areas like the Potomac River shoreline near Fort Washington, Maryland, may be susceptible to sea level rise or flooding related to increased precipitation. In such cases, protecting the area from development may be a low-cost approach to climate adaptation.

3-A Evaluate Development Incentives Provided in Vulnerable Areas

DEFINITION

Local governments typically have regulatory and financial incentives/subsidies to guide the location and design of development. Incentives and subsidies can either be designed to discourage development in vulnerable areas or to encourage proper design and placement in vulnerable areas. These programs and funding sources should be reviewed to ensure that they are properly targeted to address development in vulnerable areas. Additionally, local governments should consider the use of fiscal impact analysis (FIA) to understand the connection between development choices and local incentives/subsidies.

CLIMATE CONNECTION

Property owners make development decisions based on a number of factors, including the possibility of leveraging their development investment though incentives or subsidies available from local government. Financial incentives/ subsidies can include programs such as tax abatement, tax increment financing (TIF), brownfield redevelopment funds, capital investments (e.g., sewer lines) and a number of other programs that are authorized by state and/or federal law. Local government can also use zoning and subdivision regulations to permit density bonuses, fast-track approval of projects, waive fees, or build/fund necessary infrastructure. In some communities, local government has historically led the way to new development by extending infrastructure (or requiring private extension of infrastructure) beyond that needed by an approved development. The purpose of all of these approaches is the same – encourage new development and/or redevelopment.

In vulnerable areas, however, encouraging development may be at odds with the potential long-term impacts of climate change to harm development and the people who live and work there. Discouraging or re-directing development may be a far more valuable policy choice. Local government can help ensure that vulnerable areas are protected by reviewing the allocation of both financial and regulatory development incentives/subsidies to: 1) confirm that they do not encourage development in vulnerable areas; and 2) where appropriate, encourage development outside of vulnerable areas to provide an offsetting option to accommodate property owners in vulnerable areas. The use of development incentives and subsidies, including the appropriate location of infrastructure, should be linked to growth and vulnerable area protection policies in the local comprehensive and capital improvement plans.

ADAPTATION PLANNING STAGE

Beginner

RELEVANT SECTORS

Land Use: Most relevant sector. Development incentives and subsidies are typically linked to the encouragement new development.

Water: The extension of water and sewer lines (along with roads) is a primary driver of development. Where infrastructure is subsidized or permitted to be extended without consideration of location, vulnerable areas may be at risk.

Transportation: A number of communities limit development incentives and subsidies to "public" project components such as streets and sidewalks.

Buildings: Buildings are a relevant concern primarily in a land use context; where development is incentivized/subsidized in vulnerable areas, buildings may be constructed in vulnerable areas.

RELEVANT HAZARDS



COMMUNITY CONTEXT

Rural communities may not have as much use for financial incentives because of the scale of projects but may find "hidden" subsidies in regulatory waivers and infrastructure funding and extension.

Suburban communities may have a number of adopted incentive programs that may have seem little use in the current economy. Suburban communities may also have more lenient land use regulations that allow development timing and location that does not take vulnerable areas into consideration.

Because of the need for an economic "generator," many financial incentives are used in urban areas where larger projects generate more income. Urban communities need to review both financial incentives and the development negotiation process to ensure that vulnerable areas are systematically protected.

Both financial and regulatory incentives and subsidies can be identified and reviewed to determine if policies should be put in place to geographically restrict or prohibit their applicability or to help relieve development pressure in vulnerable areas. Having vulnerable areas mapped will assist in this effort but is not required. Additionally, there should be a coordinated effort within a local government unit to ensure that the policies of all departments are coordinated so that the public works department does not require infrastructure extension where the planning department has identified a vulnerable area. Where permitted by state law, communities might also consider the adoption of an adequate public facilities ordinance (APFO) or concurrency ordinance that places infrastructure extension costs on the private sector and should also include locational requirements addressing infrastructure extension through vulnerable areas. APFOs can help prevent premature extension of infrastructure into undeveloped vulnerable areas.

Another valuable method to identify the use of development incentives/subsidies that may be encouraging the location of new growth in vulnerable areas is through a FIA. Typically prepared to assess major projects such as subdivisions or planned developments, a fiscal impact analysis examines the costs and benefits associated with the project. FIA usually examines: 1) estimated population generated by the new development; 2) public services anticipated to be required by the development; 3) projected tax and other revenues; and 4) development induced costs to the community's budget. Looking at the project's projected impacts and costs should help a community identify locations where local policies are contributing to the development of vulnerable areas.

LOCAL EXAMPLES

The following are examples of community approaches to creating development incentives in desired areas, which could easily be aligned with climate adaptation priorities (e.g., ensure communities are not promoting development in vulnerable areas) following the completion of a vulnerability assessment:

- Washington, D.C., has established priority areas for the use of tax increment financing, including the Capital City Business and Industrial Area, Capital City Market Area, and Georgia Avenue Area. Projects must be located in one of the priority areas to qualify for TIF funds.[10]
- Counties across Maryland have APFOs, including Howard County, Montgomery County, Baltimore County, Anne Arundel County, and Prince George's County, among others.[11]
- Loudoun County, Virginia, requires fiscal impact analysis for major economic development projects, major comprehensive plan amendments, land use changes, tax increment financing, or special district tax proposals.

BENEFITS

Ensuring that development incentives are tailored to protect vulnerable areas along with encouraging development in non-vulnerable areas allows a local government to allocate community resources (funds, staff time, and political response to public questions about subsidizing development in vulnerable locations) effectively. This is one of the most basic steps a community can take to ensure it is adequately planning for climate change.

This can also reduce the resources needed in terms of money and effort to undertake hazard mitigation or clean-up at a future date. Adding fiscal impact analysis to development application review will allow local governments to take a big-picture look at the assumptions and impacts underlying major development in time to address and adjust site impacts and uses as necessary.

[10] District of Columbia Tax Increment Financing http://www.cdfa.net/cdfa/cdfaweb.nsf/ord/dctifstatute.html/$file/district_of_columbia_tif_statute.pdf

[11] Managing Maryland's Growth: APFO http://www.mdp.state.md.us/PDF/OurProducts/Publications/ModelsGuidelines/mg24.pdf

IMPLEMENTATION

Revisions to development incentive and subsidy policies require a review of current funding programs/tax and fee abatement programs as well as a regulatory review. Government officials and staff should analyze the policies and use of financial tools such as tax abatement, TIF, and special districts to ensure that there are clear limits places on the use of these programs in vulnerable areas. Local land development regulations and policies, such as zoning, subdivision, and infrastructure extension should be reviewed to ensure that they are not used to encourage development in vulnerable areas. Where possible, a specific review check should be put in place on development applications to flag development in vulnerable areas so that land use regulations can be assessed to ensure that the area is properly protected. Finally, local government should consider adding a fiscal impact analysis requirement to the land use regulations for major projects to determine whether incentives or subsidies are working to improperly encourage new development.

IMPLEMENTATION BEST PRACTICES

- Link the use of incentives/subsidies to the comprehensive plan where the community can establish policy support for development decisions.
- Think creatively in identifying incentives and subsidies to understand what encourages development.
- Draft regulatory incentives and subsidies to protect vulnerable areas such as tying development bonuses to open space provision or the availability of TIF funds to rehabilitation of buffer areas.
- Require an analysis of public funding and subsidies for every project located in or encompassing a vulnerable area.

MORE INFORMATION

The following references provide additional information on local government's approaches to create development incentives in appropriate locations:

- Managing Maryland's Growth, Models and Guidelines #24: Adequate Public Facilities Ordinances.
- For a good primer on fiscal impact analysis, see Mary Edwards, *Community Guide to Development Impact Analysis*, the National Resource Defense Council's *Development and Dollars: An Introduction To Fiscal Impact Analysis in Land Use Planning*, Florida's Fiscal Analysis and Financing Tools summary, or TischlerBise's many publications on FIA.

Three leading local fiscal impact models are the Fiscal Impact Estimates of Land Development (FIELD) developed by Hillsborough County, Florida's City-County Planning Commission, the Federal Reserve Bank's Fiscal Impact Tool (FedFIT), and Georgia Institute of Technology's WebLOCI™ Local Fiscal Impact Analysis. FedFIT (www.federalreserve.gov) is designed to help community and economic development professionals and decision-makers, primarily in small and mid-size communities, learn about the likely general costs and benefits of proposed development projects and to assess the support a community or region might be able to afford when looking at different development possibilities. WebLOC™ (innovate.gatech.edu) is a web-based version of the local fiscal impact tool LOCI™. It is designed to provide decision-makers with insight into the fiscal and economic impacts of new or expanding businesses. Uses include helping a community understand how far it can go in granting incentives.

3-B ADOPT PROTECTIVE REGULATIONS FOR VULNERABLE AREAS

DEFINITION

Protective regulations, in the form of development requirements that limit or prohibit specific types of development permitted in vulnerable areas, are used by local governments across the country. They are typically incorporated into local zoning regulations or by-laws. Some examples include: stream buffer requirements, floodplain development standards, coastal setbacks, opens space requirements, and resource-specific zone districts or overlay districts (e.g., agriculture, wildfire).

CLIMATE CONNECTION

In many communities, areas that are vulnerable to impacts from climate change are also places that are attractive, productive, and contribute to the overall character of the community. Protection of these areas - including low-lying coastal areas, floodplains, key wildlife habitats, stormwater infiltration areas, aquifer recharge areas, and agricultural production areas - through protective regulations is beneficial to both the vulnerable area and local residents.

To implement vulnerable land protection regulations, a jurisdiction identifies and delineates those areas that are anticipated to be affected by climate change based on the results of the vulnerability assessment. Alternatively, the regulations can include a method for development applicants to identify vulnerable areas based on specific measurement criteria. Once identified, vulnerable areas are protected from development by limiting or prohibiting development based on the anticipated climate impact and assessed vulnerability of the site.

Restricting development serves to leave in place natural buffers to address some of the anticipated impacts climate changes such as increased flooding or more frequent wildfires. Limiting construction in these areas also reduces the potential impacts on structures, residents, and the cost of disaster preparedness planning and response. In some cases, property owners may choose to dedicate vulnerable areas to the local government as part of a park or open space dedication requirement in local development regulations.

ADAPTATION PLANNING STAGE

Beginner

RELEVANT SECTORS

Land Use: Most relevant sector. Protects areas that are sensitive to climate change while reducing additional complications that could be created by increased structural development.

Water: Restricts development in proximity to flood-prone areas and/or sensitive areas such as aquifer recharge zones.

Buildings: Instrumental in limiting construction in areas where buildings may be subject to increased hazard potential such as flood or fire.

RELEVANT HAZARDS

COMMUNITY CONTEXT

Applicable across all types and sizes of communities.

Protective regulations are an excellent approach to climate adaptation because they can be drafted to meet a wide range of local conditions. Vulnerable area protection regulations can be incorporated into an existing land use code where they function subject to existing review and approval processes. Unlike some of the more complex regulatory approaches described in this guidebook, vulnerable area protection regulations are also relatively straightforward and acceptable to a wide variety of public constituencies. However, they can be controversial if they are highly restrictive and severely limit development. When well drafted, these regulations do not require a significant staff or resource commitment to administer.

LOCAL EXAMPLES

There are numerous examples of vulnerable land protection ordinances (e.g., stream buffer requirements, floodplain development standards,

coastal setbacks, opens space requirements, and resource-specific zone districts or overlay districts (e.g., agriculture, wildfire)) in the Washington region and across the country.

For example, in addition to the adoption of local regulations such as the Frederick County, Virginia, prohibition on the disturbance of riparian buffers, the Chesapeake Bay Act and Regulations require that a 100-foot wide vegetated buffer be located adjacent to and landward of all tidal shores; tidal wetlands; non-tidal wetlands connected to tidal wetlands, or along water bodies with perennial flow.[12] These features, including the 100-foot buffer, comprise the Resource Protection Area (RPA). The 2000 Virginia General Assembly enacted the Riparian Buffer Tax Credit. The amount of the credit is equal to 25 percent of the value of the timber retained up to $17,500. The buffer must be at least 35 feet wide, no more than 300 feet wide and be intact for 15 years.

The City of Falls Church, Virginia, has adopted a Chesapeake Bay Area Preservation Overlay District that incorporates specific criteria for development, redevelopment, or disturbance within the overlay district.[13] The overlay includes buffer requirements, tree and vegetation preservation standards, and a water quality impact assessment.

The Montgomery County, Maryland, Department of Environment Protection is responsible for the County Stream Protection Strategy.[14] Using both planning and regulatory tools, the county monitors stream quality and habitat status, measures the amount of impervious surface by watershed, and oversees stream restoration programs.

BENEFITS

Regulations to protect vulnerable areas provide a number of benefits to local governments:

- Significant contribution to local economies in the form of tourism, recreation, hunting, or fishing in/on protected areas;
- Measurable cost savings to local governments in terms of public services and infrastructure when not extended to vulnerable areas;
- Vulnerable areas are identified early in project design where changes to site layout can typically be made more easily with less cost to the applicant;
- Vulnerable areas are identified through objective standards that are uniformly applicable across all developments;
- Vulnerable areas are mapped by the community, allowing for simple identification and discussion with property owners before development application is made; and
- Extent and application of the regulations is subject to community-wide discussion and buy-in through the adoption process.

IMPLEMENTATION

Protection of vulnerable areas can be approached through varying degrees of regulatory detail and local policy depending on the information available in the community's comprehensive plan and/or open space, sensitive lands, or floodplain/coastal planning as well as existing regulations. The first step is to identify vulnerable areas through the vulnerability assessment, to determine which geographic areas are critical to protect through restricted development. Additional sources of information include local comprehensive plans, available information from state agencies and programs or enacting land dedication and set-aside standards for new development and subdivisions.

The second step is to identify the most appropriate type of land use restriction for the area. While basic restrictions typically include development restrictions in the 100 year floodplain or coastal setbacks, more ambitious approaches could include adopting development restrictions in the 500 year floodplain, large-lot zone district requirements that

[12] Frederick County, Virginia, Memorandum on Riparian Buffers http://www.co.frederick.va.us/planning/PC/pdfs/PC_10-19-11_Discussion_Riparian_Buffers.pdf; The Chesapeake Bay Act http://leg1.state.va.us/cgi-bin/legp504.exe?000+cod+TOC10010000021000000000000

[13] Falls Church, Virginia, Code of Ordinances, Chapter 48, Article IV, Division 16 http://library.municode.com/index.aspx?clientID=14329&stateID=46&statename=Virginia

[14] Montgomery County, Maryland, Department of Environmental Protection, Countywide Stream Protection Strategy http://www.montgomerycountymd.gov/content/dep/downloads/CSPS2003.pdf

do not allow significant residential development in vulnerable areas identified in comprehensive plans (e.g., 1 unit/80 acres and larger lot sizes), or enacting protective regulations for each type of vulnerable area identified in the jurisdiction. Some examples of protective regulations for vulnerable areas include:

- The County of Maui, Hawaii, calculates a shoreline setback line based on the location of the state setback line, the average depth of the lot, and the erosion rate of the site based on county mapping.
- Sammamish County, Washington, has a multifaceted approach to stream buffers that: 1) allows buffer averaging where reduced buffers in one area will not negatively impact the stream and increased buffers in another area will protect a resource area; 2) required increased buffers for specific sensitive areas; and 3) allows buffer reduction where mitigation measures such as removal of existing impervious surfaces are provided.
- Jefferson County, Colorado, has a wildfire hazard overlay district that prohibits the construction, reconstruction, or expansion of structures until the property owner received approval of a wildfire mitigation site plan that shows the creation of defensible space, fuel break thinnings, and property access.
- *Higher Regulatory Standards*, a report produced by FEMA, describes typical approaches to floodplain management in the Pacific Northwest and identifies alternative approaches used by local governments that exceed the minimum requirements of the National Flood Insurance Program.

MORE INFORMATION

The *Maryland Climate Action Plan* recommends the development and implementation of a package of appropriate regulations, financial incentives, educational, outreach, and enforcement approaches to retain and expand forests and wetlands in areas suitable for long-term survival.

FEMA's *Higher Regulatory Standards* has ideas and examples of floodplain management regulations that exceed National Flood Insurance Program minimum requirements. FEMA Region 10, February, 2002.

IMPLEMENTATION BEST PRACTICES

- Involve local stakeholders in the discussion of what types of areas should be considered vulnerable and what, if any, level of development is appropriate.
- Map vulnerable areas early in the discussion process to establish a shared understanding across property owners and stakeholders.
- Consider establishing a range of development restrictions that distinguish areas where no development will be permitted from areas where development can be accommodated with size, location, or construction modifications.
- Combine vulnerable area regulations with size or density incentives that allow property owners to develop at the same or similar density/intensity while preserving the vulnerable area.

3-C Direct Development Away from Vulnerable Areas On Large Development Sites

DEFINITION

Where an individual development site includes both vulnerable and developable areas, communities can use flexible development tools such as cluster development, planned unit development (PUD), or a vulnerable area overlay to allocate density on the site away from the vulnerable area(s) to non-vulnerable areas. The purpose of these tools is to shift development across the site to allow a project to reach the permitted density while limiting impact on and preserving vulnerable areas within same site.

CLIMATE CONNECTION

The protection of vulnerable areas is important to consider at the regional, community, and site levels. In rural and suburban areas, when larger sites are developed, protecting vulnerable areas of a site and developing that site to the maximum permitted density/square footage can be but are not necessarily mutually exclusive goals. Incorporating some flexibility in the regulatory process will allow local governments to address individual site design issues in a way that protects vulnerable area.

Where there is sufficient room on a site, local policies and regulations can be designed to require or encourage some or all of the permitted development to be located on the non-vulnerable area. This may require allowing some flexibility in lot size, building height, or setbacks to recognize the important policy goals of vulnerable area protection while permitting the property owner to develop as permitted by the land use regulations.

This approach can be most effective where the vulnerable area is located on one edge of the property, such as a shore line, stream, or forest.

Where vulnerable areas are located on a smaller single lot that will not be subdivided, local governments can adopt vulnerable area design standards that specify how permitted density or square footage will be measured and how it can be relocated, either all or in part, outside of the vulnerable area. This may be done in conjunction with a review procedure or administratively. This approach may also include a modification or waiver process that allows staff or the local government to change or waive development standards to accommodate development on parcels that have vulnerable areas. For example, on a lot that requires a 100-foot stream buffer, setback and lot coverage standards could be modified to allow construction on the remainder of the parcel. To encourage properly located development, local governments could add an incentive to this approach such as additional square footage above the permitted standard where vulnerable areas are protected.

Where development is appropriately located so that permitted densities are sufficiently high and new subdivision does not run afoul of compact development and anti-sprawl principles, cluster subdivision can be used to protect vulnerable areas. This is accomplished this by allowing residential units to be clustered on reduced-sized lots on a small

ADAPTATION PLANNING STAGE

Intermediate

RELEVANT SECTORS

Land Use: Most relevant sector. Will allow the protection of vulnerable areas regardless of land use.

Water: Where the vulnerable area is water related, approach will limit/prevent development in that area.

Transportation: May prevent the extension of transportation infrastructure through vulnerable areas.

Buildings: Will encourage construction in buildable areas with no or limited impact on vulnerable areas.

RELEVANT HAZARDS

COMMUNITY CONTEXT

The use of flexible zoning administration, cluster/conservation subdivisions, and planned unit development is typically easier to apply to rural and suburban development but may work in an urban context for larger development/ redevelopment projects.

portion of the development to promote the preservation of a larger tract (or tracts) in open space. The open space tract(s) are designed to incorporate the vulnerable areas of the parcel. The key to using cluster subdivision in this context is to first identify the vulnerable area to be protected and second to design the cluster subdivision around that area. Because cluster design is flexible, this approach can be used where the vulnerable area is located in the center of the parcel or can be identified in discrete areas across the site such as low-lying flood-prone areas that extend from a water front. In most cases, cluster subdivision has the benefit of protecting vulnerable areas in perpetuity where the protected area is donated to the local government as permanent open space.

Similarly, a PUD could be employed to allow flexibility in site design and development standards. Climate sensitive PUD regulations include provisions that encourage the preservation or protection of vulnerable areas as part of the PUD design, and provide offsets such as reduction of required landscaping or open space where vulnerable areas are protected. As an alternative to a PUD, a local government could establish a vulnerable area overlay that designates priority protection areas and allows site design to be negotiated administratively based on maximum densities or square footages on the remainder of a site that would be permitted by the underlying zoning.

The flexibility of PUD allows a multiple ways to protect vulnerable areas through the site design process, including moving development away from shorelines or streams and by designating open spaces within or across the site. PUD standards should be drafted, however, to ensure that this regulatory approach is not used as a "work around" for density and compact development requirements in buildable areas.

These approaches are not mutually exclusive and can be used in conjunction with each other depending on the project and site. The City of Scottsdale, Arizona, for example, has an environmentally sensitive land ordinance that permits the movement of the density across the site, amended development standards, and clustered development.[15]

LOCAL EXAMPLES

Fairfax County, Virginia's, Environmental Quality Corridors are incorporated in the comprehensive plan and designed to protect habitat quality; connectedness along wildlife corridors; aesthetics, such as green belts separating land uses and providing passive recreational opportunities; and pollution reduction, including vegetative filtering, steep slope protection, and microclimate control.[16] The location of the EQC on a site is negotiated during rezoning, special exception, special permit, variance, and related review processes.

