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USING SMART GROWTH STRATEGIES TO CREATE MORE RESILIENT COMMUNITIES IN THE WASHINGTON, D.C., REGION

Office of Sustainable Communities
Smart Growth Program

Contacts

U.S. Environmental Protection Agency project leads:

Kevin M. Nelson, AICP
202-566-2835
nelson.kevin@epa.gov

Megan M. Susman
202-566-2861
susman.megan@epa.gov

U.S. Environmental Protection Agency
Office of Sustainable Communities
1200 Pennsylvania Ave. NW, Mail code 1807T
Washington, DC 20460

Contractor lead:
Kate Marshall
SRA International, Inc.
3434 Washington Boulevard
Arlington, VA 22201
703-284-6234
kate_marshall@sra.com

Metropolitan Washington Council of Governments project lead:
Maia A. Davis
Metropolitan Washington Council of Governments
777 North Capitol St. NE
Washington, DC 20002-4239
202-962-3227
mdavis@mwcog.org

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Photographs on the front cover, (left to right, top to bottom): Ballston Metro Station, Arlington, Virginia; Washington Canal Park, Washington, D.C.; Eastern Village, Silver Spring, Maryland (source: Dan Reed via Flickr.com).

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EXECUTIVE SUMMARY

Climate change is having, and is expected to continue to have, an impact on communities' economies, environment, and quality of life. Many local governments recognize the need to plan for long-term solutions to prepare for and adapt to the local impacts of climate change. But how do communities prepare for projected impacts across multiple sectors? How can they balance the long-term priority of preparing for climate change with the many competing short-term priorities and resource constraints? Which strategies can effectively use local government resources to bring multiple benefits?

This guidebook presents approaches that cities, suburbs, and rural areas in the Washington, D.C., region can use to prepare for future climate risks while also meeting other environmental, economic, and community goals. These approaches respond to current and projected risks to the land use, transportation, water, and building sectors and can help make these sectors more resilient, meaning the sectors would be better able to prepare for and recover from threats. The approaches are also intended to encourage compact development that offers a range of transportation options, uses resources more efficiently, and creates attractive and thriving neighborhoods—in other words, to bring additional short- and long-term benefits that improve the community regardless of the extent of climate change that actually occurs. Many of these approaches include smart growth strategies that some local governments in the region already use but that could be tweaked to help communities better adapt to climate change.

Before determining which of these approaches might be most useful, local governments need to know how climate change is projected to affect their communities and how vulnerable their systems and populations are. Typically this step will include a vulnerability assessment to determine which areas and assets are most at risk from climate change. Local governments can use this information to prioritize where and when to take action. Many local governments also use the vulnerability assessment to create a climate readiness plan to guide decision-making for municipal facilities, services, and assets.

Regional approaches to planning for climate change can help local governments more effectively address associated risks by exploring issues beyond individual jurisdictions' borders, coordinating actions, sharing data and information, and identifying best practices. Regional approaches and their potential benefits include:

- Consolidating and distributing information and planning regionally for climate change can help ensure that land use plans protect particularly vulnerable areas and keep people and property safe.
- Making the regional transportation network more resilient and developing a regional, risk-based approach to prioritizing transportation investments can help adapt transportation systems to climate change.
- Using a watershed framework to manage water resources regionally and developing a regional stormwater management strategy can help localities protect water resources.
- Identifying best practices for climate-resilient building appropriate to the region and educating building professionals about building for resilience can help make the region's building stock safer and more durable.

The local government approaches are categorized under three main goals:

- Discourage new development in particularly vulnerable areas by:
    - Evaluating development incentives provided in particularly vulnerable areas.
    - Adopting protective regulations for particularly vulnerable areas.
    - Directing development away from particularly vulnerable areas within individual development sites.
    - Adopting or adapting a purchase or transfer of development rights program.
    - Establishing a fund to acquire or protect land in particularly vulnerable areas.

- Protect people and assets in vulnerable areas by:
    - Improving stormwater management approaches.
    - Adapting zoning and building codes to evolving risks.
    - Creating special districts to fund retrofits and upgrades for public buildings and infrastructure.
    - Identifying and addressing transportation system vulnerabilities.
    - Implementing heat island reduction strategies.
    - Streamlining and funding the relocation process.
- Encourage sustainable growth in appropriate, less-vulnerable areas by:
    - Promoting compact, mixed-use development.
    - Promoting infill development in appropriate locations.
    - Removing roadblocks to appropriate development.
    - Adopting green, complete streets design standards.
    - Updating building code requirements.
    - Incorporating passive survivability into new and existing projects.

While this guidebook was developed for communities in the Washington, D.C., region, it can be helpful to other areas because the region includes a range of community types—urban, suburban, and rural—and because the projected climate impacts are similar to what many other regions are expected to see.

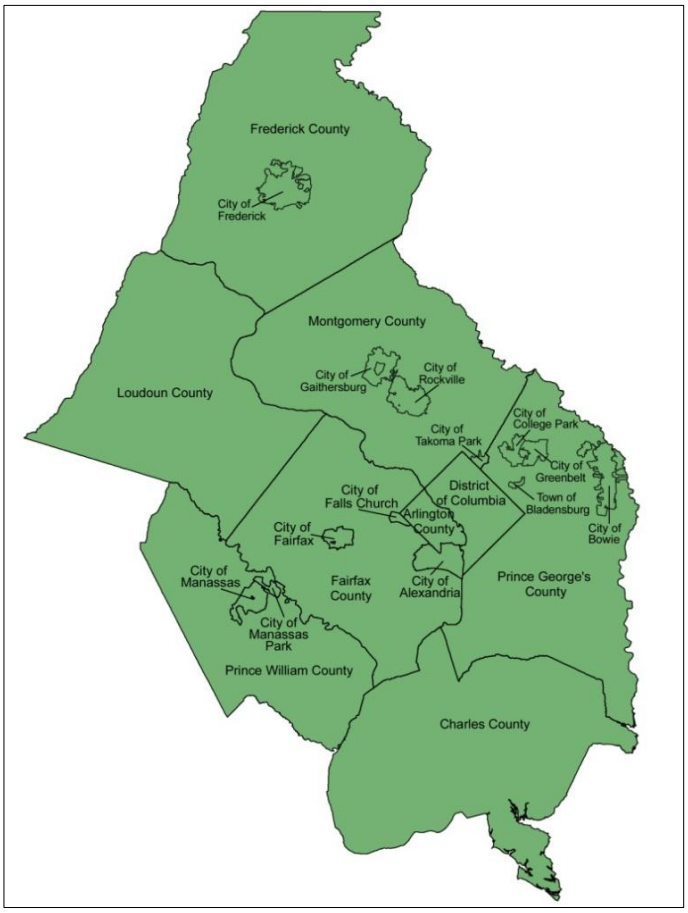