Howard County, Maryland, uses cluster subdivision in rural areas for agricultural land preservation. This approach can serve as a model for vulnerable area protection.[17] Baltimore County, Maryland, has established "density residential" zones that do not have minimum lot sizes and are intended to be used (among other reasons) for the protection of natural features and open spaces.[18]

Park City, Utah, has adopted a sensitive lands overlay that addresses wetland and stream protection as well as wildfire regulations.[19] In applying the overlay, staff and the applicant delineate sensitive lands and those available for development. The SLO specifies how much density may be transferred out of the sensitive areas onto the remainder of the site.

These examples demonstrate the use of a common sustainable community approach that could easily be modified by communities to become more climate resilient.

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[15] Scottsdale, Arizona, Citizen's Guide to Environmentally Sensitive Lands http://www.scottsdaleaz.gov/Assets/Public+Website/codes/CitizenGuide_ESLO_06-24-04.pdf

[16] Fairfax County, Virginia, Comprehensive Plan http://www.fairfaxcounty.gov/dpz/comprehensiveplan/policyplan/

[17] Howard County, Maryland, Rural Cluster Development and Density/Cluster Exchange Options http://www.howardcountymd.gov/Departments.aspx?ID=4294967781

[18] Howard County, Maryland, Rural Cluster Development and Density/Cluster Exchange Options http://www.howardcountymd.gov/Departments.aspx?ID=4294967781

[19] Park City, Utah, Sensitive Area Overlay Zone, Title 15, Land Management Code, Section 2.21.

BENEFITS

- Allowing carefully located development on parcels with vulnerable areas both recognizes the development expectations of the property owner as well as the climate adaptation needs of the community. By balancing the two, the local government can conserve the vulnerable area(s) through rather traditional and fairly non-controversial means while avoiding the threat of takings litigation on the part of the owner.
- Moving development out of vulnerable areas may help avoid fragmentation of those areas.
- Protection of vulnerable areas from development will mean that infrastructure such as roads and water/sewer lines will not be extended across and through these areas.

IMPLEMENTATION BEST PRACTICES

- Undertake a public education program to help residents understand the value of protecting vulnerable areas and the methods available to do so.
- Identify vulnerable areas in the comprehensive plan and cross-reference the plan maps in the land development regulations.
- Ensure the cluster/conservation regulations are clearly written and easy to understand so that property owners do not seek "work around" options to avoid their use.

IMPLEMENTATION

Code and policy changes to implement regulatory controls to relocate development on a site can range from simple mapping methods to identify vulnerable areas to more extensive regulatory programs, including requiring the use of cluster/conservation subdivisions or PUD on any parcel with mapped vulnerable areas and establishing a vulnerable area overlay district that permits modification of bulk, lot size, and other land use regulations either administratively or through local government review.

At a minimum, local governments should review their current regulations to make sure that there are no impediments to vulnerable area protection, such as requirements for: 1) only contiguous open spaces or open spaces that are linked to paths or trails that would negatively impact the opportunity to preserve non-contiguous vulnerable areas, 2) height or setback requirements that would prohibit density relocation on a site; or 3) requirements for existing street and/or grid connections that would hamper cluster subdivision design in vulnerable areas.

An excellent explanation of the importance and use of cluster development is provided in Reid Ewing's "Best Development Practices: A Primer for Smart Growth" and in Randall Arendt's seminal book "Rural by Design: Maintaining Small Town Character."

MORE INFORMATION

"Natural Hazards, Smart Growth, and Creating Resilient and Sustainable Communities in Eastern North Carolina," in Facing Our Future: Hurricane Floyd and Recovery in the Coastal Plain, pp. 271-282 (Coastal Carolina Press, 2001).

Reid Ewing, *Best Development Practices: A Primer for Smart Growth*

Randall Arendt, *Rural by Design: Maintaining Small Town Character*

The North Shore Land Alliance's (Long Island, New York) website provides a wealth of model regulations geared toward sensitive land preservation.

Envision Utah's *Urban Planning Tools for Quality Growth, Chapter 1: Protecting Sensitive Lands* describes the reasons for protection and the outcomes when sensitive and vulnerable areas are not protected, along with lists of tools that are helpful to local governments.

3-D ENHANCE OR RESTORE WETLANDS

DEFINITION

Coastal wetlands (also known as salt or tidal marshes) are transitional areas in the coastal and intertidal zones. Inland wetlands (non-tidal marshes) are typically located in floodplains. In addition to serving as a unique habitat for a range of plants and animals and serving as a natural filter to improve water quality, these areas play an important role in storing water during storm events.

Land development in the U.S. has depleted the total amount of wetlands as well as divided continugous wetlands into non-continugous areas, increasing the risk of flooding. For example, about 60 percent of historic wetlands in the Chesapeake Bay area have been lost due to anthropogenic and other factors.[20] Enhancing or restoring natural wetlands (i.e., improving the functionality or restoring a previously lost wetland) can significantly increase the capacity of natural systems to accommodate flood waters.

ADAPTATION PLANNING STAGE

Intermediate

RELEVANT SECTORS

Land Use: Enhancement and restoration of coastal wetlands will require modification to policies for waterfront development.

Water: Most relevant sector. Numerous positive impacts including ecosystem values, enhanced fish population and recreational/educational opportunities.

RELEVANT HAZARDS

COMMUNITY CONTEXT

It may be easier to enhance or restore wetlands in rural areas with reduced pressure on waterfront development and in areas with natural resource-based tourism.

Waterfront development and recreational activities near shorelines will limit opportunities for wetlands in urban and suburban areas.

CLIMATE CONNECTION

Under natural conditions, coastal wetlands adjust to rising seas and local storm patterns, so they moderate damages to upland areas. Enhancing or restoring wetlands can improve climate change resiliency by providing temporary storage of water during storm or other high water runoff events. Coastal wetlands naturally absorb water inundation from storm surge during major storms and rising sea level. In forested ecosystems (i.e., the Washington, D.C., region), wetlands can reduce storm surge and wind energy during tropical storms and cyclones, minimizing hurricane impacts on property and lives. Inland wetlands can also provide cost-effective flood control during storm events, if properly managed.

LOCAL EXAMPLES

Some communities have restored wetlands or are working with recommendations to restore wetlands in order to increase their climate resiliency in the U.S. and Asia:

- The Charlotte Harbor National Estuaries Program has adopted implementation of mangroves (coastal wetland) as part of their toolbox to mitigate the impacts, along with other strategies as part of their conservation and coastal management program: http://www.chnep.org/projects/climate/ClimateChangePlanning-Audubon.pdf
- Ducks Unlimited has been supporting a Chesapeake Bay Ecosystem Initiative to fulfill the annual life-cycle needs of waterfowl by restoring, enhancing, protecting and managing wetlands. These are also aimed at improving the water quality of Chesapeake Bay.
- The NOAA's Chesapeake Bay program has extensive funding and wetland restoration initiatives aimed at several eco-regions including the Chesapeake Bay region, which could be used to enhance climate change resiliency.

[20] http://chesapeakebay.noaa.gov/wetlands

BENEFITS

Enhancement and restoration of wetlands, especially those with forested vegetation, can provide significant resiliency for coastal areas to sea level rise and storm surge, and inland areas to increased precipitation and severe storm events.

- Absorption of sea level rise. The degree to which wetlands can help respond to sea-level rise depends on local interactions between sediment and organic matter accumulation, hydrology, subsurface processes, and storm events.[21] In general, wetlands can build up coastal land with sediments and organic matter so that this area will serve as buffer between the land with developed areas and sea water. They also reduce coastal shore erosion. When this buffer is sufficiently built, increases in sea level do not reach developed land areas.
- Protection from storm surge damages. Excessive energy associated with storm surges are dissipated by the dense vegetation in coastal wetlands, so that their impacts on developed areas adjacent to shoreline are minimized. Mature vegetation is critical to increasing the resiliency to protect against storm surges, so a combination of short to long-term plant/tree growth considerations are necessary to achieve mature coverage over time.
- Reduced erosion associated with increased precipitation and severe storm events. Increase in peak flow and volume of runoff will exacerbate the coastal erosion and the wetlands slow down this flow and enhance settling of silt. This reduces the coastline erosion and also increases the buffer zone for additional protection against sea level rise.

Major secondary benefits from enhancing or restoring wetlands include improved water quality, increased recreation potential, and enhanced fish population.

WETLAND PROTECTION ACTIVITIES IN THE CHESEPEAKE BAY REGION

In the Chesapeake Bay region, wetland restoration activities are primarily focused on water quality and habitat enhancement for migratory birds. A concerted effort for lower portions of all tributaries to the Chesapeake Bay is needed to restore and enhance wetlands to also achieve resiliency to sea level rise impacts on upland areas. This would require an expansion of the existing EPA and NOAA Chesapeake Bay initiatives.

In addition to these federal initiatives, collaborative efforts among the States of Maryland, Virginia and District of Columbia are needed to dedicate resources and develop implementation plans. Each state has its own wetland enhancement strategy that can be enhanced, but a coordinated effort towards the restoration of wetlands in the Chesapeake Bay area that responds to anticipated climate changes should also be initiated.

IMPLEMENTATION

A strategic and systematic restoration plan that accounts for both climate change and human engineering of the environment should be developed to reestablish wetlands.[22] As noted in Section 2, a regional approach to stormwater management may include developing a regional wetland plan. In addition, individual jurisdictions should develop a wetland restoration plan to ensure the most valuable and/or at risk wetlands are protected and enhanced.

Wetland restoration plans establish the intellectual footprint for long-term restoration and creation of wetlands. For example, as part of the Coastal Zone Management Programs, Virginia and Maryland already have established educational and restoration initiatives.

Development of a wetland restoration plan requires envisioning a target wetland coverage that would protect the communities against sea level rise. The first step is to review academic literature and also the existing initiatives to develop a correlation between wetland coverage and the buffer it will provide in terms of a protective buffer. Building on the extant programs in Virginia and Maryland, a comprehensive review of local, regional, and state wetland enhancement initiatives could be performed by an academic institution or through the National Estuarine Research Reserve System of NOAA.

[21] Reed, D.J. 1995. The response of coastal marshes to sea-level rise: survival or submergence? Earth Surface Processes and Landforms 20:39-48

[22] Morris, J.T., P.V. Sundareshwar, C.T. Nietch, B. Kjerfve, and D.R. Cahoon. 2002. Response of coastal wetlands to rising sea level. Ecology 83:2869-2877.

Wetland restoration traditionally focuses on habitat enhancement, therefore additional criteria or guidance must be developed and provided to the state/local governments to restore wetland for climate change. For example, wetland restoration plans could be enhanced to reflect the results of a community's vulnerability assessment, indicating which wetland areas are at greatest risk and/or have the greatest value from a climate change perspective. The local governments can then identify changes to the wetland enhancement plan and set goals and prioritize areas/projects for short to long-term implementation. Identification of areas/projects can be performed using a Geographic Information Systems-based procedure such as the one used by North Carolina or the Great Marsh Program in Massachusetts.

Implementation, however, will be enhanced by regional vision for wetland planning and funding from federal and state governments. Priority projects (identified as having short-term or high value) can be selected based on a competitive grant program administered by the NOAA CEERS program. Each grant can cover the basic elements of wetland restoration or creation including, but not limited to, the following: zoning changes to limit or prevent development applications, increased setbacks or buffers from the existing shoreline, abandonment of high-risk properties in the shoreline, acquisition of additional property for wetland creation, creation of educational and outreach programs to get buy-in from the community and political leadership, and periodic performance evaluation to assess the progress made relative to the original wetland restoration plan.

Participation of local governments in the seeking of grants and implementing restoration projects is key to long-term success, as they will have the ultimate responsibility for revision of pertinent codes and ordinances and also for acquisition of properties to facilitate restoration or creation of wetlands.

MORE INFORMATION

Environmental Law Institute has developed guidance for local governments about wetland buffers to combat the impacts of climate change.

EcoAdapt's *The State of Marine and Coastal Adaptation in North America: A Synthesis of Emerging Ideas* recommends enhancement of healthy coastal wetlands to trap sediments and contribute to build-up of coastal land, so that there is increase in resiliency to sea level rise.

The State of Maine Coastal Wetlands website provides information educational and implementation aspects of coastal wetlands.

The Southern California Wetland Recovery Project reviews a regional partnership to restore wetlands.

3-E Purchase and Transfer of Development Rights

DEFINITION

Nationally, the number of successful purchase of development rights (PDR) and transfer of development rights (TDR) programs has increased rapidly in recent years as jurisdictions gain more experience with the mechanics of these tools. These programs are typically put in place to preserve sensitive natural areas and agricultural lands. In concept, these programs are simple.

In a PDR program, the local government buys development rights on a parcel that it wishes to protect and allows a low-impact use to continue. After purchase of the development rights, development is prohibited in or near the vulnerable hazard areas and low-impact uses can continue.

In a TDR program, sensitive or vulnerable lands in a designated sending area are zoned to severely restrict development. Landowners in the sending area are granted development credits for the density they have "lost" and can sell those credits to developers in a designated growth or receiving area. Developers buy those credits to increase the allowable density on their property. TDR programs can be an effective melding of regulations and incentives that may be more palatable than regulations alone.

ADAPTATION PLANNING STAGE

Advanced

RELEVANT SECTORS

Land Use: Most relevant sector. Allows restriction of development while providing compensation to property owner.

Water: May be used to protect vulnerable areas impacted by flooding or increased runoff.

Transportation: Possible to use funding source to take vulnerable transportation infrastructure out of local system; however, will probably not be able to be used to fund infrastructure replacement

Buildings: May be used for the purchase and demolition of structures in vulnerable areas.

RELEVANT HAZARDS

COMMUNITY CONTEXT

Purchase/acquisition is relevant across urban, suburban, and rural community types. Some funding sources that depend on individual contributions, such as sales taxes or special districts, will generate fewer funds in areas with smaller economies and/or slower activity.

CLIMATE CONNECTION

From a climate adaptation perspective, PDR and TDR programs could be particularly useful in situations where a local government desires to restrict development in vulnerable area such as floodplains, coastal areas subject to sea level rise or tidal surges, and aquifer recharge areas. A vulnerability assessment and local comprehensive plans would typically be used to gather necessary information and identify such vulnerable areas in sufficient detail to facilitate their mapping. Alternatively, a specific vulnerable area plan and map could be created as part of the PDR/TDR program regulations. The plans would also identify areas particularly suitable for development in existing built up areas or newly designated growth areas. Under a TDR program, these vulnerable areas would then be designated as sending areas and rezoned to limit development to an appropriate level (e.g., by forbidding or greatly limiting residential subdivisions). The landowners would be granted development credits to help offset any loss in value, and such credits could be sold to developers in approved receiving areas that desired to increase densities in accordance with the comprehensive plan.

The creation of a PDR/TDR program is typically public-involvement intensive. There are many parties to this conversation and the concepts of transferrable values and overall densities are not usually resolved in a single public meeting. This affords local government the opportunity to explore the relative value of vulnerable areas in the process of establishing regulations. The purchase/transfer calculations can be tailored to reflect the relative importance of limiting development in the vulnerable areas to improve the community's

resiliency to climate change and the level of community acceptance of the program. As an example, a coastal community could decide that the transfer of beach-front development rights is quite valuable and may be equal to double or triple the same development right located on an inland lot.

LOCAL EXAMPLES

Several local governments both in Virginia and Maryland have adopted PDR and TDR programs. The Virginia legislature authorized TDRs in 2006 and then amended that legislation in 2009 to make use of TDRs easier. The Virginia Municipal League has published a model TDR ordinance and supporting materials to assist local governments. In Maryland, a dozen counties have PDR programs, and there are several well-established and successful TDR programs like that in Montgomery County, Maryland, that can provide useful guidance to local governments considering using such tools for climate adaptation purposes.

The programs listed above are geared towards preservation of open space or agricultural lands, not climate adaptation purposes per se. However, the basics of these programs could easily be adapted to climate adaptation purposes as noted above by focusing such programs around climate adaptation might give them added justification for preserving sensitive areas beyond natural resource, scenic, and agricultural values.

BENEFITS

Use of PDR/TDR programs for climate adaptation purposes has multiple benefits:

- Protection of areas potentially vulnerable to climate change impacts such as flooding, rising sea levels, more violent storms. Particularly useful in preventing development in areas susceptible to flooding.
- Reduced opposition from land owners as compensation is provided for change in development rights, making it easier for local governments to protect vulnerable areas.
- Under TDR programs, development is focused in designated growth (receiving) areas in accordance with smart growth principles and supporting community efforts to channel future development into less vulnerable areas.
- Less demand for costly municipal-level services in rural areas as land remains undeveloped.
- Could provide a means for a significant amount of open space preservation and reduced fragmentation of sensitive natural areas.

IMPLEMENTATION

Successful PDR and TDR programs must be grounded a solid understanding of what areas within a community should have limited development. In communities that already have PDR or TDR programs, local governments should first analyze the results of its vulnerability assessment to determine if adjustments should be made to the areas already designated for restricted development (e.g., adding vulnerable areas). If a TDR program already exists, the local government should also consider the vulnerabilities associated with the designated receiving areas to ensure it is incentivizing development in the most appropriate areas. In both cases, the comprehensive plan should be updated to reflect these changes.

For communities looking to initiate a PDR program, PDR programs can be funded annually out of general fund revenues, through a bond issuance, or adoption of a dedicated funding source (such as an earmarked sales tax). The adopting jurisdiction can also work with special districts (water supply, drainage) to use utility and other targeted fees/taxes for targeted acquisitions (e.g., development in vulnerable areas that would be expensive to service and likely result in infrastructure damage in the event of a flood or violent storm). Purchases should be related to vulnerable areas identified in vulnerability assessment and updated comprehensive plan.

To take a PDR program to next level, local governments could consider the fee purchase of vulnerable lands and resale of those lands with conservation restrictions. Such programs (e.g., King County, WA) need more up-front funding and have longer carrying periods, but may be more effective because land can be resold to recoup most of sales price and will still be protected.

TDR programs—when designed correctly with a clear understanding of how large the sending and receiving areas should be in relationship to one another to create a viable market for development rights—can be an effective tool to protect large tracts of open space while reducing potential opposition and legal questions. In establishing a TDR program, attention must also be paid to the mechanics of the process (e.g., how to determine how many development rights are assigned to a particular property and the documentation of the transfer).

Local governments can start by adopting a voluntary TDR program covering designated vulnerable areas. For greater impact, the local government can instead adopt a mandatory TDR program combined with the downzoning of vulnerable areas (sending zones) and a permitted increased density with development credit purchase. As an incentive, bonus development credits could be granted that can be sold by landowners who participate.

Subject to state law limitations, regional governments could adopt a multi-jurisdiction TDR program with transfers between vulnerable areas located in rural areas and city development (receiving) areas.

IMPLEMENTATION BEST PRACTICES

- Involve local stakeholders in the discussion of what types of areas should be considered vulnerable and what, if any, level of development is appropriate.
- Map vulnerable areas early in the discussion process to establish a shared understanding across property owners and stakeholders.
- Consider establishing a range of development restrictions that distinguish areas where no development will be permitted from areas where development can be accommodated with size, location, or construction modifications.
- Combine vulnerable area regulations with size or density incentives that allow property owners to develop at the same or similar density/intensity while preserving the vulnerable area

MORE INFORMATION

Rick Pruetz, Beyond Takings and Givings, American Planning Association Planners Book Service, Aerie Press, (2003), is the leading publication on transferable development rights strategies and programs.

For excellent overviews of PDR programs, see the Western Governors' Association's Purchase of Development Rights: Conserving Western Lands, Preserving Western Livelihoods; John Wright and Rhonda Skaggs, College of Agriculture and Home Economics, New Mexico State University Purchase of Development Rights and Conservation Easements: Frequently Asked Questions; and Gayle Miller and Douglas Krieger's, Purchase of Development Rights: Preserving Farmland and Open Space.

The Virginia Municipal League has published a model TDR ordinance and supporting materials for Virginia communities.

Other available resources include: case studies of Maryland TDR programs and proposed state legislation; a discussion of counties with purchase of development rights and agricultural land protection programs in Maryland; Field Guide to Transfer of Development Rights (TDRs) from the National Association of Realtors; and a good listing of TDR articles and program references from the National Center for Appropriate Technology.

For King County, Washington, Farmland Preservation Program (PDR) details, including how the county has purchased and is protecting over 13,000 acres of farmland, see the Water and Land Resource Division webpage.

3-F Establish Fund to Purchase/Acquire Land in Vulnerable Areas

DEFINITION

In addition to, or as an alternative to adopting regulations to protect vulnerable areas as described in Approach 3A, local governments may establish a fund to fully purchase or acquire an interest (e.g., easement) in vulnerable areas that permits the local government to place appropriate limits on the development of that area.

CLIMATE CONNECTION

There are some vulnerable areas that are best protected long-term through local government purchase and management of the area. This may be because development pressure is great and may play a role in local economic and policy choices over time, such as allowing resort development in a coastal area susceptible to sea level rise. It may be because private sector action to protect a vulnerable area would be difficult to coordinate, such as in the creation of a wetland buffer across a number of individually-owned parcels. Or it may be because local government ownership would be to the economic benefit of both the community and the current property owner, such as property located in a high fire hazard area that is suitable for outdoor recreational activities.

Where local government ownership or long-term oversight is a good investment for the community and will resolve issues about appropriate use in vulnerable areas, the local government will need to establish a funding source for purchase or partial acquisition through an easement. Funding sources can be varied and each may have restrictions on activation and use; e.g., passage of a dedicated sales tax may be limited by a cap on the total amount of local sales taxes and must be submitted to the electorate for a vote. Because of this, there may be significant lead time in putting together an acquisition program.

ADAPTATION PLANNING STAGE

Advanced

RELEVANT SECTORS

Land Use: Most relevant sector. Allows restriction of development while providing compensation to property owner.

Water: May be used to protect vulnerable areas impacted by flooding or increased runoff.

Transportation: Possible to use funding source to take vulnerable transportation infrastructure out of local system; however, will probably not be able to be used to fund infrastructure replacement

Buildings: May be used for the purchase and demolition of structures in vulnerable areas.

RELEVANT HAZARDS

COMMUNITY CONTEXT

Purchase/acquisition is relevant across urban, suburban, and rural community types. Some funding sources that depend on individual contributions, such as sales taxes or special districts, will generate fewer funds in areas with smaller economies and/or slower activity.

LOCAL EXAMPLES

Frederick County, Maryland, uses monies collected from a Forest Resource Ordinance Fee In-Lieu program to purchase forest easements over stream buffers and then address any reforestation needs in those areas.[23] The authority for this is Maryland's Forest Conservation Act (FCA). The FCA requires developers to mitigate forest losses with the rate of allowed clearing and required replacement depending on the land-use category. As an element of the FCA, riparian areas are priority areas for

[23] Frederick County, Maryland, Linganore Watershed Forest Conservation Easement Purchase Program. http://frederickcountymd.gov/documents/Permits%20&%20Development%20Review/Forest%20Resource%20Ordinance/Linganore%20Easement%20Purchase%20Program/Linganore%20Watershed%20Forest%20Conservation%20Easement%20Purchase%20Program%20Overview%2010-1-10.PDF

protection and mitigation and may be transferred to public ownership as an easement.

BENEFITS

The benefits of local government acquisition of vulnerable areas include:

- Allowing a more comprehensive and long-term approach to management of vulnerable areas;
- Takes the sting out of regulatory programs and is less likely to be controversial;
- Potential elimination of the need to change approaches to regulations if conditions change; e.g., if flooding is greater than anticipated there will not need to be another round of regulatory changes to establish new setbacks to protect property owners;
- Potential for significant contribution to local economies in the form of tourism, recreation, hunting, or fishing in/on protected areas; and
- Measurable cost savings to local governments in terms of public services and infrastructure when not extended to vulnerable areas.

IMPLEMENTATION

For most communities, establishing a fund to purchase vulnerable area either in fee (complete ownership) or through the acquisition of partial title (such as through an easement) will be a new program. The purchase of vulnerable lands is not a regulatory action. It should, however, be closely coordinated with the goals and policies expressed in the comprehensive plan or other appropriate plan such as open space and recreational plans. Because this is not a regulatory program, the local government may need to determine a specific source of enabling authority for the purchase program and funding beyond normal police power or state statutory authority relied upon for land use regulations. Depending on the jurisdiction and funding source, the funds may need to be accounted for in the capital improvements program.

1. Funding Source

The first step in a purchase/acquisition program should be the preparation of a methodology report that examines the goals of the program, the potential funding sources, and the anticipated outcomes. The methodology report should provide detailed estimates of the revenue streams of each of the potential funding sources.

Examples of funding sources include: sales taxes, general obligation or revenue bond issuances, gaming or lottery revenues, excise/transfer taxes, general fund appropriations, and special districts (taxing or self-funded).

Once the local government has selected a funding source, it will need to be established and maintained in the manner provided for by state or local law or through the appropriate use of home rule authority. In some cases, state and federal funds, such as CDBG or FEMA funds, may also be leveraged into a local vulnerable lands purchase program.

2. Purchase Program

Once funding is made available, the local government will need to determine how aggressive it wishes to be in acquiring vulnerable areas. This will run the gamut from purchasing properties as they come on the market, to offering to purchase property through a willing seller/willing buyer program, to acquisition through eminent domain. The level of activity will depend on both available funds and the community's perception of how best to act to protect the vulnerable area.

Based on the community's comprehensive, open space, or recreational plans and the purchase project methodology report, the local government should establish a set of policies that identify the property(ies) to be purchased, the method of purchase, and specify how the property(ies) will be managed long-term. In some cases, a separate oversight body or advisory board may need to be established to provide consistent guidance about the use of local funds in a subject area.

IMPLEMENTATION BEST PRACTICES

- Prepare a methodology study at the outset of the purchase project to identify: areas to be purchased, potential cost, available funding sources and the fund generating capabilities of each, and potential maintenance and operation fees over time.
- Leverage funds from other sources such as CDBG or FEMA that may be available as part of typical program funding or hazard mitigation and/or clean-up.
- Identify early "victories" where funds can be used to purchase properties that are immediately useful to the community to show that the program can be successful where long-term support will be necessary.
- Maintain funds separately or account for funds separately from the general fund so that all monies identified for vulnerable area purchase/acquisition are used for that purpose.

MORE INFORMATION

A discussion of the legal authority to use "rolling" easements that move with changes in sea level in Virginia is provided in Andrew Silton and Jessica Grannis, *Virginia Case Study: Stemming the Tide: How Local Governments Can Manage Rising Flood Risks*.

Other relevant resources include:

- Baltimore County, Maryland, Agricultural Land Preservation program
- Chris Duerksen and Cara Synder, Nature-Friendly Communities: Habitat Protection and Land Use Planning, Key Elements and Best Tools pg. 46 (Island Press 2005). See Chapter 4, Baltimore County, Maryland: Using the Entire Toolkit for Habitat Preservation (easement and purchase/leaseback program); Chapter 7, Fort Collins and Larimer County, Colorado: A Tale of Two Jurisdictions (easement and purchase program); and Chapter 17, King County, Washington: Benchmark Program (defined urban growth area and protection of natural resources).

4 PROTECT PEOPLE AND ASSETS IN VULNERABLE AREAS

While no single weather event can be defintively linked to climate change, some communities are experiencing impacts that are assumed to be related to long-term shifting weather patterns. For example, in the Washington, D.C., area, spring arrives earlier than it it used to, as evidenced by earlier plant flowering and due to rising temperatures.[24] Numerous additional studies have documented a rise in severe rainstorms, heavy snowfalls and similar precipitation events. As demonstrated by the devasting 2011 floods in Pakistan (September), as well as record-breaking flooding in Vermont and upstate New York (August), and along the Mississippi River (April and May), communities large and small can be significantly impacted by individual storm events. Local governments needs to protect people and assets (transportation and utility infrastructure, buildings, and cultural and natural resources) in vulnerbale areas.

Protective options include building engineered protective structures like seawalls (see image below), retrofitting buildings to incorproate protective designs, employing softer techniques to increase resiliency (like maintaining wetlands in key areas), or, in some cases, relocating people or assets. Sustainable community approaches provide a framework though which to evaluate these options against one another, considering social, environmental, and econmic impacts.

Again, for the approaches described in this section of the guidebook to be effective, communities need to first complete a robust vulnerability planning process to identify "vulnerable areas"—those with the greatest vulnerability and risk, and where people and assets are located and likely to be impacted—and then review and select from the following approaches to identify those that are most appropriate for their community.

Image Sources: http://photoguidedc.com/files/2011/06/169-15540980-600x398.jpg

Sea wall reinforcement project in front of the Jefferson Memorial on the Tidal Basin in Washington, D.C.

[24] http://si-pddr.si.edu/dspace/bitstream/10088/3371/1/Abu-Asab_et_al_2001_early_flowering.pdf; http://www.washingtonpost.com/local/plants-earlier-bloom-times-hurting-some-creatures/2011/04/08/AF42He4C_story.html

4-A Develop a Climate Readiness Plan for Local Government Facilities

DEFINITION

As part of the vulnerability planning process, local governments should consider the vulnerabilities of its own facilities (e.g., buildings, parks), and develop a climate readiness plan. A climate readiness plan can guide local government decision-making for long-term facility planning.

CLIMATE CONNECTION

The role of local government is to provide needed services to residents that would otherwise be unmet and to ensure the health and safety of its residents. To do so, local governments govern land use, guide the development and support the operation and maintenance of transportation and utility infrastructure, and provide basic social, health, emergency, and education services.

To maintain functioning, vibrant communities, these services must be provided continuously, even when communities are impacted by climate change (e.g., severe storm events).

Local governments should use the vulnerability assessment process to examine the ability of its facilities, infrastructure, and assets to be resilient to climate changes, and develop a climate readiness plan to ensure continuity of service.

For existing facilities located in vulnerable areas, local governments should determine whether to protect in place or relocate those activities if they cannot be adequately protected, and are unsuitable for retrofitting either due to age or design. For planned future facilities, local governments should ensure that they are located in less-vulnerable areas.

BENEFITS

Local governments that develop climate readiness plans:

- Ensure continuity of local governments services.
- Have an economic, social, and environmental basis for facility planning that accounts for projected climate changes.
- Serve as leaders in climate adaptation preparedness.

ADAPTATION PLANNING STAGE

Beginner

RELEVANT SECTORS

Water: Water systems and resources may be affected by relocations including possible changes to storm drain networks.

Buildings: Most relevant sector. Local government offices and facilities may be relocated or retrofitted to ensure long-term resiliency and continuation of government services.

RELEVANT HAZARDS

COMMUNITY CONTEXT

In rural communities that may lack redundancy in public services, it is critical that primary government services function continuously.

Urban areas may offer more opportunities for office relocation, but intensely developed land area and travel patterns pose challenges for infrastructure relocation options.

IMPLEMENTATION

Local governments should first identify all facilities (e.g., buildings, maintenance facilities, parks) it is directly responsible for. Next, based on the results of the community vulnerability assessment, it should identify which of these facilities and assets are located in vulnerable areas and prioritize the facilities and assets based on their community value and vulnerability.

Once this determination has made, for each facility and asset, the local government should identify the best approach to increase its resiliency or relocate it. The rationale for selecting the approach may depend on economic, social, or environmental factors and should be documented. Next the local government should develop a cost estimate and timeframe for completing each action.

For facilities and assets that will be retrofitted to increase resiliency, options may include:

- Increased flooding from sea level rise or increased storm severity or precipitation: Constructing hard engineered barriers to avoid flooding (e.g., sea walls or dikes); raising a structure to one, two, or three feet above the 100-year flood level; improving onsite stormwater management; improved site access, allowing residents and employees access to local government services through alternative transportation modes (e.g., walking, biking).
- Change in temperature: Retrofitting the heating and cooling systems in the building to ensure comfortable temperatures with or without electricity; increasing tree canopy; modifying roofing and siding to better reflect or retain heat.
- Increased severity of storms: Installation of backup power systems to provide electricity when primary source is disrupted.

Relocation is a long-term process that involves identifying alternate sites or systems with lower vulnerability where the same or identical system or service can be provided. While often expensive up-front and complex to plan for, relocation can be the best long-term investment for very critical and highly vulnerable facilities or assets.

For facilities and assets that will be relocated, local governments should:

- Develop a cost-benefit analysis that accounts for economic, social, and environmental aspects of planned relocation.
- Engage the community in the relocation decision process.
- Identify new locations in less-vulnerable or non-vulnerable areas; where appropriate seek locations that are sustainably located near a mix of uses and that provides improved resident and employee access to the facility.
- Develop a sustainable reuse plan for the original facility location (e.g., return to greenspace or develop as appropriate).
- Develop a service continuity plan to ensure local governments services are not disrupted or are minimally disrupted.

Finally, the actions described in the climate readiness plan should be incorporated as appropriate into the community capital improvement plan, the region's long term transportation plan, local government budget, emergency and/or hazard mitigation plan, and zoning codes.

MORE INFORMATION

Australian Government, Department of Climate Change and Energy Efficiency's *Climate Change Adaptation Actions for Local Government*

ICLEI's Climate Change Adaptation publications for local governments, including the *Climate Adaptation Guidebook* and *Local Government Climate Change Adaptation Toolkit*.

National Wildlife Federation's *Improving the Odds: Using Climate-Readiness to Reduce the Impacts of Climate Change on the Great Lakes Ecosystem*

4-B Improve Stormwater Management Approaches

DEFINITION

Stormwater management is the practice of managing the quantity and quality of water resulting from precipitation. Over 750 communities in the U.S., including Washington, D.C., have combined sewer systems that collect rainwater runoff, domestic sewage, and/or industrial watewater in the same pipe for treatment at a wastewater treatment plant. However, during heavy precipitation periods, the sewer system or wastewater treatment plant may not have enough capacity to accommodate the added water volume. In these cases, the systems are designed to overflow into nearby streams, rivers, or other water bodies, which can impact water quality and cause streambank erosion.[25]

In addition, areas with a higher amount of impervious surface (e.g., through which water cannot naturally infiltrate), can have higher peak volumes of stormwater runoff. This runoff typically carries a range of pollutants that can cause degradation of streams, rivers and estuaries. In communities with combined sewer systems, this stormwater is treated, at notable expense, just like other wastewater sources at the wastewater treatment plant.

Managing stormwater to reduce the volume or speed of water that enters the sewer system or to reduce the pollutant load of that water near the source where it is generated reduces the burden on aging water infrastructure and the pollutants potentially carried into waterways. Stormwater management can reduce flooding by slowing or reducing how much water accumulates in low-lying areas.

CLIMATE CONNECTION

In areas where climate change is expected to result in increased precipitation or an increase in severe storm events, there will be an increase in stormwater runoff which could lead to severe localized flooding and an associated increased burden on water infrastructure systems. Even a small variation in rainfall can cause stormwater infrastructure to reach catastrophic failure if the soil is already saturated with water or precipitation is concentrated in areas with limited stormwater management technologies (e.g., December 14, 2006, Seattle flood caused by rain falling at a rate of two thirds of an inch in 30 minutes).[26]

Municipal governments and states have historically used regulations and new development ordinances to reduce peak stormwater runoff. Water quality-based

ADAPTATION PLANNING STAGE

Beginner

RELEVANT SECTORS

Land Use: Requires zoning and land use changes to reduce the stormwater quantity and associated pollutant loads.

Transportation: Roadways are major contributors of flow and pollutant loads, therefore, greenscaping of transportation corridors will reduce stormwater impacts and also enhance sustainability elements such as urban heat island mitigation and air quality. Impacts from atmospheric deposition can also be reduced with green stormwater infrastructure practices.

Buildings: Trees, raingardens, bioretention and other vegetative practices around buildings can provide stormwater control and auxiliary benefits such as reduced cooling needs and increased property values.

Water: Most relevant sector. Management of stormwater can increase groundwater infiltration, reduce the peak and volume reaching sewers, and reduce potable water demand by meeting certain uses such as cooling tower makeup, lawn irrigation and toilet flushing.

RELEVANT HAZARDS

COMMUNITY CONTEXT

Rural areas are at greater risk for disruption of capacity of natural systems to absorb stormwater through new development. May be able to better take advantage of natural wetlands than more developed areas.

Urban and suburban areas have a higher percentage of land with impervious cover requires more widespread and a greater range of stormwater management practices.

[25] http://cfpub.epa.gov/npdes/home.cfm?program_id=5

[26] http://www.stormh2o.com/july-august-2007/adaption-climate-change.aspx

regulations such as combined sewer overflow or municipal separate storm sewer (MS4) permits impose specific requirements that guide stormwater management. Historically, hard engineering solutions have often been used to meet these requirements. However, softer "green" stormwater infrastructure that is distributed throughout a watershed helps retain and/or reuse stormwater near where it is generated. This reduces the energy required to transport and treat stormwater, serving as both an effective climate adaptation and mitigation strategy.

Specific stormwater management approaches most relevant to climate adaptation include:

- Reducing the amount of impervious surface by using pervious concrete, pavement, or pavers.
- Stormwater improvement techniques in small lots such as cisterns, rain barrels, and rain gardens.
- Practices such as bioswales and enhanced treepits in public right of ways.
- Reusing rainwater onsite for landscaping, gardening, or irrigation (i.e., rainwater harvesting) in large industrial, institutional, commercial and residential lots.
- Integrated site/building stormwater management systems that capture most or all rainwater onsite and put to beneficial use in individual buildings.
- Green roofs or other rooftop retention elements such as small dams to induce storage and drain over a long period of time with passive controls such as small orifices.
- Large-scale best management practices including constructed or natural wetlands, wetponds, and dryponds.
- Storage underneath parking lots, streets and sidewalks that can be designed to empty through passive controls such as small orifices into the sewer system or infiltration into the ground.

LOCAL EXAMPLES

As part of its regulatory toolbox for addressing combined sewer overflows, EPA has encouraged the adoption of improved stormwater management practices, including green stormwater approaches nationwide. The Washington, D.C., region has been at the forefront of pilot testing and application of green infrastructure practices (e.g., Prince Georges County, Washington, D.C.).

- The Low Impact Development Center has implemented numerous stormwater control projects in Maryland, the District of Columbia and Virginia as demonstration initiatives to develop effectiveness information and also guidance manuals to municipal and regional agencies for LID implementation.
- Virginia Department of Conservation and Recreation has a stormwater management handbook that details different approaches to control stormwater including retention basins, and bioretention procedures.
- Casey Trees in Washington, D.C., has conducted an inventory of trees in the district and assessed the existing urban tree canopy with a GIS-based analysis to provide guidance on where additional potential for tree canopies exist. This will reduce the runoff volume entering the sewer system.

BENEFITS

Improving stormwater management has numerous community benefits:

- Infiltration of stormwater near where it is generated will enhance groundwater levels and yield as baseflow during non-rainy periods. Stormwater can be put to beneficial use instead of being discharged into combined sewers.
- Returning streams that have been buried in aging, underground infrastructure to the ground surface (i.e., daylighting) can allow fresh water to be used beneficially.
- Modification of plumbing code and treatment requirements for water needs for non-potable uses can allow for significant capture of rainwater for uses such as toilet flushing, cooling tower makeup and lawn irrigation.
- Neighborhood-scale opportunities for storage (e.g., wetponds) can be implemented to reduce the volume and peak runoff reaching the aging infrastructure.
- Reduction of impervious surface area associated with transportation (roads, alleys, and sidewalks) and integrated stormwater impediment techniques (cisterns, bioswales, enhanced treepits, and stormwater basins/ponds) can reduce stormwater volume and pollutant loads.

- When designed to capture the first 1-1.5 inches of rainfall, green infrastructure can marginally reduce the flooding extent for even large storm events.
- Above-ground stormwater management systems offer flexibility and scalability depending on future (e.g., changing regulatory requirements or climate changes).

IMPLEMENTATION

Increased precipitation intensity, volume and frequency due to climate change exacerbates the risk of flooding and erosion in watersheds. The structural and low impact practices suggested here are intended to mitigate these impacts. Although many of the suggested implementation steps are more appropriate for urban and suburban drainage areas, they can be applicable and effective for many rural areas where erosion and increased runoff will need to be controlled.

Local communities can initiate controls with both voluntary programs/incentives and regulatory requirements in the beginning of a phased implementation program and eventually progress toward requiring the use of controls to meet regulatory targets. In highly urbanized areas, almost all of the following controls can be effective. On the other hand, implementation can be challenging in highly urbanized areas due to limited available land and high costs. In suburban and rural areas, the benefits from some of the practices can be marginal yet the footprints of controls can be increased to achieve better results. Therefore, each local community will need to review the suggested control practices and adopt based on the ease of implementation, cost and anticipated benefits.

- Ordinances/Codes — Municipal governments can require stormwater controls and beneficial use at site and neighborhood-scales, in addition to the existing pre and post-development runoff regulations. Multiple criteria aimed at protecting water quality uses and erosion control can be included as additional regulatory considerations. For example, the capacity of local storm or combined sewers can be assessed and the development permits can require site-scale detention to achieve a lower discharge limit of say, 0.25 cubic feet per second, from each acre of impervious area. This will typically far exceed the detention necessary to achieve a pre- vs. post-construction runoff for a 5- or 10-year design storm. In a combined sewer system, the overflows occurring on a watershed-scale can be imposed as additional criterion for a developer to achieve a no-net-increase in combined sewer overflow volumes or frequencies after construction. The capacities of sewers or combined sewer overflow discharges must be assessed by the local governments and parcel-based apportioning of capacities can be performed to derive site-scale criteria for the developers. Another criterion is to capture and infiltrate up to one or 1.5 inches of rain generated from the impervious portion of a development site. In essence, this translates into disconnection of that portion of impervious cover from contributing runoff to the sewers until the rain is in excess of a 3 or 6-month design storm. Site-scale detention, rain gardens, rain barrels, and bioretention are some examples of green stormwater approaches that can achieve this requirement. For new and redevelopment projects, this criterion must be imposed as mandatory and for existing development, the local municipalities can initiate this as voluntary program and can transition to a mandatory requirement over a period of say, 5 years.
- Building standards and incentives — Green building standards can support stormwater capture through green roofs or infiltration practices or reuse from storage. Financial incentives to reduce potable water demand or the installation of green roofs (i.e., New York City) can be vital to widespread implementation of practices. Enhanced standards can include targets such as 90% reduction or zero-discharge for stormwater generated at a site and incentives can include 25% decrease in water rates for every gallon of potable water offset by the beneficial use of retained stormwater. Similar incentives can be offered for the use of grey water for non-potable uses such as toilet flushing and gardening. Another incentive can be based on the capture rate of precipitation such as one or 1.5 inches and the sewer charges can be reduced in accordance with the design criterion used in individual green buildings. These standards must be described in simple terms so that permit applications from individual developers will be consistent and beneficial to achieve community goals. Over time, voluntary or incentive-based programs can be

transitioned into mandatory programs. Enhanced standards can be made mandatory in new and redevelopment projects, while remaining voluntary for existing buildings.

- Community involvement – Existing developments dominate impervious cover in urbanized areas and innovative and voluntary strategies are necessary to improve stromwater management. Improved practices at individual households and small businesses (e.g., rain barrels, rain gardens, swales and bioretention) can provide the distributed controls necessary to achieve watershed-wide benefits. Public outreach and community involvement can support individuals in identifying best practices, implementing projects at a neighborhood scale, and sharing information on operation/maintenance. An example is the 10,000 raingarden initiative in Kansas City, steered by a local non-profit agency with support from the local and federal governments. This is a low-cost, high-impact technique, however, it can take much longer timeframe for implementation due to its voluntary nature.
- Transportation sector — A significant amount of urban landcover is represented by transportation infrastructure, including roads, bus turn outs, and service yards. In addition, this land cover has a higher level of pollutants such as metals and solids. Communities can develop a regional street design manual for consistent and widespread adoption of enhanced or new strategies that minimize stormwater flows by diverting stormwater to irrigate street trees and landscaping, roadside infiltration beds and rain gardens.
- Parking lots – Communities can adopt standards to require the use of pervious pavement or pavers, and stormwater diversion techniques to minimize stormwater runoff from parking lots. Large shopping malls and private/public parking lots are ideal candidates for implementation of stormwater controls.
- Park space – Communities can repurpose abandoned sites or brownfields in their neighborhoods into usable green spaces (e.g., neighborhood parks) to remediate the sites so that the potential for pollution of surface and ground waters is minimized and to increase the sustainability of the watershed by adding green space. In addition, stormwater ponds in existing parks can be expanded.
- Resizing or reconfiguring existing stormwater controls – This strategy is particularly useful for urban areas with numerous existing detention ponds sized and constructed based on outdated criterion, say 5-year design storm. A new design standard can be adopted by local communities, (e.g., a 10-year storm), and where feasible, the existing stormwater ponds can be resized or their outlet structures can be reconfigured to induce additional storage. This can be initiated as mandatory program for shopping malls, row houses, industries, institutions and commercial buildings with large impervious covers.
- Partnerships — Local agencies responsible for parks, transportation sector and municipal wastewater have their own programs for green infrastructure implementation. Streamlining technical and financial resources will allow for systematic implementation of stormwater control practices at neighborhood to watershed scales to result in immediate and significant improvements in the watersheds. Coordination of administrative, financial and programmatic elements can require additional time, therefore, this can be pursued as voluntary initiative over a period of 5-10 years.

IMPLEMENTATION BEST PRACTICES

- Establish multiobjective stormwater control criteria for new and redevelopment projects.
- Work with other local governments to develop a watershed-wide stormwater management plan.
- Develop innovative maintenance plans for and consider contracting out maintenance of stormwater controls.

MORE INFORMATION

- Vancouver, Canada, has integrated climate change considerations into its stormwater management programs.
- Climate change adaptation and mitigation case study of the City of Portland, Oregon.
- Virginia's Department of Forestry webpage on rain gardens.

- Portland, Oregon's, fact sheet on pervious pavement.
- Green Roofs for Healthy Cities webpage and EPA's green roofs webpage.
- Urban Stormwater Management in the United States. 2009. National Research Council Report on Reducing Stormwater Discharge Contributions to Water Pollution.
- Commonwealth of Virginia Department of Conservation and Recreation. Stormwater Management and Urban Best Management Practices.

4-C Adapt Zoning and Building Codes to Evolving Risks

DEFINITION

Many communities rely on zoning and building codes to protect health and safety. Zoning relies on requirements such as set-back (or set-to) lines, specific lot sizes, limited building heights, maximum amount of impervious surface area, and permitted uses, while building codes specify ventilation, insulation, fireproofing, structural integrity, and other design aspects. Once zoning and building code requirements are met, development is typically permitted with no review of whether the adopted standards have resulted in the best development for either the residents/users of the new project or the community as a whole.

Land use regulations tend to be difficult to change, while building codes are updated more frequently to protect public health and safety. However, these regulations and codes and their associated revision processes are typically not designed to respond to projected climate changes. Going forward, projected climate changes should be considered as local governments update these requirements.

CLIMATE CONNECTION

Because the development of land use and building codes coincided with an extended period of climate stability, many of their requirements are based on historical weather patterns and their associated risks. Also, some communities have permitted "risky" development patterns over the years that should be reconsidered and either reduced or eliminated. For example, there are communities that have permitted development in, or very near, floodplains if the development was elevated. These floodplains may carry increased flood volume in the future, causing damage to property and residents. Local government might consider discontinuing this practice. Other communities have allowed development at significant densities along coastal areas or in wildfire risk areas. New development in these areas could be allowed only if at significantly lower densities and accompanied by a risk assessment.

ADAPTATION PLANNING STAGE

Intermediate

RELEVANT SECTORS

Land Use: Most relevant sector. Dimensions and development standards can be adjusted to move development out of vulnerable areas.

Transportation: Transportation structures can be designed in light of regularly updated land use projections.

Buildings: Lot dimension and building envelope standards should be updated to prevent construction in hazardous vulnerable areas. Building regulations should be reviewed and updated in a continuous process related to increasing levels of risk.

Water: Flooding, sea-level, and drought conditions can be evaluated in the update of development standards.

RELEVANT HAZARDS

COMMUNITY CONTEXT

This regulatory update is applicable in all community contexts where land use regulations and building codes are in use.

Local governments seeking to adapt to climate changes will need to use new and continuously evolving assumptions, with higher levels of both risk and uncertainty related to extreme weather and temperature events, flooding, and related conditions.

In communities where currently buildable or already built out areas may become increasingly vulnerable to climate changes (e.g., sea-level rise and more extreme weather and temperatures, hurricanes, flooding, and droughts) or must respond to needs such as protecting aquifer recharge areas, land use regulations and building code requirements and processes will need to be more anticipatory and dynamic.

Where climate change is likely to cause hazards to development that were not anticipated when the codes were adopted, there should be a process to determine whether the adopted standards should be updated. In addition, many of the potential

strategies that reduce climate risk also contribute to mitigation goals, and the most advanced approaches incorporate passive survivability features that greatly lessen risks associated with extended utility outages.

LOCAL EXAMPLES

Many communities have completed climate change vulnerability assessments and created climate action plans. Some of these plans include changing zoning and building codes in response to increasing risks related to climate change. However, few have yet gotten to the stage of adopting those changes. The Georgetown Climate Center's *Adaptation Took Kit: Sea-Level Rise and Coastal Land Use* lists some examples of states that have recommended implementing building code changes and development of resilient design guidance, including the California Adaptation Strategy, the Florida Action Team recommendations and the Maryland Working Group.

The following are some communities or jurisdictions that are farthest along this path.

- The City of Chula Vista, California has recently released their 2011 Climate Adaptation Plan which include code changes for Cool Roofs, Water Reuse, Cool Paving, Sea Level Rise and land development codes and detailed plans and budgeting projections.
- The City of Chicago's Climate Action Plan includes updating the Chicago Energy Conservation Code, among many other measures.

BENEFITS

Annual update of zoning dimensional standards and development regulations in vulnerable areas can discourage future development from vulnerable areas and encourage this development in more suitable, buildable areas. In many cases, this process will allow a community to consider climate-related zoning changes as a policy and regulatory discussion without the added pressure of consideration of a specific development application. It will also significantly increase community resiliency to climate changes.

Incorporating evolving, rather than static predictions of climate-related stresses on buildings will enable greater innovation in design and construction practices while encouraging all projects to consider resiliency, durability, performance, and functionality during extreme weather and temperature events, power and utility outages not currently part of the design or permitting process. This should result in safer and more efficient buildings with lower operating costs, impacts, and demands on community services. As more buildings become more climate resilient, there will be associated decreases in loss of life, economic losses and socioeconomic upheaval from climate related events.

IMPLEMENTATION

Preferably, land use regulation and building code updates should be undertaken by local government on an annual basis, and include a process to allow permit applicants to suggest updated standards based on a project site analysis and local or regional climate change information. Building codes, standards, and their permitting and enforcement processes should also be reviewed and modified to be more responsive to changing risks and circumstances.

The implementation of this approach is akin to the process for many national standards that are under continuous improvement rather than fixed periodic review. The difficulties that typically accompany updates and changes to codes, standards, or policies include real and perceived increased uncertainty for those seeking approvals, the learning curve—the time it takes everyone to become familiar with the new rules, and the usual resistance to change. Although the types of changes involved here may represent a tightening of building and development codes, they could also be viewed as creating more flexible and responsive policies and requirements that are more open to innovative solutions to evolving problems. There is an opportunity in the process of addressing these emerging risks to incorporate more clearly defined community goals and aspirations, rather than focusing only on preventing undesirable outcomes.

As a first step, local governments should rely on the results of the vulnerability assessment to map vulnerable areas. At the time of review, the map will need to be compared to updated climate change

data to determine whether standard regulations should be updated, particularly in vulnerable areas.

To update land use regulations, local governments should consider amending standards that permit development in areas that will be subject to increased danger over time, and establishing regular review dates for land use regulations. Communities in some states are required to undertake regular comprehensive plan review, and the code review could be undertaken as a similar process.

As part of the initial code review, the local government should adopt a process that permits an applicant to submit suggested updated site development standards based on a project site analysis. For example, Kauai, Hawaii, has established a progressive shoreline setback that is changeable based on the average depth of the lot. Projects that are reviewed pursuant to this process may need to be approved through a flexible zoning technique such as PUD as described in Approach 3C.

In states with statewide code adoption, the process to update building codes can be more challenging; however there are provisions in all building codes for incorporating local climate and other conditions, including wind, snow loads, and issues affecting durability, energy performance, and more. Communities can look at the full range of changing hazards related to climate change and develop higher requirements for buildings in areas vulnerable to flooding, high winds, wind-driven rain, extreme temperatures, drought, wildfires, and areas predicted to be more vulnerable to extended loss of utility services.

Communities can also look at adopting "stretch" codes, or more stringent voluntary codes that incorporate innovative practices for higher performance buildings. These codes ease the design and approvals process for higher performance buildings and can be accompanied by incentives to encourage their use. The first version of the International Green Construction Code will be available in early 2012 and incorporates many provisions related to greater resiliency in the built environment. This code could be considered for adoption as either a mandatory or voluntary code.

For upgrading existing buildings, changes and increased requirements could be tied to changes in occupancy, ownership and significant renovations or additions to minimize hardship on owners and occupants.

IMPLEMENTATION BEST PRACTICES

- Review current codes and standards to evaluate their ability to meet climate challenges and modify or develop regulations aimed at increasing resiliency and are anticipatory rather than reactive.
- Develop a flexible, risk-based approach to adaptation that includes regular reviews of building and development codes, standards and policies to keep current with evolving risks.
- Consider adopting building codes that are more open to higher performance design and more innovative practices such as the International Green Construction Code—as a voluntary reach code if state law pre-empts local adoption of more stringent mandatory codes.
- Include appropriate levels of government and all stakeholder experts to build support for adaptation strategies and policies.
- Create a process to link updates in FEMA and NOAA maps and climate change projections to regular reviews of codes and standards.
- Look for opportunities to address multiple goals by working across regulatory and disciplinary boundaries.

MORE INFORMATION

- Architecture 2030 and The 2030 Challenge offer many excellent resources related to the built environment and climate change including a white paper on the 2030 Challenge and building codes.
- The 2012 International Green Construction Code will be published in March 2012 as part of the set of buildings produced by the International Code Council.
- The State of Massachusetts has a Stretch Code for higher energy performance for buildings.
- The State of Oregon has a similar code, the Oregon Reach Code.
- New York City's 2010 report, *Climate Adaptation in New York City: Building a Risk Management Response* includes many relevant recommendations.

4-D Create Special Taxing and Assessment Districts to Fund the Protection of Buildings and Infrastructure

DEFINITION

Public structures and infrastructure may need to be periodically rehabilitated or upgraded to remain structurally sound. Typically, communities build these costs into their capital improvements plan and annual budget. In some cases, however, it may be necessary establish special taxing or assessment districts to accomplish changes beyond the scope of typical capital improvements programming.

CLIMATE CONNECTION

Public buildings and infrastructure very often need to function continuously throughout weather emergencies such as hurricanes or major storms, and through periods of extreme temperatures and drought. Frequently, though, they either were not constructed with these extremes in mind or they (and their attendant mechanical systems) have aged significantly since their original construction. An example of this is the combined sanitary/stormwater sewer system that can still be found in many communities. Increased flooding with higher volumes of water causes both stormwater and sanitary sewer loads to combine and backflow. Similarly, the electrical grid can strain to provide the power needed to generate electricity for air conditioning during prolonged heat waves, such as the Mid-Atlantic states saw with power outages in the summer of 2010.

By retrofitting these facilities in advance of stress or disaster, local governments may be able to save money by not having to conduct expensive reconstruction following a disaster, as well as recognize cost-savings through a well-managed bid/construction process and from the newly updated and potentially more-efficient structures. In addition, they will ensure smoother functioning in an emergency situation.

To accommodate the costs of these changes, local government can create special taxing or assessment/improvement districts that disperse tax/fee payment across all of the users of the public

ADAPTATION PLANNING STAGE

Intermediate

RELEVANT SECTORS

Land Use: This approach does not directly impact land uses, although changes to infrastructure location will have impacts on future land use.

Water: Water, sewer, and stormwater infrastructure may be upgraded and/or relocated.

Transportation: Transportation infrastructure may be updated and/or relocated.

Buildings: Most relevant sector. Community-based funding can be used to upgrade structures in anticipation of future climate change induced stresses.

RELEVANT HAZARDS

COMMUNITY CONTEXT

This approach is applicable in any community context. Where taxes or fees are allocated across the community, it will take longer for smaller communities to generate the pool of funds required for pay-as-you-go projects.

building or infrastructure. The monies that are collected from the special tax or assessment can be used to either fund upgrades on a pay-as-you-go basis; to support the issuance of bonds; and/or, particularly with respect to transportation infrastructure, to create a public-private partnership for reconstruction.

Local funds may be able to be used in conjunction with state emergency preparedness funds, a FEMA Pre-Disaster Mitigation Grant and/or U.S. Department of Housing and Urban Development Community Development Block Grant funds.

LOCAL EXAMPLES

The use of special taxing or financing districts is common across the U.S. The following are examples of special districts established in the Washington, D.C., region.

- In Virginia, where local government authority is subject to Dillon's Rule, community development authorities (CDAs) are geographic districts authorized by city or county government. CDAs have the authority to establish, finance, and operate infrastructure projects paid for through special assessment, tax increment financing, or both.[27]
- Anne Arundel County, Maryland, uses special community benefit districts such as the Arundel-on-the-Bay district to pay for non-shore erosion prevention and protection, repair of non-county owned roads, and acquisition and maintenance of real property.[28]
- The Downtown D.C. Business Improvement District levies a tax on commercial space and hotel rooms that is used in part to fund programs to increase energy efficiency and reduce dependency on carbon-based fuels[29].

In other areas of the country:

- The State of Oregon permits local governments to issue general obligation bonds to pay for earthquake rehabilitation of schools and emergency facilities, similar to funding building and site upgrades in vulnerable areas.[30]
- The City of San Diego, California, has established a series of policies regarding the repair and replacement of infrastructure in environmentally sensitive areas that provide an example of how thoughtful planning about retrofitting and relocation can have potential cost-saving impacts.[31]
- The Sacramento Area Flood Control Authority charges a special assessment to properties within the district based on special benefits received from levee and flood drainage operations.[32]

BENEFITS

The benefits of anticipatory upgrades to public structures and infrastructure through the creation of a shared-funding source are the ability to:

- Contain design and construction costs;
- Recoup structural and functional efficiency savings over time;
- Study alternative approaches and alignments where reconstruction is not required following a disaster or climate change induced structural damage; and
- Allocate costs to users across the community and avoid re-allocation of general fund finances out of their budgeted task.

IMPLEMENTATION

Similar to the funding options identified in Approach 2C and Approach 3A, to implement this approach the local government should study the issue and identify priorities first, and determine appropriate sources of funding second.

The local government should identify structures and infrastructure in need of retrofit, upgrade, or relocation. This can be done as part of the vulnerability assessment process where the local government identifies structures and infrastructure that are located in or near vulnerable areas and that will be subject to the potential off-site impacts of climate change. For example, a fire station located outside of a floodplain but in a low elevation area that could be subject to inundation might be considered for relocation to ensure that emergency personnel and equipment can respond in case of a storm or flood event. Similarly, a beachfront roadway that links neighborhoods but that could be subject to wash-out in a hurricane should be rebuilt in a safer location.

To encourage a comprehensive approach to assessing vulnerable structures and infrastructure the local government should encourage the participation of all relevant departments, including: planning, public works/engineering, police, fire, emergency management, and finance.

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[27] Andrew Painter, Community Development Authorities, 45 University of Richmond Law Review 81 (2010) http://lawreview.richmond.edu/wp/wp-content/uploads/2010/12/Painter-451.pdf

[28] Anne Arundel County Code Section 4-7-204, Special Community Benefit Districts.

[29] DowntownDC Business Improvement District assessment and programs http://www.downtowndc.org/

[30] http://www.oregongeology.org/sub/projects/rvs/EERI-GO-Bond-text.pdf

[31] http://docs.sandiego.gov/councilpolicies/cpd_400-13.pdf

[32] http://www.rd1000.org/index.php?option=com_content&view=article&id=22&Itemid=22

An estimate of the cost associated with each project should also be developed. In addition, the nature and anticipated benefit of each retrofit should be clearly identified. Finally, each potential funding source should be identified along with the total funds available from the source. With the needs study in place, local government can follow the regulatory requirement of adopting and implementing the selected funding option.

IMPLEMENTATION BEST PRACTICES

- Identify structures, infrastructure, and assessment/taxing districts in a mapped format for the purposes of public discussion in both the preparation of the needs assessment report and the fund adoption education program.
- Determine the measurable benefits to the community of adopting the retrofit funding and make that information available to the public.
- Consider the creation of a separate board or authority to making spending recommendations and address public comment in an open and transparent process.

MORE INFORMATION

For a basic overview of special districts, see the Municipal Research and Service Centers of Washington (MRSC) website at "What is a Special District?"

4-E Amend Non-Conforming Use Provisions to Allow Safer, Sustainable Redevelopment in Vulnerable Areas

DEFINITION

A common practice in most communities is to place strict zoning and building code controls on the expansion or renovation of nonconforming structures and uses, the goal being to have them replaced or removed over time. These regulations usually require full compliance with all current standards—setbacks, height, lot area—if a nonconforming structure or use that does not meet those standards is reconstructed or redeveloped following significant damage ("significant" typically means repair costs exceed a specified dollar amount or percentage of the structures value). Moreover, they rarely allow any type of expansion (e.g., elevating a building to a greater height to make it more flood resistant).

CLIMATE CONNECTION

While these regulations make sense in many circumstances, they can have serious unintended consequences in areas that have been or may be subject to major storm damage. Because of the potential cost of full compliance with current standards, property owners will be tempted only to undertake minor repairs to make their structures habitable and will avoid major expenses to ensure the structures are more hazard resilient for fear of triggering the nonconformity provisions. This may not only lead to disinvestment in a storm-damaged area, but actually render a property less safe. Additionally, properties may actually be abandoned leading to long-term blight in a neighborhood with the accompanying loss of local government tax revenues and increases in crime. Local governments also often have very complicated procedures to get approval to renovate or expand nonconforming uses, another hurdle to fast economic recovery in storm-damaged areas.

To address these problems, several communities are implementing nonconforming regulations that recognize partial compliance with development standards and incorporate incentives for redevelopment or reconstruction of nonconforming structures that are more hazard resilient.

ADAPTATION PLANNING STAGE

Intermediate

RELEVANT SECTORS

Land Use: Most relevant sector. Focuses on increasing disaster resiliency in the most vulnerable areas of a community.

Water: Applied in areas subject to flooding; may be used to foster sustainable development practices like rain water harvesting.

Buildings: Fosters greater hazard resiliency from floods or wind events; can also foster more environmentally-sustainable developments.

RELEVANT HAZARDS

COMMUNITY CONTEXT

Applicable across all types and sizes of communities.

From a climate adaptation perspective, incentives for redevelopment of nonconforming structures, when coupled with requirements for greater hazard resiliency, could help ensure that existing development in danger-prone areas (e.g., coastlines and riparian areas) becomes more capable of withstanding adverse weather events.

For example, many coastal areas in the country, particularly in the South, were platted and developed in the 1940s through the early 1960s-before implementation of the National Flood Insurance Program, and requirements for elevation above the base flood elevation (BFE) or flood proofing. As a result, many coastal communities have large stocks of residential and nonresidential development that do not comply with flood damage prevention requirements. Often, these homes and businesses also fail to comply with other zoning-related requirements such as setbacks, off-street parking, or design-related provisions. Because modifications to these older structures would trigger

the requirement for full compliance with all development standards, and such compliance can be cost-prohibitive, these nonconformities continue unchanged through the years. Standards that allow identical replacement of these nonconforming structures following storm events are politically popular, but do little for the community's long-term hazard resiliency.

Modifications to the nonconforming provisions that provide an incentive for redevelopment (for example, expansion of floor area) help home and business owners justify the costs of achieving compliance, and foster redevelopment that is more consistent with current zoning and building codes. Coupling the incentives with requirements for partial compliance with key development regulations (e.g., flood damage prevention standards within special flood hazard areas or minimum wind loading construction requirements in tornado-prone areas) helps foster greater overall hazard resiliency than might otherwise result without the allowance for partial compliance. In other words, a win-win situation—the home or business owner can increase the value of their property without incurring the expenditure of full code compliance, while the community benefits from a structure that is less likely to sustain serious damage during a storm event.

LOCAL EXAMPLES

Two communities that recently suffered severe damage from hurricane Katrina, Biloxi and Pascagoula, Mississippi, have adopted a more realistic approach to nonconforming uses.[33] In both these cities, nonconforming structure footprints within special flood hazard areas may be expanded by up to 15 percent through approval of a special or conditional use permit and provided the expanded structure incorporates a series of features that result in greater compliance with flood damage prevention standards—without requiring full compliance with all zoning and floodplain standards (e.g., flood proofing residential walls below BFE or partial elevation of habitable floor area above BFE).

Several communities in the western U.S., such as Tucson, are considering new standards that allow nonconforming structures to redevelop without achieving full code compliance (with aspects like parking, landscaping, setbacks, etc.) if the development is retrofitted with sustainable development features such as rain water harvesting systems, shading structures, solar arrays, or other changes that result in LEED certification or Energy Star compliance.

BENEFITS

Regulations that create incentives for redevelopment of nonconformities while requiring only partial code compliance produce several benefits:

- They allow quick rebuilding in climate impacted communities, while providing improved hazard resilience.
- They avoid blight in damaged areas.
- They allow regulatory standards to be targeted to specific areas (like special flood hazard areas).
- They are flexible in that they may be applied administratively by staff, approved as part of a conditional or special use permit by a community's elected officials, or approved by a board of adjustment or board of zoning appeals as a special exception.
- They are flexible in terms of the kind of standards that can be incentivized.
- They can result in property tax revenue as nonconforming structures are redeveloped.

IMPLEMENTATION

Protection of vulnerable areas can be approached through varying degrees of regulatory detail and local policy depending on the information available in the community's comprehensive plan and/or open space, sensitive lands, or floodplain/coastal planning as well as existing regulations. Initial steps might include identifying key aspects of the current development standards that must be addressed by a redeveloping nonconforming structure or use, mapping vulnerable areas to more-easily identify where those structures would be located, and

[33] Pascagoula, Mississippi, Unified Development Code, Article 8, Nonconformities http://cityofpascagoula.com/wp-content/uploads/2011/06/Final-Unified-Development-Ordinance-5.pdf; Biloxi, Mississippi, Land Development Ordinance, Article 23-8, Nonconformities http://library.municode.com/index.aspx?clientID=15020&stateID=24&statename=Mississippi

revising the zoning regulations to exempt adaption-oriented improvements from the applicability of the typical prohibitions on changes to nonconforming uses and structures. Santa Barbara County, California, permits the reconstruction, alteration, and relocation of structures housing nonconforming uses in coastal erosion areas provided they meet specified standards such as compliance with setback and height requirements. Additionally, seismic retrofits are allowed for all nonconforming structures. Similar provisions to enhance structural resiliency can be incorporated into updated nonconforming use and structure zoning regulations.

Additional action might be taken by amending the nonconforming use and structure standards of the zoning regulations to allow nonconforming structures or uses to expand with administrative approval, subject to specific criteria. Communities could consider using special or conditional use permits for larger changes. The City of Santa Cruz, California, has recommended changes to the zoning regulations to permit alterations, remodels, and additions to nonconforming structures with a building permit, as long as the value of such work does not exceed 90% of the market value of the structure. Where the nonconforming structure is located within a vulnerable area, the community may consider adding conditions to any new or reconstruction that makes the structure more resilient.

IMPLEMENTATION BEST PRACTICES

- Ensure the procedure relies on clear, measurable approval criteria.
- Use menus that set out the range of development features that must be incorporated into redevelopment nonconformities.
- Limit applicability to those areas that will further the community's hazard resiliency goals.

MORE INFORMATION

The City of Fort Myers Beach, Florida, has a process that allows nonconforming development (density and height) to be replaced and redeveloped if hazard resiliency is improved.

For a discussion of the impact of regulating nonconformities, see Arthur Ientilucci, Pigs in the Parlor or Diamonds in the Rough? A New Vision for Nonconformity Regulation in Zoning News (American Planning Associations, Feb. 2003).

Santa Barbara County, California, County Land Use and Development Code, *Chapter 35, Nonconforming Uses, Structures, and Lots*

Santa Cruz, California, nonconformity zoning amendments

4-F Identify Transportation System Vulnerabilities

DEFINITION

While local governments typically own only local roads (state governments own state and interstate highways, while regional agencies or authorities typically own airports and transit infrastructure), they are often best able to identify weaknesses in their community's transportation system, regardless of who owns an individual transportation asset. As such, local governments have an important role to play in maintaining and enhancing transportation infrastructure.

Nearly all local governments perform longer term transportation vision planning (e.g., a 20 year vision plan) and near-term capital improvement planning (a six year capital improvement plan). This local transportation planning process is closely coordinated with the regional MPO. MPOs and federal agencies provide critical guidance, coordination and oversight to the regional transportation planning process, and the MPO coordinates local transportation planning activities in the region's TIP and long range transportation plan (see Section 2, Consider Regional Approaches).

A region's TIP and long range transportation plan analyze economic growth, changing development patterns, and asset preservation demands. However, few transportation plans explicitly address expected impacts from climate change. By including these considerations in the regular transportation planning process, local governments can identify transportation system vulnerabilities to be addressed by the local government or through the regional transportation planning process.

CLIMATE CONNECTION

Climate changes such as increased temperatures, precipitation, and frequency of severe storms, and sea level rise can cause severe disruptions to transportation systems. Flooding, extreme heat, ice, or other storm events cost regions millions of dollars annually in the form of delayed freight deliveries, lost productivity, wasted fuel, physical repairs, and incalculable frustration. In turn, this can weaken regional economic competitiveness, quality of life, and health and safety.

ADAPTATION PLANNING STAGE

Intermediate

RELEVANT SECTORS

Land Use: Protected or retrofitted facilities will improve reliability of transportation operations and mobility; relocated facilities will affect surrounding land uses.

Transportation: Most relevant sector. Will inform transportation programming, location, and design of facilities for reliable operations even should climactic disruptions occur.

RELEVANT HAZARDS

COMMUNITY CONTEXT

Risk assessment will have to calculate the risks/benefits of preserving critical infrastructure to support rural communities.

In urban and suburban areas, this approach should promote a shift in investment toward areas that minimize the extent (smart growth vs. sprawl) and exposure (disinvestment in vulnerable areas) of critical infrastructure.

Working within the existing transportation planning process, local governments have an opportunity to analyze potential vulnerabilities to transportation assets in their jurisdiction and prioritize adaptation strategies to avoid potential impacts. By integrating climate change vulnerabilities into the established transportation planning process, local governments can develop plans (and provide input into regional plans) that can serve as proactive strategies to address vulnerable assets.

Local governments have both the authority and responsibility to determine the preferred strategy for adapting their assets to the potential hazards of climate change either through protection, retrofitting, or relocating infrastructure. Owners of transportation assets must ultimately identify prioritize actions for funding; the regional TIP process serves as a means to ensure local priorities help maintain a functioning regional system.

LOCAL EXAMPLES

The State of Maryland has begun to analyze the state's transportation vulnerabilities in the *Maryland Climate Action Plan* released in August 2008. Maryland identified vulnerable infrastructure using a specialized GIS tool.

In 2011 the District of Columbia Department of Transportation (DDOT) adopted a new approach to develop the agency's Transportation Improvement Program. Using a software system, the agency was able to weigh and prioritize investments over a range of factors that included typical factors such as maintenance and safety, but also enhanced mobility and system redundancy, environmental performance, and economic encouragement. Using this powerful tool, the agency was able to evaluate each proposed project against its level of environmental risk and its ability to improve climate change objectives. The system allows for greater weight to be given to projects in areas of greater risk in the prioritization algorithm.

BENEFITS

- Local governments have a credible, data-supported basis for making transportation investments to adapt to climate change.
- Climate adaptation planning can be integrated into the established transportation planning process.
- Local government investments in transportation vulnerability planning will strengthen the region's transportation system, helping to maintain transportation continuity in the region.
- Transportation planning, funding, and implementation is a long term process; by beginning to anticipate climate change now, local governments can be better prepared for future impacts.

IMPLEMENTATION

Local governments and transportation asset owners should begin by understanding which assets are located in vulnerable areas and the probability and cost of a debilitating event occurring. One potential source of information is historic data on transportation system impacts from past weather events. Understanding what transportation assets are already impacted by weather events similar to what is expected from climate change (e.g., in the Washington, D.C., region it may include high temperature and precipitation events), the impact to the asset and transportation system, and the estimated cost impact is a good starting point for understanding potential future system vulnerabilities. The local vulnerability assessment process, described in Section 1, is another critical information source.

To develop a transportation vulnerability assessment local governments should consider:

- Assessment of hazards (how, which, and where climate changes are likely to affect assets and modes).
- Inventory of critical assets in areas affected by climate change hazards.
- Estimated vulnerability of asset, probability of impact by a major climactic event, and assessment of the system's resilience to loss of assets.
- Estimated social and economic costs of probable incident(s).

Using this assessment, localities can map planned capital projects already in their existing program and long range plan and inventory those that are not currently programmed for investment.

A major challenge for transportation asset owners is determining the most appropriate adaptation response strategies. Often, protection or retrofit strategies are less expensive and more acceptable to existing communities than relocation options, however all options should be considered, especially for challenging assets or contexts. In addition to preserving the asset and/or its function, adaptation strategies ideally should also enhance the overall system resilience and performance by providing more mobility options or redundancies, addressing other network challenges (such as congestion), enhancing safety, and/or encouraging and supporting preferable development patterns.

To evaluate potential adaptation strategies, local governments may consider:

- Adaptation response options (protection, retrofit, or relocation) and the trade-offs among them.
- Preferred adaptation response strategy, estimated cost and proposed programming.
- Party responsible for facility and implementation and associated plans and programs.

- Specific horizon year for implementation of adaptation actions.
- Evaluation methodology and cycle for reassessment of strategies and plan.
- When scoring transportation infrastructure/ services investments, give preference to options that add redundancy to at-risk infrastructure. A BRT line that could reduce the incidence-costs for a rail line expected to become vulnerable to storm surge, for example.

While funding determinations and strategies for adaptation are generally the responsibility of the individual owners, the MPO also has a role to play in ensuring that those facilities of regional importance are included in the regional TIP and that separate adaptation investments work together as a whole (for instance once jurisdiction is not planning to relocate a roadway segment downstream from where another jurisdiction is planning to retrofit their portion of that corridor). Therefore, results from the local government transportation vulnerability assessment should be considered in the regional transportation planning process.

MORE INFORMATION

Transportation Research Board's Report 290 is one of the most comprehensive resources on responding to climate change impacts on transportation.

U.S. Department of Transportation, Federal Highway Administration, *Integrating Climate Change into the Transportation Planning Process*

National Academy of Sciences (www.nas.org) has a wealth of information available on transportation adaptation planning strategies.

Climate of Opportunity: A Climate Action Plan for the District of Columbia, Government of the District of Columbia, District Department of the Environment, September 2010

U.S. Department of Transportation Policy Statement on Climate Change Adaptation, June 2011

Sea-Level Rise: A Transportation Vulnerability Assessment of the Wilmington, DE Region produced by WILMAPCO, July 2011

4-G Implement Integrated Heat Island and Stormwater Reduction Strategies

DEFINITION

Heat island is a term used to describe an urban area that has air and surface temperatures higher than nearby rural areas. Heat islands typically form in areas with a higher amount of land cover that is pavement, buildings, and other infrastructure, rather than natural land cover. Heat islands can result in temperatures up to 22 degrees Fahrenheit warmer than surrounding open land areas, causing stress on people and infrastructure.[34]

Many strategies that can be used to reduce the heat island effect can also improve the management of stormwater. Implementing such integrated strategies provides added benefits to communities.

CLIMATE CONNECTION

Strategies to reduce heat island effects have been successfully implemented for many years, and typically involve increasing tree or vegetative cover, installing green or cool roofs, and using cool pavements. By reducing heating and cooling costs for buildings, these approaches often provide significant energy savings and reductions in greenhouse gas emissions, making them common climate change mitigation strategies. However, they can also serve as low-cost climate change adaptation strategies by reducing the direct effects of climate change.

Climate changes are expected to bring higher temperatures to many communities, which will likely exacerbate the heat island effect. In some cases, this could pose a significant health and safety threat to residents and impact transportation infrastructure (e.g., deform rail lines, thermal expansion of bridge joints, degrade pavement). Implementing strategies to reduce heat island effect will help communities facing increased temperatures be more resilient to those changes. Strategies that also help improve stormwater management can make communities more resilient to expected increases in precipitation or severe storm events.

Not all urbanized areas experience a significant heat island effect. However, implementing strategies to reduce the heat impacts and improve stormwater management is something that every urbanized area can do to be more sustainable and resilient in the face of a changing climate.

ADAPTATION PLANNING STAGE

Intermediate

RELEVANT SECTORS

Land Use: Zoning and land use changes can be made to increase vegetated areas, and protect and increase tree canopies.

Transportation: Complete Streets and strategies increasing street trees, vegetated medians and areas adjacent to roadways provide shade and cooling, improving comfort of pedestrians and bicyclists, and provide significant stormwater reduction benefits.

Buildings: Most relevant sector. Trees and other vegetation around buildings can provide shading and microclimate benefits, reducing cooling loads and energy use. Green roofs and walls, as well as vegetated terraces can provide heat island benefits and stormwater reduction benefits.

Water: Many of these strategies reduce or slow stormwater runoff. Strategies that divert stormwater from storm drains into vegetated rain gardens and street landscaping basins can aid in reducing non-point source water pollution.

RELEVANT HAZARDS

COMMUNITY CONTEXT

Heat island effects generally occur in urbanized areas, including more densely populated suburban areas.

Although heat island effect is not often seen in rural areas, these areas could implement heat island mitigation strategies to reduce the impacts from the built environment on local residents and the environment.

LOCAL EXAMPLES

Arlington, Virginia, has implemented a green building program that includes rain gardens, vegetated roofs, and pervious pavement measures.

[34] http://www.epa.gov/hiri/

Charlottesville, Virginia, has environmental sustainability policies, including stormwater management, water resources protection program, sustainable buildings, and rain gardens, and an urban forestry program.

The Virginia Department of Conservation and Recreation has a Stormwater Management Program that details different approaches to control stormwater including retention basins, and bioretention procedures.

Casey Trees in Washington, D.C., has assessed the existing urban tree canopy in the district with a GIS-based analysis to provide guidance on where additional potential for tree canopies exist.

Georgetown Law Center maintains a library of urban heat island resources.

BENEFITS

- Trees, vegetation, and green roofs can reduce cooling energy use and associated air pollution and greenhouse gas emissions, remove air pollutants, sequester and store carbon, improve stormwater control and water quality (literature show annual rainfall interception of 11-18 percent, with higher rates in the summer for urban tree canopies).[35] Trees and vegetation can also reduce noise levels, create wildlife habitats, improve aesthetic qualities, increase outdoor social interaction and physical activity, and increase property values. Trees can also improve groundwater recharge and increase soil water storage. Deciduous trees can provide shade in summer without significantly reducing passive solar gain in winter.
- Cool roofs can lower cooling energy use, peak electricity demand, air pollution and greenhouse gas emissions, heat-related incidents, and solid waste generation due to less frequent re-roofing.
- Cool pavement can indirectly help reduce energy consumption, air pollution, and greenhouse gas emissions. Depending on the technology used, cool pavement can improve stormwater management and water quality, increase surface durability, enhance nighttime illumination, and reduce noise.
- Reducing urban temperatures in a warming climate will benefit public health through reduction of heat stress, particularly for the very young, elderly, sick or disabled.
- Reducing temperatures during warm months can reduce the use of potable water typically used by businesses and high-rise buildings for cooling their hot paved areas.
- As summer temperatures rise, the rate of ground level ozone formation, or smog, increases. By lowering temperatures, urban heat island strategies can help reduce ground-level ozone concentrations.

IMPLEMENTATION

Local governments can use publically available tools to evaluate the potential benefits of different heat island mitigation approaches, such as EPA's Mitigation Impact Screening Tool. Based on this information, communities can develop a comprehensive and interagency plan for implementation that may include:

- Urban forestry – Promoting urban forestry can increase shading; reduce stormwater volumes and pollutants through interception of a portion of the precipitation, evapotranspiration and infiltration; and improve water quality. Trees, shrubs and other vegetated areas can be designed to receive runoff from adjacent impervious areas such as roofs and parking lots. A systematic urban forestry master plan can be developed at the regional or local level, by undertaking an inventory of existing number and types of trees, associating existing stormwater impacted areas (flooding, stream bank erosion) and prioritizing the enhancement of tree canopies with the objective of reducing such impacts. The plan should include planting, protection, maintenance, and management of existing trees and other appropriate vegetation; encourage green (vegetated) roofs and walls and vegetated building terraces; and take into consideration the effect of future climate changes on the types of trees and vegetation that will be appropriate to plant.
- Procurement — Local governments can require cool technologies (e.g., reflective roofing and green roofs, pervious and light-colored pavement) for government buildings, roads and projects.
- Green building standards — Modified green building standards can support heat island

[35] http://edis.ifas.ufl.edu/pdffiles/FR/FR23900.pdf

reduction strategies, such as green roofing, preserving trees and vegetation, etc.

- Building codes —Local governments can include green and cool roofing in their building codes as voluntary energy savings measures even in locations where these cannot be mandated because of state preemptions.
- Community involvement – Stakeholders can be organized to work together on developing programs to implement heat island mitigation strategies, develop neighborhood programs for maintenance of projects, and implement volunteer programs.
- Improve street designs — Upgrade street standards to include strategies that minimize stormwater flows by diverting stormwater to irrigate street trees and landscaping, roadside infiltration beds and rain gardens.
- Maintenance plans – Develop a comprehensive inspection and maintenance program to ensure stormwater control strategies function as long as they were originally designed.

IMPLEMENTATION BEST PRACTICES

- Create awareness and education campaign.
- Develop an urban forestry master plan and prioritization process.
- Use evaluation tools to establish priorities .
- Include plan to measure benefits.
- Identify strategies to overcome institutional barriers.
- Include a range of voluntary and policy approaches.
- Include policy efforts that remove barriers and provide incentives as well as establishing minimum requirements.
- Coordinate strategies with air quality requirements and programs.
- Create partnerships with agencies or organizations focused on related issues such as air quality, urban forestry, energy efficiency, health care, green jobs, etc.
- Implement strategies on broadest level possible (I.e. city, regional, state).
- Develop voluntary programs such as Urban Forestry Programs, Demonstration projects, and Outreach and Education programs.
- Review case studies for pitfalls to avoid such as poor post-planting tree care.
- Use comprehensive plans to institute new and longer term strategies.
- Design communication tools such as a local website, a database, webcasts, and a list serve.
- Develop community grants to assist local communities in their programs for climate change initiatives.

MORE INFORMATION

EPA's *Reducing Urban Heat Islands: Compendium of Strategies*; Urban Heat island Webcasts; Mitigation Impact Screening Tool (MIST); *Excessive Heat Events Guidebook*; green roofs webpage

ICLEI's *Hot Cities = Dirty Air, Cool Cities = Clean Air* Fact Sheet

Lawrence Berkeley National Laboratory's Heat Island Group Resources

The Energy Star roof products and comparison calculator; information on tax credits for cool roofs

Center for Neighborhood Technology's *The Value of Green Infrastructure*; Green Values Stormwater Toolbox

Virginia's Department of Forestry webpage on rain gardens

Portland, Oregon's, fact sheet on pervious pavement

Green Roofs for Healthy Cities webpage

U.S. Forest Service's Urban and Community Forestry website

4-H Use Non-Structural Flood Mitigation Measures for Buildings in Floodprone Sites

DEFINITION

Structural flood mitigation measures keep floods away from people and property, while nonstructural measures keep people and damageable property away from the floods.[36] Non-structural approaches are aimed at reducing the impact or consequences of flooding by avoiding putting people or assets into areas that are likely to be flooded. Non-structural flood mitigation measures, while not aimed at altering the characteristics or probability of a flood, are a key component in overall flood risk reduction for a community.

These measures can reduce community susceptibility to floods through measures such as emergency preparedness, flood proofing, community education, and flood insurance, and by reducing hazardous uses of floodplains through land use and building codes, design and location of services and utilities, public acquisition, tax incentives, and modifications to regulatory and public policy, management practice, and pricing policy.[37]

Sustainable, flood aware land planning is the most promising strategy for successful flood risk management in the long run.

CLIMATE CONNECTION

Climate change and variability is creating unprecedented challenges for those tasked with managing risks from floods, as historical hydrologic patterns are no longer a basis for adequate planning. Broader and more holistic assessment and strategies are required to effectively address the range of impacts from increasing climate-related flood risks. While the focus historically has been on the hydraulic and engineering aspects of flood management, at-risk communities will benefit from including spatial, ecological, political and socio-economic aspects of risks and addressing these through comprehensive and multi-faceted planning processes.

Through climate modeling, climate vulnerability assessment and adaptation planning processes, more areas will be identified and designated as vulnerable to floods. Existing buildings in those areas will need to be assessed for risks as well. An integrated set of strategies are needed to deal with the range of conditions and needs to mitigate the risks to existing buildings to provide appropriate options to communities and building owners.

An assessment process is used to determine the appropriate integrated approach for risk reduction balancing and evaluating structural and non-structural approaches. In cases where it is determined that the risk to vulnerable buildings will not be sufficiently reduced by structural measures

ADAPTATION PLANNING STAGE

Intermediate

RELEVANT SECTORS

Land Use: Protects floodplains, ecosystems, and structures and can minimize risk through long-range projections and land use planning.

Transportation: Transportation planning can be a unique approach to reducing risk in less developed areas by discouraging development of high-risk areas.

Buildings: Most relevant sector. The building sector offers the most directly related opportunities to employ non-structural mitigation including wet and dry flood proofing of structures, building codes, flood insurance.

Water: Water management largely falls under structural mitigation but is nonetheless a critical element in adaptation.

RELEVANT HAZARDS

COMMUNITY CONTEXT

This approach can be used in all community contexts.

[36] www.corpsnedmanuals.us/FloodDamageReduction/FDRID094NonstrucFldDmgMeas.asp

[37] www.corpsnedmanuals.us/FloodDamageReduction/FDRID094NonstrucFldDmgMeas.asp

or are best mitigated by nonstructural measures, this wider set of options should be available to assist property owners in minimizing risk and losses. Communities can create implementation processes that tailor response actions to the specific characteristics of each at-risk property, with the ability to incorporate elements that reduce risks at the community scale.

Non-structural flood mitigation measures for water and sanitary structures and other critical public facilities can serve as invaluable demonstrations for community education.

LOCAL EXAMPLES

Prince George's County, MD, has a comprehensive flood plain management program incorporating non-structural approaches such as technical assistance, low cost flood insurance, public education, emergency management assistance, improved flood warning systems, research and development of new technologies, development review, floodplain regulation, and assessments of redevelopment and future land use impacts. While the program does not overtly state that it is addressing impacts from a changing climate, this is a set of approaches, which can be effective when combined with climate risk projections.

BENEFITS

Employing non-structural flood mitigation measures can have many benefits for communities including a broader reach of flood risk reduction, cost effectiveness, reduction of environmental damage, and reduction in flood insurance premiums as well as often being less disruptive to residents than structural approaches. A holistic and integrated approach that includes non-structural mitigation measures can also address and have benefits to community resiliency in terms of economics, business, health and security

IMPLEMENTATION

While most local governments are experienced with flood management, implementing climate responsive integrated plans or steps will likely require a shift to include more non-structural mitigation approaches, incorporate a broader range of considerations such as socioeconomic impacts of increased flooding, and need to coordinate with the most up to date climate vulnerability data.

Implementing non-structural mitigation efforts to flooding should be coordinated with structural mitigation efforts and with the widest set of departments, agencies, technical assistance, and stakeholders possible. Efforts must be coordinated across administrative and division boundaries.

Up to date and comprehensive flood risk assessment that incorporates climate change predictions and uncertainty should form the basis of prioritization and decision-making. Similarly, monitoring a community's efforts and regular evaluation enables the identification of best practices under the specific circumstances and encourage adaptive management in improving flood risk management plans.

Some methods of non-structural mitigation, particularly with modification of buildings will be limited by regulations in building codes, approval for flood insurance, or other limitations. Communities should examine whether these barriers are still valid under changing conditions.

IMPLEMENTATION BEST PRACTICES

- Involve cross-sector agencies and participants and all stakeholders in developing a non-structural flood risk plan
- Prioritize a regular schedule of comprehensive flood risk assessment which incorporates awareness of climate risk predictions
- Consider the application of adaptive management strategies to facilitate flood risk management
- Apply the precautionary principle in risk assessment and decision making
- Encourage the use of a broad range of measures and implement them in a coordinated way
- Include monitoring and evaluation of the plan and its measures to foster a feedback loop for adaptive management.

MORE INFORMATION

An excellent primer on integrated flood management, which includes a discussion of the paradigm shift towards more non-structural flood

mitigation is "Flood Management in a Changing Climate" published by the Associated Programme on Flood Management (APFM). While global in scope, it incorporates approaches such as adaptive management and the precautionary principle, and will serve local governments in designing implementation strategies that create the most resiliency and adaptability. APFM's resources include excellent articles on flood management in a changing climate, and urban flood risk management.

Local Flood Proofing Programs, a document published by the U.S. Army Corps of Engineers National Non-Structural Flood Proofing Committee, provides an excellent set of recommendations and examples for creating a community program and has a wealth of feedback from U.S. communities already implementing such programs. The Committee has a number of other relevant publications online.

Other relevant information sources include:

- Georgetown Climate Center's *Virginia Case Study: Stemming the Tide: How Local Governments Can Manage Rising Flood Risks*
- U.S. Army Corps of Engineers Flood Risk Management overview of non-structural flood damage reduction measures.
- FEMA's floodproofing information includes land management and use, and residential and non-residential guidance.
- The Precautionary Principle is an approach to risk assessment and gives a path to decision making when an activity raises threats of harm to human health or the environment. It provides a basis for taking precautionary measures even if some cause and effect relationships are not fully established scientifically.
- The Louisiana Cooperative Extension Service's The Louisiana Floods website offers an excellent resource for information on flooding and flood damage reduction planning.
- The Association of State Floodplain Managers is an organization of professionals involved in floodplain management, flood hazard mitigation, the National Flood Insurance Program, and flood preparedness, warning and recovery.
- NAFSMA - The National Association of Flood and Stormwater Management Agencies also offers resources for stormwater management.

4-I STREAMLINE THE RELOCATION PROCESS

DEFINITION

In response to climate change vulnerability assessments, local government may determine that it will be necessary to relocate people, structures, and businesses in order to ensure their safety. Where this occurs, the process can be expedited through the use of streamlined relocation processes targeted and providing quick and efficient review of zoning and building code issues. This may take the form of a coordinated package of relocation services and resources involving all relevant government agencies and levels at both the vacated and receiving locations.

CLIMATE CONNECTION

The impacts of climate change may dictate that some structures and neighborhoods will become sufficiently unsafe over time for continued use and habitation. This is most likely in communities that anticipate sea-level rise, increased storm events and flooding, and increased risk of wildfire. Many of these communities will have already dealt with the impacts of flood or fire but allowed reconstruction on the original site. The increased possibility of these events triggered by climate change may tip the cost-benefit balance toward relocation rather than reconstruction or may result from changes in FEMA or national flood insurance program maps or requirements.

To encourage relocation as a high-priority goal for the community, local government should make changes to building, zoning, and subdivision regulations that encourage relocation, incorporate relocation across a number of development decisions, and make it easier to achieve.

LOCAL EXAMPLES

There are no known examples of communities that have streamlined the relocation process for climate change adaptation purposes.

BENEFITS

Establishing a streamlined relocation process will allow local governments to substantially advance the process of moving people and structures to safer locations prior to an extreme weather event, fire, or sea-level rise caused by climate change, with all the associated avoided costs of such disasters.

Approaching relocation in an anticipatory manner with the goal of streamlining the necessary approvals and construction will permit more detailed planning to identify the most vulnerable areas of the community as well as targeting those buildable areas best-suited to absorb new development, potentially at a higher density. Additionally, local government will be able to address some or all of the costs of relocation over a longer period of time. This will allow for identification of necessary changes to infrastructure priorities through the normal capital improvements process. The work done to develop a more broadly integrated, anticipatory, and streamlined approvals process for climate-related relocation can improve the approvals processes and their outcomes for all building and development, saving time, money and improving the resiliency of the entire community.

Many of the zoning and subdivision changes recommended in this section will require amending existing regulations through the appropriate drafting and public review process. The benefit of creating a

ADAPTATION PLANNING STAGE

Intermediate

RELEVANT SECTORS

Land Use: Procedures and development standards can be adjusted to relocate development out of vulnerable areas.

Buildings: Most relevant sector. This applies directly to buildings identified through climate vulnerability assessments as being located in areas with risks significant enough to require the relocation of the buildings, people and businesses or uses of those buildings.

Water: Areas subject to water inundation can be identified as sites from which people and structures will be relocated.

RELEVANT HAZARDS

COMMUNITY CONTEXT

The need for streamlined relocation processes applies in all community contexts where land use regulations and building codes are in use.

streamlined relocation process is that local government is telegraphing the importance of this choice to residents and these amendments will involve a public discussion prior to adoption.

IMPLEMENTATION

Once a vulnerability assessment process has determined that people, buildings, and or businesses will need to relocate from vulnerable developed areas, a process is needed to assess and respond to the issues entailed in relocation, whether achieved voluntarily or as a result of a regulatory requirement. Relocation is complicated by the need to address circumstances at both the vacated and receiving location. It is in the interest of all concerned to facilitate and streamline this process.

Among the most effective options local government has is to package relevant government services and streamline approvals processes to remove inter- and intra-departmental or jurisdictional conflicts and delays while insuring that the process incorporates short and long term community goals. This may entail the adoption of new policies, requirements, and incentives, as well as providing general and technical support as part of a comprehensive strategy. The aim should be both easing the challenges associated with relocation and insuring that all resulting new construction and development that results from the process increases community resilience, not vulnerability.

Approaches to streamlining the relocation process can be grouped into three categories: 1) changes that save time and money, 2) changes to standards that make the redevelopment in less vulnerable locations both easier and ensure that they are more resilient, and 3) creative approaches that encourage development innovation.

Category 1, changes that save time and money, could range from:

- Establishing a priority permitting process for development projects that include relocation (e.g., shorten the average six-month permitting process to a two-month process) through systematic coordination among approving entities, or alternatively establishing a “relocation permit” that has a fast turn-around and requires priority review from all applicable local government departments such as planning, building, public works, water and wastewater, and transportation.
- Allowing reduction or waiver of application fees.
- Setting priorities for public-sector funding or construction of project infrastructure such as roads or sewer prorated to reflect the amount of relocation provided or provision of a transit station where possible to increase the value of project development.
- Establishing a tax increment financing district, business improvement district, or alternative funding source on the proposed redevelopment site to reduce property, housing, or structure costs to relocated residents and businesses.

Category 2, changes to standards that make redevelopment easier, might include:

- Allowing more compact development and increased density for projects that include sites for relocated structures and/or infrastructure. This may require waivers to landscaping and open space requirements along with alternative setback and height (dimensional) standards.
- Establishing alternative minimum parking requirements for businesses that relocate from vulnerable areas to buildable areas.
- Creating a relocation zone district that allows by-right development of small lots, mix of development density, accessory dwelling units, and has priority development approval processing.
- Authorizing the building department to use more flexible, performance-based review process to enable more innovative and climate responsive designs to be cost-effectively used. This can be achieved by either changing code provisions or allowing reviews incorporating emerging categories of risk to be included when determining whether proposed alternative designs are "as safe and effective" as current practice.

Category 3, creative approaches that encourage development innovation, could include:

- Establishing a process to develop non-contiguous PUDs that link the vulnerable areas subject to relocation with the buildable area. A PUD would allow the vulnerable area to be used to meet open space/park dedication requirements while

increasing the density in the buildable areas. This approach is currently used by Boulder County, Colorado to protect environmentally sensitive areas.

- Allow projects to comprehensively integrate responses to categories of risk tied to climate change across traditional regulatory boundaries (such as land use, building safety, water, wastewater, stormwater, and transportation) and other necessary approvals through a comprehensive permitting process that allows integrated solutions to be approved at least as easily and quickly as standard projects.

Enabling more innovative and broadly responsive solutions and projects should be an essential aspect of processes addressing emerging risks. The ongoing climate adaptation planning process should include regular periodic assessment of all current codes, standards, policies, and approvals processes involved in relocation. When carried out in the context of enabling the most effective responses to climate risks using a multi-disciplinary process that engages all relevant agencies and levels of government with stakeholders, the benefits will be broader than just those related to relocation.

IMPLEMENTATION BEST PRACTICES

- As part of the climate action planning process, create a process to regularly review and assess all relevant building and zoning requirements and policies affecting climate-related relocations specifically within the context of increasing levels and types of climate-related risk. This can be part of the regular periodic updating of codes and standards that most communities already do, but requires explicit focus on changing risk assumptions not typically part of the code development, review, or adoption process.
- Develop innovative policies to enable innovative solutions to changing patterns and levels of risk. This requires risk-balancing and comparative risk analysis that has not traditionally been part of the process. Those in the approvals process need clear signals that they have the authority to consider a broader array of risks and collaborate with other regulatory authorities outside the usual scope of concern or authority to be able to address risks that cross traditional regulatory boundaries.
- Consider strategies such as allowing the newly created open space on vacated sites to count toward open-space requirements at relocation development sites.

MORE INFORMATION

The Delaware River Basin Commission Floodplain Regulation Evaluation Subcommittee produced a study of a variety of approaches to creating more effective floodplain regulations, including providing incentives to relocate structures.

Boulder County, Colorado Non-contiguous PUD Regulations. Boulder County, Colorado, Land Use Code, Section 6-500.

The September 2011 Massachusetts Climate Adaptation Report is a comprehensive resource for current assessment, planning, adaptation and mitigation strategies including recommendations related to land use and building codes.

The New York State Energy Research and Development Authority (NYSERDA) report *Response to Climate Change in New York State (ClimAID)* includes discussion of adaptation strategies for both technical and non-technical approaches.

One aspect of relocation response is reflected in King County Washington's Flood Buyout Program.

4-J Establish Fund to Relocate People and Assets from Vulnerable Areas

DEFINITION

Communities can establish a relocation fund to assist residents and property owners to move structures and infrastructure to less vulnerable areas where existing or previous policies and regulations have permitted construction in vulnerable areas.

CLIMATE CONNECTION

Although it is an incredibly difficult decision to relocate existing residents and businesses from any neighborhood, in extreme cases, it may be in the best interests of the community and its residents to reduce the number of people or structures located in vulnerable areas. This is certainly true where the potential for storm or fire impacts is imminent, unpredictable, and the likelihood of harm to the public is great. Where it will be difficult to safely rescue people during a storm event or where allowing people to return home following water or fire destruction is unsafe, anticipatory relocation may be the best option.

Approached from a long-term investment perspective, anticipatory relocation is also a good investment for local government where the cost and impact of road, sewer, and other infrastructure repair following a damaging event or erosion will be significantly more expensive than undertaking a program to relocate facilities and services prior to encountering problems. A proactive relocation program also allows local government the time to undertake the necessary due diligence to identify buildable areas where people and infrastructure should be moved and to properly procure design and construction services at a reasonable cost.

Depending on the projected climate changes for a region or community, and to prepare conservatively for those changes, communities may want to establish a dedicated fund to help cover or defray costs over an extended period of time. A local relocation fund can be targeted to the specific climate changes anticipated in the region. For example, coastal communities may want to establish a road relocation fund that will be used to build new roads outside of sea-level rise areas as well as areas subject to hurricane flooding inundation. Fire-prone areas may want to consider underwriting the costs of moving structures, providing safe access, or purchasing homes in buildable areas to "trade" for homes in the wildland-urban interface.

ADAPTATION PLANNING STAGE

Advanced

RELEVANT SECTORS

Land Use: Most relevant sector. Can be used to start or speed-up relocation from vulnerable areas.

Water: May be used to move people and infrastructure out of potential flooding areas.

Transportation: Could be used to provide funding beyond typical capital improvement plan allocations to relocate roads and bridges.

Buildings: Funds may be used to move families and businesses from structures in vulnerable areas into more appropriate locations.

RELEVANT HAZARDS

COMMUNITY CONTEXT

Rural funding may be most effective when partnered with state/federal funds and when used in conjunction with municipal funds for vulnerable areas that cross jurisdictions.

Suburban areas may be able to link relocation funding to the provision of vulnerable areas as community open spaces as provided in community comprehensive, open space, and recreation plans.

Urban areas can use relocation funding as part of an entire toolbox of approaches to change density patterns and protect vulnerable areas.

LOCAL EXAMPLES

Disaster resistance planning provides a roadmap for the use of relocation planning for climate vulnerable areas. Napa County, California, voted for a ½ cent sales tax over a twenty-year period to pay the local share of federal flood project that will result in the purchase of 350 properties.

BENEFITS

- Establishing a fund to relocate people and assets from vulnerable areas will encourage this process to take place more quickly than it would otherwise happen.
- Funding can be targeted to the most sensitive vulnerable areas to establish priority relocation areas.
- Infrastructure can be moved/replaced in an orderly but expedited manner that allows for normal design and bidding processes and does not wait for emergency relocation caused by a disaster.
- In addition to paying for relocation , funding can be used to cover site development costs in non-vulnerable areas to encourage new development in growth areas.

IMPLEMENTATION

Local jurisdictions should be prepared to make strong case for anticipatory relocation where it will have an impact on local budgets and available funds. Communities considering this approach should first prepare a relocation assessment to identify: 1) the range of uses, services, and facilities eligible for funding: 2) priorities for protecting vulnerable areas; 3) potential impacts of the anticipated "event," e.g., hurricane, fire, flooding, to both people and structures; and 4) the potential total funding created by each available source. Communities should also prepare a cost-benefit analysis for structures and infrastructure that compares: 1) anticipatory relocation, 2) post-impact relocation, and, where applicable 3) status quo with no further action needed for the damaged service or infrastructure (e.g., a utility substation that will not be replaced). Where residents are going to be relocated, the community will want to host a comprehensive community outreach program to determine resident's concerns and preferences. Based on this, the community can make a determination about the best and most effective source of funding and undertake to adopt/elect that method.

For a relocation fund to be successful, it must be backed by a long-term, reliable funding source such as a dedicated sales tax. Additional available funding sources may include: annual appropriations from the general fund; bond issuance; and potentially, where the funding will be used to relocate infrastructure, a tap fee or utility fee. Where the vulnerable areas will eventually be converted to natural or open spaces, funding may also be available from foundations, nonprofit land preservation organizations, or federal government grants.

In addition to local funding, there may be opportunities to leverage federal assistance, such as that provided by the FEMA Pre-Disaster Mitigation Grant program (authorized by the Stafford Act) and the CDBG program.

The funds collected as part of the relocation fund can be provided directly to recipients as grants or could be used to underwrite low interest loans.

IMPLEMENTATION BEST PRACTICES

- Identify vulnerable areas in a mapped format for the purposes of public discussion in both the preparation of the relocation assessment report and the fund adoption education program.
- Determine the measurable benefits to the community of adopting the relocation fund and make that information available to the public.
- Identify local partners apart from government officials who can help "champion" the program. Adopting a long-term funding source may require both educational outreach and a supportive advertising campaign.
- Conduct community outreach early and often to educate affected residents, understand and respond to their concerns, and develop an effective relocation strategy.

MORE INFORMATION

The Environmental Finance Center at the University of Maryland anticipates that a stormwater utility fee, which might partially be used to fund relocation, would capture $500,000 to $10 million per county per year, and approximately $70 million statewide per year. This assumes $20 per year per residential unit, and no charges for undeveloped, tax exempt, and agricultural lands.

For information about floodplain relocation programs, see the Association of State Floodplain

Managers, *Mitigation Success Stories in the United States* (Jan. 2002).

FEMA Pre-Disaster Mitigation Grant Program, §203 Robert T. Stafford Disaster Relief and Emergency Assistance Act, 42 U.S.C. § §5121-5206 (Stafford Act)

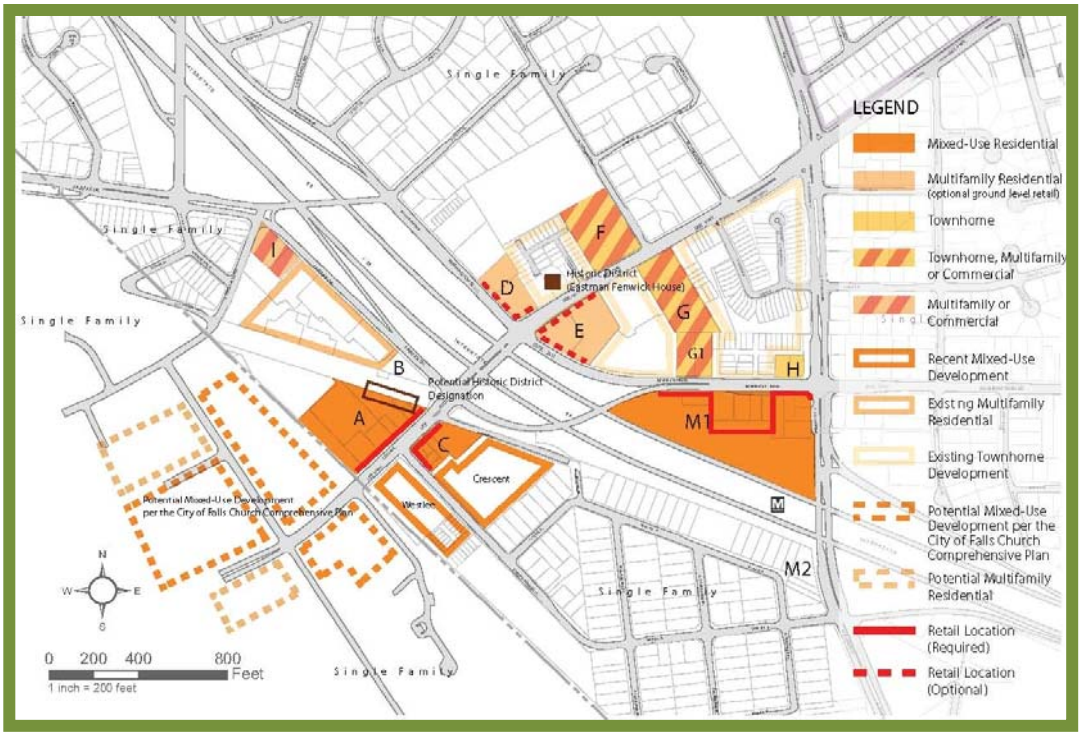
5 ENCOURAGE SUSTAINABLE DEVELOPMENT IN APPROPRIATE, LESS-VULNERABLE AREAS

The projected impacts from climate change are uncertain. Most communities do not know exactly where or when they will experience flooding or changes in temperature. However, even with limited data, local governments can begin to identify areas that are expected to be less vulnerable to climate related impacts and encourage sustainable development in those areas.

By encouraging sustianable development (in the form of smart growth and green building approaches), local governments will be equipped to accommodate population growth; improve air quality through reduced greenhouse gas emissions from reduced household and transportation energy use; improve water quality through improved stormwater management; and foster vibrant communities with a mix of uses, tax sources, and incomes. By doing so in less-vulnerable areas, local governments will improve quality of life for local residents; reduce long term costs associated with responding to climate change impacts; and increase their community's resiliency, or ability to adapt to climate changes.

As a first step, communities should complete a robust vulnerability planning process to identify specific geographic areas that are likely to be less vulnerable to impacts from a changing climate. Once the "less-vulnerable areas" are identified, local governments can align less-vulnerable areas against areas currently being prioritized for future development, and determine whether any changes are required in planning for future development. Next, communities can review and select from the following approaches to identify those that are most appropriate to encourage sustainable development.

Image Source: www.arlingtonva.us/departments/CPHD/forums/page79636.aspx



East Falls Church Area Plan (Draft) for enhanced transit oriented development.

5-A Promote Smart Growth

DEFINITION

The built environment—the places where we live, work, shop, and play—has both direct and indirect effects on the natural environment. Separating land uses, spreading development out, and providing little or no public transportation or safe walking and biking routes foster greater reliance on motor vehicles.

Smart growth practices can lessen the environmental impacts of development with techniques that include compact development, reduced impervious surfaces and improved water detention, safeguarding of environmentally sensitive areas, mixing of land uses (e.g., homes, offices, and shops), transit accessibility, and better pedestrian and bicycle amenities.[38]

Smart growth is widely understood to embrace principles ranging from compact, mixed-use development to protecting open space to promoting mobility and housing.

CLIMATE CONNECTION

Zoning tools that support smart growth can also be important elements in local government efforts to implement climate adaptation plans. With regard to climate adaptation, the link with compact, mixed-use development and transit-oriented development is particularly relevant. Encouraging more compact, mixed-use and transit-oriented development in less vulnerable areas helps move more people out of harm's way. Mixed-use infill development can also help reduce the amount of new infrastructure required to support growth, especially in vulnerable areas where transportation and other infrastructure may be exposed to climate change impacts such as violent storms and flooding.

As development is restricted in vulnerable areas, local governments will need to consider the most appropriate location for new growth in their jurisdictions. And because there will be less total land area available for development, they will also need to consider how additional population and density can be accommodated in preferred growth areas less likely to be affected by climate change. In effect, local governments will be looking to promote more compact, higher density developments in such areas. Mixed-use and transit oriented developments are proven smart growth tools that can also have positive climate adaptation impacts by promoting higher density development in safer areas. By providing alternative locations for homes and businesses not able to be constructed in vulnerable areas, mixed-use projects help offset any density losses the jurisdiction might face.

Moreover, one of the most obvious and daunting realities inherent in preparing for transportation-related impacts from climate change is that maintaining current levels of access and mobility by retrofitting, relocating, or making-redundant key transportation assets will be extremely expensive. Having to retrofit,

ADAPTATION PLANNING STAGE

Beginner

RELEVANT SECTORS

Land Use: Most relevant sector. Historic pattern of developing most new destinations within single-use clusters, beyond the reach of existing populations and infrastructure would be replaced by an emphasis on infill and "complete community" development patterns.

Water: Protects critical open space areas to absorb rainfall. Although not a major issue in the metropolitan Washington region, can be used to protect aquifer recharge areas.

Transportation: Would shift emphasis away from major roadway infrastructure serving low-density communities, to multi-modal networks serving high-density nodes.

Buildings: Tools and incentives would make building near existing, multi-modal assets the most profitable, least complicated option.

RELEVANT HAZARDS



COMMUNITY CONTEXT

Would make costs of maintaining and adapting rural transportation infrastructure, as well as the mechanisms by which those costs are subsidized, more apparent.

In urban and suburban areas, this approach would make clear the costs/ benefits of infill versus greenfield, and low-density versus high-density development.

[38] For more information, please refer to EPA's Smart Growth website.

move, or replicate these investments will be well beyond the economic resources of many communities and jurisdictions. Maximizing the level of access and mobility that can be attained from each dollar of infrastructure investment, by shifting growth closer to existing investments and creating use-mixes that make walking, cycling, and transit more viable, will be a key strategy for keeping adaptation economically feasible.

LOCAL EXAMPLES

Local jurisdictions across the region have adopted smart growth and transit oriented development zoning tools and incentives. Some of the most successful are:

- Arlington County's Site Plan Approvals process provides significant density bonuses for developing within Metrorail corridors.
- Montgomery County's Parking Lot District program eliminates parking requirements for developments that help fund shared, public facilities within mixed-use urban centers.

BENEFITS

Smart growth zoning code provisions and incentives that promote mixed-use TOD developments and infill projects reduce the vulnerability of local economies to disruptions within regional transportation networks. Increasing the number of people who live within walking, cycling, or transit distance of daily goods, services, and jobs will reduce stress on regional roads and transit networks during service impacts and significantly increase the quality of life for residents that are not stuck in multi-hour weather-induced traffic jams.

Successful mixed-use and TOD projects have positive local economic benefits (increasing land values, economic activity, and tax bases). Smart growth is also linked with improved water and air quality, a reduction in greenhouse gas emissions, and preservation of critical natural lands.

IMPLEMENTATION

Local governments can choose among a variety of implementation steps, including:

- Identifying and rezoning activity centers where mixed-use development will be permitted and promoted.
- Removing zoning barriers to mixed-use and infill development by tailoring parking, landscaping, and open space regulations for more urban projects versus suburban-oriented standards.
- Creating transit oriented development zoning districts (where transit service is provided), within which development will be encouraged through higher permitted densities and heights and development potential maintained through minimum density requirements, ;
- Creating by-right mixed-use zones in which the combination of commercial and residential uses is allowed without any special hearings or lengthy review processes.
- Retrofitting aging strip malls and commercial centers to become mixed use centers.
- Using form based codes, which rely on physical form rather than type of use as the organizing principle.

IMPLEMENTATION BEST PRACTICES

- Take advantage of market forces such as developers' economic self-interest to maximize density and minimize on-site parking in high-demand, multi-modal areas. This creates an opportunity to shift development toward areas where these market forces support smart growth — and let these market forces fund adaptation.
- Lead the way by developing new government services and jobs in residential areas.

MORE INFORMATION

EPA's *Essential Smart Growth Fixes for Urban and Suburban Zoning Codes* provides 11 "essential fixes" to help local governments amend their codes and ordinances to promote more sustainable communities.

EPA's *Restructuring the Commercial Strip: A Practical Guide for Planning the Revitalization of Deteriorating Strip Corridors*

EPA's Smart Growth Resources

Form Based Code Institute resources

Center for Transit Oriented Development resources

Mixed-Income Transit-Oriented Development Action Guide

5-B Promote Infill Development

DEFINITION

Infill development is the carefully planned, compatible use or reuse of property located in already developed areas. This may take the form of reuse and/or redevelopment of underutilized or vacant property, revitalization of brownfields, adaptive reuse of abandoned structures, or higher density development at an existing site. Many

CLIMATE CONNECTION

Long-term community resiliency to climate change will require local governments to foster the development and enhancement of vibrant neighborhoods in less-vulnerable areas. In communities where existing neighborhoods are already located in less-vulnerable areas, it will be critical to make these areas as strong as possible, to continue to attract future development and enhance the community's well-being. If there are properties that are underutilized, vacant, or otherwise not contributing to the vibrancy of the neighborhood, compatible infill can fill these gaps. Through careful planning, local governments can ensure that infill projects also meet critical community needs (e.g., job creation, locally serving retail, affordable housing).

In addition to strengthening neighborhoods in less vulnerable areas to enhance resiliency, infill development is a recognized approach for climate change mitigation. When a well-planned infill project is constructed in lieu of a greenfield development project, greenhouse gas emissions associated with transportation can be reduced due to the infill project's improved location efficiency and a reduction in vehicle miles traveled. For example, Eugene Oregon, encourages infill to meet community greenhouse gas emission goals.

LOCAL EXAMPLES

- The Rosslyn-Ballston metro corridor in Arlington, Virginia, is a national example of how infill development concentrated at transit stations can strengthen neighborhoods, improve economic and fiscal performance, and reduce vehicle miles traveled. Although this area was not planned explicitly to be resilient to climate change, the county's zoning and site planning process has effectively encouraged significant amount of infill over the last 30 years.
- Montgomery County, Maryland, has prioritized infill development as a means of accommodating projected population growth.

ADAPTATION PLANNING STAGE

Intermediate

RELEVANT SECTORS

Land Use: Most relevant sector. Maximizes infrastructure investments by revitalizing underutilized property in areas with infrastructure access.

Water: Minimizes impacts from flooding by encouraging reuse of property in less-vulnerable areas.

Transportation: Increases efficiency of the transportation sector by aligning land use and future population growth with areas that already have access to transportation infrastructure.

Buildings: Infill and reuse of vacant properties raises the value of surrounding properties and preserves the fabric and character of the existing neighborhood.

RELEVANT HAZARDS

COMMUNITY CONTEXT

Infill, vacant property reuse and adaptive reuse are fundamental aspects of sustainable community development that should be encouraged in all community contexts. In rural communities, it may be more difficult to address and reuse infill sites unless there is strong market demand for a property's reuse. However, in rural town centers, this can be an essential strategy to maintain economic vitality and have a greater positive fiscal impact due to the cost savings from infrastructure reuse. In urban and suburban areas there may only be a small percentage of developable land remaining, emphasizing the need for sustainable infill planning.

BENEFITS

Infill development is a strategic tool to promote sustainable community development because it can preserve the fabric and characteristics of the existing neighborhood, can be an effective tool to discourage development on greenfields, and makes better use of existing infrastructure rather than requiring the development of new infrastructure, including roads, transit, and water and sewer lines. Infill development

can strengthen property values and restore vibrancy to declining communities, by improving access to needed services, jobs, and affordable housing.

IMPLEMENTATION

The first step to implement an effective infill development program to increase climate resiliency is to review the results of the vulnerability assessment to identify less-vulnerable areas that will be prioritized for development. This step can be done in coordination or partnership with neighborhood organizations and community development corporations, local residents and property owners, realtors, and developers.

The list of areas where infill is desired should then be prioritized based on community-specific criteria. Within the highest priority areas, local governments should develop an inventory of vacant, abandoned or underutilized properties, using desktop data and windshield surveys. For each site, information on site size and configuration, current ownership, tax status, current zoning, soils, floodplains, wetlands, public infrastructure (availability and condition), potential contamination, and site access should be collected. Sites that are located near existing infrastructure, particularly transit locations, should be highlighted. This data can be easily analyzed when mapped using a geographic information system, which can help identify opportunities for consolidating multiple parcels and areas with high vacancy.

In addition to the quantitative site characteristics, consideration should be given to qualitative characteristics such as local market dynamics, character of the neighborhood or block, area vacancy rate, nearby amenities, and community needs. With this information, communities can then develop concepts for redevelopment of the infill sites, based on community- or government-driven preferences.

Local government should also consider potential barriers to redevelopment of the infill sites, such as lack of developer interest, cost of development, community concerns, and regulatory barriers. In addition, local government should consider ownership of key sites, and the potential for local government acquisition.

For each priority area, a detailed infill development strategy should be developed to identify specific reuse preferences, potential barriers to development, and approaches that should be used to facilitate reuse. There are dozens of approaches that can be used to incentivize infill development, some of which are listed below. Communities will need to select the most appropriate approach depending on their unique conditions.

- Offering a density bonuses in priority infill areas
- Providing brownfield redevelopment financial incentives
- Developing a local land bank to manage property acquisition and disposition through the tax foreclosure process, voluntary conveyance, purchase, or eminent domain (note: state legislation may be required to establish a land bank)
- In areas with high vacancy rates, launching a vacant property reuse campaign
- Reducing barriers to reuse of abandoned properties by streamlining the tax foreclosure process and allowing properties to leave foreclosure with a clear, marketable title
- Creating infill overlay zones or special zoning
- Conducting outreach to developers
- Providing infrastructure upgrades
- Reducing development costs (e.g., land write-downs, provision of infrastructure upgrades, loan guarantees, tax abatement)
- Implementing interim uses

The comprehensive plan should be updated to reflect the infill redevelopment plan priorities.

IMPLEMENTATION BEST PRACTICES

- Prioritize areas for infill development in less-vulnerable areas.
- Develop infill site inventory for each priority area, capturing quantitative and qualitative characteristics of each site.
- Develop tailored redevelopment plan for infill sites in priority areas.
- Update the comprehensive plan to reflect infill development priorities.

MORE INFORMATION

Municipal Research Services Center of Washington's Infill Development: Completing the Community Fabric resources

Maryland Department of Planning's *Models and Guidelines for Infill Development*

National Vacant Properties Campaign

EPA's Brownfields Program resources

Urban Land Institute's *Barriers and Solutions to Land Assembly for Infill Development*

Oregon Transportation and Growth Management Program, *Redevelopment Code Handbook*

Massachusetts Pioneer Valley Planning Commission *Model Infill Development Overlay District Bylaw*

5-C Remove Roadblocks to Development in Appropriate Areas

DEFINITION

While most communities seek to ensure development is appropriate through zoning and subdivision regulations, these regulations can sometimes serve as unintended roadblocks to appropriate development. "Appropriate development" in this context means development that is: properly located (outside of vulnerable areas), sustainable (in terms of resource consumption), and protective of resources (e.g., clean air and water, open spaces, alternative energy sources, discretionary time, etc.). Examples of regulatory roadblocks include:

- Prohibitions on higher density, mixed-use developments;
- Requirements for suburban-level parking and landscaping applied to infill and redevelopment projects in urban areas;
- Limitations on porous or permeable paving;
- Open space requirements that do not include credit for floodplains, wetlands, or unbuildable areas;
- Inflexible yard and setback encroachment provisions that prohibit any construction in required yards or setbacks; and
- Complicated permitting procedures in less vulnerable infill and redevelopment areas.

Modern development codes are incorporating various flexibility and "safety valve" provisions to minimize the impacts of these unintended consequences. For example, administrative adjustments are minor deviations from dimensional requirements (e.g., reducing yard requirements or allowing fewer parking spaces) that can be approved administratively. Procedures for alternative or equivalent compliance allow development applicants to deviate from general requirements through administrative review and approval of a detailed alternative plan, subject to specific criteria. For example, an applicant could be allowed to substitute a development plan that protects an entire beach front for a required open space dedication. This type of modification could be used to encourage site design that protects vulnerable areas. Incentives like density bonuses or height increases can be used to encourage developers to undertake higher density, compact projects. Zoning district standards can be revised or new districts created that allow use-mixing by right instead of through a process that requires extensive review and local government app.

ADAPTATION PLANNING STAGE

Intermediate

RELEVANT SECTORS

Land Use: Most relevant sector. Making changes that encourage development in appropriate areas can relieve development pressure in vulnerable areas.

Water: Indirectly applicable to the protection of sensitive riparian areas by relocating development elsewhere.

Transportation: Transportation funding and development can be directed to buildable areas.

Buildings: Vulnerable areas will be protected from inappropriate construction.

RELEVANT HAZARDS

COMMUNITY CONTEXT

This approach is useful in all community contexts where land use regulations are used.

CLIMATE CONNECTION

Flexibility and safety valve provisions like administrative adjustments, alternative equivalent compliance, and incentives for appropriate development are useful in helping to promote climate adaption. Administrative adjustment provisions can be used to allow for development to encroach into a required yard or setback on one side of a lot in order to retain a mature tree, avoid a sensitive area on the other side of a lot, or a home in a special flood hazard area could be allowed to exceed a maximum height limit by up to 15 percent to ensure living space is elevated above base flood elevation.

Permeable (or porous) pavement could be used for sidewalks and parking areas, along with stormwater

infiltration in landscaped areas to allow a retail development to meet the permitted square footage while decreasing the overall impervious footprint of the site.

Incentives such as additional density or building height might be included to promote green roofs and rain water harvesting devices that can significantly reduce stormwater runoff from a site.

Modifications to zoning district provisions that allow for greater use-mixing (either residential/ nonresidential or mixing of single-family and multi-family residential) by right foster higher density development in preferred locations thus reducing some pressure for development in vulnerable areas. They also help to reduce carbon emissions and transportation infrastructure costs by clustering development.

LOCAL EXAMPLES

Portsmouth, Virginia, is one community that has incorporated all these concepts into its new zoning ordinance. The procedures in Portsmouth's zoning ordinance allow administrative review and approval of requests for minor deviations from any numeric or dimensional standard in the ordinance by up to 15 percent. The code includes a variety of alternative equivalent compliance mechanisms such as alternative parking plans, alternative landscaping plans, security plan exemptions (from various fencing and lighting standards), as well as compensating public benefits provisions that allow applicants to seek a waiver from one or more code requirements (such as required design standards) through provision of some other form of compensating public benefit (such as provision of extra open space, landscaping, or public gathering areas beyond required minimums).

Almost every zoning district in the city's new zoning ordinance allows use-mixing by right, and some zoning districts even require mixed-use development. Finally, the code includes a voluntary density bonus system that allows additional residential density, additional building height beyond the maximum, reduced parking requirements, and even increased lot coverage through provision of various sustainable development features such as LEED certification, green roofs, recycled building materials, or other elements.

The City of Falls Church, Virginia, is considering similar provisions, included a blended approach that requires inclusion of sustainable development features with density or height incentives for the provision of sustainable features beyond the minimum required.

The Silver Spring, Maryland, "Green Tape Zone" is a downtown redevelopment area where Montgomery County and private developers targeted four square blocks for redevelopment around a Metrorail transit station. The county department of permitting services created a Green Tape review team to provide priority review to development applications from the project area – typically issuing permits within a two-week timeframe. The initial $400 million town center project leveraged $1.37 billion in private investment from the construction of residences, office space, and retail.

BENEFITS

Removal of roadblocks to appropriate development helps to:

- Make development regulations more flexible;
- Make site design that includes vulnerable area protection the easier and more quickly approved form of development instead of the more difficult; and
- Establish policy priorities, particularly on sites with significant vulnerability or natural resources to be protected.

IMPLEMENTATION

The regulatory tools described in this section are most effective when local plans and land use regulations direct development into buildable areas. The first step in this implementation process should be a review of the comprehensive plan and land development regulations to ensure that they clearly identify and encourage development in buildable area while also identifying and protecting vulnerable areas. The effective removal of other roadblocks found in the land development regulations then depends, in part, on the community's comfort level with administrative/staff- decision making to allow minor modifications and alternative approvals. Full

implementation depends as well as the level of community support for sustainable development incentives.

Initial implementation steps could include incorporating administrative adjustment procedures for modifications to some dimensional standards such as setbacks or yard requirements.

Other, more ambitious measures might that might be considered include modifying zoning district provisions to allow more use-mixing in key areas already well-supported by infrastructure and public investment and out of harm's way or tailoring development standards for urban areas, including allowing closer building spacing, the use of structural screens instead of landscaped buffers, reduced parking requirements, substitution of streetscaping (plazas, benches, pedestrian-scale lamps, art, water features) for required open space.

IMPLEMENTATION BEST PRACTICES

- Establish clear approval criteria for all administrative waivers, adjustments, and means of alternative compliance so that outcomes are predictable.
- Ensure approval criteria are measurable and objective.
- Incorporate standards that protect local character and adjoining neighborhoods from potentially incompatible mixed-use development.
- Provide menus of climate adaption features to help make these incentives practical .

MORE INFORMATION

Portsmouth, Virginia, Zoning Ordinance

Silver Spring, Maryland, "Green Tape Zone"

5-D Adopt Complete Streets Design Standards

DEFINITION

The dominant approach to street network design for the last 60+ years has focused on maximizing the throughput of vehicles. This has resulted in the widespread use of street hierarchies, where smaller streets feed into increasingly larger collector and arterial streets. If a route becomes blocked, significant traffic congestion can result because there are few alternate routes with similar capacity. Most of these roads are also designed to exclude cycling and walking, to maximize the use of automobiles.

The complete streets concept offers a different approach, where the streets are designed for multiple users and can safely accommodate pedestrians, bicycles, transit, and automobiles. In meeting the needs of these different users, complete streets are typically designed for areas with a finer-grained road system that allows for better connectivity through a higher number of intersections per square mile and smaller block size. The scale of a complete street system is much more person-oriented than car-oriented.

Complete streets can also enhance the market appeal of smart growth by ensuring that more compact, transit-accessible neighborhoods include by walkable, bike-friendly local roads. This concept is gaining significant traction across the country for the many mobility and community-development benefits it offers compared to hierarchical road design.

ADAPTATION PLANNING STAGE

Intermediate

RELEVANT SECTORS

Land Use: Makes mixed-use development more viable by expanding safe, comfortable means of access by local community. Reduces cost of providing sufficient parking at new development by improving pedestrian, bicycle, and transit accessibility.

Water: By incorporating green-streets technology, Complete Streets standards can reduce runoff impacts from urban development.

Transportation: Most relevant sector. Creates modal redundancies for accessing local goods, services, jobs, and recreation, reducing exposure to service disruptions within particular mode networks.

Buildings: Increased accessibility reduces the amount of lot space dedicated to parking, providing more footprint for building or green uses.

RELEVANT HAZARDS



COMMUNITY CONTEXT

Less relevant in rural areas. The impact of distances between uses in these areas will likely outweigh those from street design changes in terms of creating meaningful modal choices for rural travelers.

In urban and suburban areas, effective complete streets implementation will reinforce the benefits of living and working in more compact, mixed-use areas, as the benefits of resiliency in the face of network disruptions and fuel cost volatility become more readily apparent.

CLIMATE CONNECTION

Creating redundancies within hierarchical regional networks can be extremely expensive, and often unrealistic in the face of significant maintenance costs on existing roads, bridges, and tunnels and constrained public budgets. Hierarchical transportation systems reinforce local and regional vulnerability to single points of disruption within regional highways (i.e., flooded roadways resulting from increased precipitation or severe storms).

Complete streets design, including a focus on increasing connectivity within local and regional street networks, can increase the level of mobility and access resiliency in the event of regional network disruptions. Through increased connectivity, the road network provides a wider array of alternative routes that can be used in instances of flooding. Complete streets also create another form of redundancy by expanding the range of viable mode options for many trips, including those made to access daily jobs, goods, and services.

As a proxy for evaluating the use of transportation systems in response to climate changes, the importance of multimodal street design on transportation resiliency is reinforced by observations made among different types of built neighborhood environments during recent gasoline price spikes.[39] In

[39] Condon, P., Seven Rules for Sustainable Communities: Design Strategies for the Post-Carbon World. Island Press, 2010, page 63.

more walkable, transit-served neighborhoods, the response was primarily to reduce car use (and shift trips to other modes), while in more auto-dependent neighborhoods, the response was primarily to reduce trips overall. In other words, the loss of mobility from non-transportation conditions was much more significant in areas with less walkable, transit-friendly streets.

Complete street designs can provide communities with more resilient local mobility options that can adjust to a range of different hazard conditions.

LOCAL EXAMPLES

Local examples of complete street policy implementation include the.[40]

- Arlington County - Master Transportation Plan
- Prince George's County - Master Plan of Transportation
- Washington, D.C. - Departmental Order 06-2010
- Montgomery County - County Code Chapter 49, Streets and Roads (Bill 4806)
- Rockville, MD - Complete Street Policy

BENEFITS

- Improved redundancy in safe and accessible transportation modes available to local residents (bicycle, walking, automobile, transit).
- Improved redundancy within the street network, helping to offset or minimize direct impacts from flooding that would be more acute in a hierarchical single-mode road system.
- As more space-efficient modes become viable means of transport (e.g., replacing single-occupancy vehicle trips), the carrying capacity of roads increase.
- Improved traveler safety through the incorporation of many traffic calming techniques that have proven effective in reducing crashes.
- Increased proportion of trips completed by walking and cycling. Studies have shown that people will walk and cycle more frequently where and when conditions make these activities safer.
- Reduced greenhouse gas emissions resulting from shifting trips to more efficient modes without constraining mobility.

IMPLEMENTATION

Communities can consider adopting complete street design standards throughout a community. In vulnerable areas, complete streets provide enhanced resiliency; in less- or non-vulnerable areas, complete streets improve the quality of life and long-term sustainability of the community.

Adopting complete street design standards begins with establishing a policy that mandates consideration of all modes when constructing or reconstructing any street. This policy should set a vision for what is desired from complete streets, promote connectivity and integrated implementation, set a high burden of proof for seeking exceptions, direct the use of "latest and best design criteria", and be adopted by all agencies involved in street design/ construction.

Policies will be more effective when complemented by complementary implementation steps, such as:

- Street design guides — Establishing or updating official guidelines for "completing" different types of streets. This can include a locally-produced Street Design Manual or the endorsement of a set of design standards such as the Institute of Transportation Engineers (ITE) "*Designing Walkable Urban Thoroughfares*". The importance of developing design guides is demonstrated by Massachusetts' 1996 "bicycle and pedestrian inclusion" law essentially being ineffective in changing Massachusetts Department of Transportation's road-design approach until the its highway design manual was rewritten in 2006.[41]
- Workshops/ Training — To help agency staff understand what they are implementing and why, cities like Chicago have developed training sessions for city planners, engineers, elected officials, community stakeholders, and project managers.

[40] National Complete Streets Coalition. Complete Streets Atlas, completestreets.org/complete-streets-fundamentals/complete-streets-atlas/. Accessed 11/21/2011.

[41] McCann, B. and Rynne, S. *Complete Streets: Best Policy and Implementation Practices*. American Planning Association, 2010, page 46.

- Adopting performance measures — Cities like Charlotte have adopted performance measures that can serve several roles in supporting complete streets realization, including: demonstrating need for complete streets (crash data), prioritizing investment options (maximize impact), assessing impacts (before and after).

IMPLEMENTATION BEST PRACTICES

- Don't overlook low-cost options. When repaving a street, City of Seattle staff explore opportunities such as: reconfiguring the right-of-way to create space for cyclists, painting and signing stop bars to improve pedestrian safety, and installing bike loop detectors, when moving signal detectors, to allow cyclist-activated signals.
- Don't forget the sidewalks. The surest way to complete local sidewalk networks is to make the same party responsible for providing and maintaining each road, responsible for its sidewalks. Cities like Colorado Springs have taken back this responsibility, and the city of Charlotte has launched a program that prioritizes sidewalk retrofits based on need and resident requests.
- Consider regional implementation. The Metropolitan Transportation Commission (MTC), the metropolitan planning organization for the San Francisco Bay Area, adopted a resolution in 2006 that requires local jurisdictions to consider the needs of bicyclists, pedestrians, and transit riders when applying for federal or regional transportation funds for any new or renovated road project. The policy supports the agency's commitment to provide access by multiple modes, including safe bicycle and pedestrian travel, and provides a routine accommodation implementation policy for the region. The MTC also adopted a routine accommodation checklist in 2008 to help ensure that local jurisdictions were following through on this commitment.

MORE INFORMATION

The National Complete Streets Coalition

ITE's *Context Sensitive Solutions in Designing Major Urban Thoroughfares for Walkable Communities*

5-E Upgrade Building Code Requirements

DEFINITION

Building codes are designed to ensure the construction of buildings that are safe for people to use and operate. Building codes are reviewed and updated on a periodic basis (e.g., annually) to reflect industry and technology changes.

CLIMATE CONNECTION

Buildings both impact the climate and are impacted by it. The building sector is the single largest contributor to climate change and buildings are highly vulnerable to its effects, representing one of the biggest sources of economic risk to individuals, businesses, and communities. Because buildings last a long time, their design and construction have both short- and long-term consequences.

However, most building codes were not developed to address the kinds of changing temperature extremes and weather events, more extensive droughts and flooding, and extended weather-caused utility disruptions projected with climate change. Current codes don't require buildings to be able to maintain safe temperatures during heat waves, only minimum temperatures in cold weather, and typical assume that utility services will be uninterrupted. Existing provisions addressing many of the types of hazards anticipated to increase are based on historic weather and flood data, not projected changes in weather or flooding related to sea-level rise.

All future new building and substantial work done to existing buildings, whether in vulnerable areas or those designated as safer, should be guided by design and construction standards that consider the increasing levels and categories of risk and climate stress projected during the lifespan of the building. Building to these higher standards and performance levels can reduce future losses of life and property, while continuously reducing operating expenses and helping meet both climate mitigation and adaptation goals.

An effective way to do that is through upgraded building codes and standards along with higher voluntary standards and the guidance for the approvals process afforded by more advanced regulations.

ADAPTATION PLANNING STAGE

Advanced

RELEVANT SECTORS

Land Use: Building requirements for vulnerable areas can be tied to specific changes in zoning and land use.

Water: Building codes incorporate many provisions related to water from water supply to use and reuse, wastewater, stormwater, and flooding.

Transportation: Building codes may affect such things as alternative transportation options such as more bike and pedestrian friendly design, showers in non-residential projects, electric vehicle charging stations and such.

Buildings: Most relevant sector through the modification of building codes.

RELEVANT HAZARDS

COMMUNITY CONTEXT

Rural areas have more buildings exempt from codes (e.g., agricultural).

Codes typically apply to all but exempted structures in rural, suburban and urban contexts.

LOCAL EXAMPLES

The green building programs in Arlington County and the City of Alexandria in Virginia demonstrate what can be accomplished within the codes in Virginia without seeking specific additional authority from the State.

The District of Columbia Green Building Act of 2006 established higher building code requirements for all buildings.

BENEFITS

When communities adopt codes that respond proactively to the predicted increasing impacts of climate change, they can expect reductions in losses to life and property, as well as the benefits resulting from more durable and efficient buildings. In addition, they will experience reduced strain on utilities and public services during disasters and severe weather events. The better a community's built environment is able to

withstand climate threats, the more resilient the community, its citizens, and businesses will be. The economic benefits include lower operating, repair, rebuilding, utility and maintenance costs, and lower insurance premiums because communities with the most current codes and the best enforcement pay the lowest insurance rates.[42]

IMPLEMENTATION

Building codes require local governments to establish local climatic and geographic conditions and criteria that buildings must be designed to meet. Further, codes typically contain climate, wind, flood, soil, weathering and other maps used to establish building requirements according to expected conditions. Projected vulnerabilities or risks identified through the vulnerability assessment process represents the basis for using higher than historic requirements to deal with higher than historic risks.

Each state and local jurisdiction has differing laws governing local authority to adopt or modify building codes. However, all jurisdictions have the right and authority to determine zoning provisions and respond to varying levels of risk including those related to flood and weather variability, and all building codes contain provisions that attempt to match local conditions to construction performance requirements.

The ability to respond to increased climate risk through building codes is available, even in Dillon Rule states with state mandated codes, where local governments only have the authority granted them by the state.[43] All local governments have the authority to create zoning districts with specific provisions to address health and safety concerns, which can include the increasing climate-related risks.[44] Such districts can impose more stringent requirements for flood mitigation and respond to other hazards to protect the public.

In addition, the International Building Code and International Residential Code, which are either adopted directly or form the basis of most state building codes, reference FEMA, the National Flood Insurance Program, their maps and information, and ASCE 24-Flood Resistant Design and Construction, all of which require higher design and construction standards for flood prone areas. Communities can establish risk zones based on the results of their own vulnerability assessment processes, and require higher performance levels for buildings according to their predicted risk level of risk.

When desired options are limited by state law, communities can seek specific authority for higher mandatory standards from their legislative bodies.

Where local governments have limited authority to vary from state mandated building codes, they can focus on using incentives and voluntary use of higher design and building standards. The same strategies that have been used in communities to establish green building programs and requirements should be applicable for climate adaptation, and many green building practices double as climate mitigation and adaptation strategies.

Given the likelihood and serious consequences from more severe weather and flooding events causing long disruptions in utility services, communities can consider encouraging passive survivability goals (for more information, see Approach 5F) by adopting voluntary stretch or reach codes.[45,46] Local governments can also consider using the International Green Construction Code[47] to establish higher requirements tied to incentives. Another option is to adopt ordinances that give greater flexibility to building and zoning departments to approve a fixed number of projects pursuing certification under a third party certification system. For example, in the City of Seattle[48] and Clark

[42] The Building Code Effectiveness Grading Schedule (BCEGS) of the Insurance Service Office (ISO) grades communities on their codes and enforcement and sets insurance rates accordingly. www.isomitigation.com/bcegs/0000/bcegs0001.html#.TuDgFko711A

[43] Virginia Uniform Statewide Building Code, Section 103.10, Use of Certain Provisions of Referenced Codes, 4. "Section R301.2 of the International Residential Code authorizing localities to determine climatic and geographic design criteria."

[44] Virginia Case Study: Stemming the Tide: How Local Governments Can Manage Rising Flood Risks," www.georgetownclimate.org/virginia-case-study-stemming-the-tide-how-local-governments-can-manage-rising-flood-risks

[45] The Massachusetts Residential Stretch Code, http://www.stretchcode.com

[46] The Oregon Reach Code, www.bcd.oregon.gov/programs/reach.html

[47] International Green Construction Code is a new non-residential overlay code for the International Building Code, http://www.iccsafe.org/cs/IGCC/Pages/default.aspx

[48] www.seattle.gov/dpd/Permits/GreenPermitting/LivingBuildingPilot/default.asp

County, Washington,[49] the building code allows approval of buildings designed under the Living Building Challenge,[50] a certification program for projects striving to exceed net-zero performance for energy, water, carbon emissions, environmental impact and more.

The specific steps required to implement an upgraded building code will vary among jurisdictions depending upon the authority that local governments have to enact mandatory code provisions as well as the needs and desires of the community.

Local governments can assess the need to adjust the climatic and geographical design criteria in the codes they enforce. Integrated into the process of climate adaptation should be an assessment and adjustment of the weather, flood, and other local design criteria established in the locally enforced building codes according to the current and future projections of risks.

IMPLEMENTATION BEST PRACTICES

- Assess the existing weather and climate vulnerable design criteria established in locally enforced building codes and based on the results of the community vulnerability assessment process adjust these to incorporate heightened climate change related risks projected to exist during the lifespan of built projects.
- Use climate change based risk levels to establish zoning areas with heightened building code requirements according to projected increased risk levels.
- Create incentive programs tied to voluntary higher standards.
- Consider adopting passive survivability goals for buildings.
- Consider adopting stretch or reach codes with climate change risk reduction provisions to encourage the construction, and facilitate the approval of above code minimum projects.

MORE INFORMATION

In 2010, the Georgetown Climate Center published a study analyzing the authority of Virginia local governments to use land use regulations to adapt to sea level rise impacts: *Virginia Case Study: Stemming the Tide: How Local Governments Can Manage Rising Flood Risk*. This document argues that even in Dillon's Rule States local governments have authority for adaptation responses using existing zoning laws and more.

Example Building Codes, Ordinances and Incentives

- Virginia Uniform Statewide Building Code
- Massachusetts Residential Stretch Code
- Oregon Reach Code
- International Green Construction Code
- International Living Future Institute, Living Building Challenge

The Building Codes Assistance Project Online Code Environment & Advocacy Network (BCAP-OCEAN) has state and local information and guidance about building energy codes, green building and climate adaptation. Some of the regional resources for the Metropolitan District of Columbia can be found here:

- Washington, D.C.
- Virginia
- Maryland

Rocky Mountain Land Use Institute, Sustainable Community Development Code Framework

[49] www.co.clark.wa.us/news/news-release.asp?pkNewsSeq=2108
[50] The living Building Challenge is a project of the International Living Future Institute, www.ilbi.org

5-F Incorporate Passive Survivability Into New and Existing Projects

DEFINITION

Passive survivability refers to the ability of buildings to maintain habitability without relying on external utility systems for power, fuel, water, or sewer services, as well as being better able to withstand floods, severe weather events and temperature extremes. This can be achieved through both passive means—typically combining a highly energy-efficient thermal envelope with passive heating, cooling, ventilation and daylighting strategies—and active on-site renewable energy, water harvesting, treatment and storage, and wastewater systems.

While all buildings can benefit from these strategies, police, fire, critical infrastructure support facilities, hospitals, schools, and buildings designated as emergency shelters should receive critical consideration for elevated levels of passive survivability.

CLIMATE CONNECTION

More frequent and longer utility service disruptions can reasonably be expected to accompany climate-related increases in storm frequency, intensity, flooding, and temperature extremes. For example, climate related utility outages could result from increased electric power demands during high temperature periods, or power generation could be jeopardized as a result of inadequate availability of sufficiently cool water for coal and gas fired or nuclear power generation during extended drought periods. This has already been a problem during summertime droughts in the Southeastern U.S. Similarly, the flooding and high winds accompanying hurricanes frequently cause extensive damage requiring extended timeframes for restoration of services.

Current building codes do not require buildings to provide adequate health and safety to occupants beyond very short utility service disruptions and a large percentage of buildings are unsafe when disconnected from their external utility support. Most strategies enabling buildings to continue to safely provide shelter and necessary life support services during extended utility service disruptions also address climate adaptation and resilience goals while simultaneously reducing climate impacts.

Requiring critical public facilities to be habitable and useable during extended utility service disruptions allows the public to continue to receive necessary services and shelter during extreme weather and related events. Incorporating passive survivability strategies into the climate adaptation planning process enables communities to directly reduce vulnerability to climate risks. This increases resilience at all levels from individual buildings, neighborhoods, and larger developments to the entire community. Enabling people to continue to use buildings during such events enhances the safety of building occupants while reducing demand for emergency services, freeing them

ADAPTATION PLANNING STAGE

Advanced

RELEVANT SECTORS

Land Use: Land use and site issues include solar access, approvals for cisterns and renewable energy systems.

Water: Strategies include onsite water harvesting, storage, treatment, reuse, onsite wastewater systems, composting toilets, water-free urinals, highly efficient fixtures.

Transportation: Minimal relevance to transportation

Buildings: Most relevant sector. Primarily building-related to enable buildings to remain safe and habitable during natural disasters and extended utility service disruptions, through very high energy efficiency, passive solar heating and cooling and ventilation design, and renewable energy systems.

RELEVANT HAZARDS

COMMUNITY CONTEXT

Enabling buildings to maintain livable conditions during extended utility service disruptions meets needs in urban, suburban and rural communities. In urban and suburban contexts, implementing higher levels of passive survivability for emergency services facilities, hospitals, schools, and public buildings that may be used for emergency shelters is an essential element for community resilience.

to respond to more urgent needs. This also reduces demands on utility repair operations and utility systems as they are brought back online, reduces direct and longer-term health impacts as well as damage to buildings typically resulting from extended power and fuel outages in extreme heat or cold weather events.

LOCAL EXAMPLES

- The Chesapeake Bay Foundation building in Annapolis, MD, has passive and active solar, daylighting, natural ventilation, composting toilets and large cisterns.
- The combined Langston High School and Langston-Brown Community Center in Arlington, VA incorporates passive solar and cooling-load avoidance strategies, operable windows for ventilation in the event of power failures, and large rainwater cisterns.

BENEFITS

Community benefits from the implementation of passive survivability strategies begin with local governments being able to continue to provide emergency services from critical facilities during extreme weather and climate-related events. This is a significant public benefit, with associated reduced loss of life and harm. In addition, having public or private buildings that can be safely occupied during these events also reduces demands on emergency responders and utility repair crews, reduces immediate and longer-term health impacts, reduces damage to buildings and property typically resulting from extended power outages with all the associated reductions in financial losses.

Addressing the health and safety implications associated with people being unable to safely occupy buildings during extreme weather events or other extended utility service disruptions offers significant public health, safety and welfare benefits, particularly for the very young, elderly, sick or disabled, and to the general population when their buildings can't maintain minimum conditions for safe occupancy.

Because this approach involves such elements as high efficiency and passive solar building envelopes and active renewable energy and water systems, this adaptation also reduces the climate impact of these buildings.

Communities also benefit from the economic reductions in energy and water operating costs and pressures to expand water treatment facilities.

IMPLEMENTATION

A key step in vulnerability assessment and planning processes should be to identify critical buildings and facilities related to emergency services (including their command and communication facilities), emergency shelters, hospitals, infrastructure support buildings for power, water and sewer, and communications utilities. Once identified, implementation plans can be developed to upgrade the survivability of these facilities, prioritized by the level of importance of the building, the level and type of vulnerability, and available resources. Public facilities are typically both the highest priority and least problematic for implementation from a regulatory and political standpoint.

Implementation rests on design and building elements that enable buildings to maintain livable temperatures, safe levels of light and ventilation, and access to water and minimal sanitation services independently from external utility connections. Since many of the energy-efficiency, renewable energy, ventilation, passive solar, daylighting and other techniques used in current net-zero energy projects are identical to those required for passive survivability, their incorporation should not pose unique regulatory or technical challenges. Similarly, many of the water-related strategies are in current use throughout the country and should not present significant challenges in the approvals process. These include onsite rainwater harvesting, storage, treatment and reuse systems, and onsite waste and wastewater treatment systems (such as gray water systems, composting toilets and water free urinals) that enable buildings to continue to provide necessary water and sanitary services during utility outages. Implementation strategies may differ in retrofitting existing buildings because of design, construction or other limitations.

Once there is greater familiarity with the strategies and benefits, informational, technical and incentive programs can be developed for private sector buildings. Facilitating the process can involve addressing regulatory barriers in building and land use codes and

standards and developing incentives to assist private citizens to undertake steps to upgrade their homes.

Making passive survivability mandatory for private sector buildings or incorporating such requirements into building codes may be possible in some communities or considered as specific development requirements for projects in areas known or projected to be more vulnerable to service disruptions but will be developed nonetheless.

IMPLEMENTATION BEST PRACTICES

- Assess vulnerability of key emergency response facilities and public buildings to extended utility service disruptions. Develop prioritized plans for upgrading the passive survivability of those buildings and incorporate those plans into all community planning efforts.
- Encourage design, construction and development best practices for achieving passive survivability in all building types by publicizing community goals to the public and key design and building sector groups. Additionally, upgrade technical support for all related regulatory approval processes.
- Create incentive programs for the private sector to incorporate these strategies into buildings throughout the community, thereby increasing community resilience.

MORE INFORMATION

Two excellent online resources on Passive Survivability are from Environmental Building News:

- Wilson, Alex. "Passive Survivability: A New Design Criterion for Buildings." *Environmental Building News*, Building Green. Volume 15, Number 5, May 2006.
- Wilson, Alex and Ward, Andrea. "Design for Adaptation: Living in a Climate-Changing World." *Environmental Building News*, Building Green. Volume 18, Number 9, September 2009.

A report on the results of a set of planning charrettes sponsored by the U.S. Green Building Council following Hurricane Katrina, "The New Orleans Principles," provides planning and design guidance for the reconstruction of New Orleans based on a set of principles which include "Passive Survivability," with practical benefits for any community designing to be more resilient, sustainable and better prepared for climate change and natural and other disasters.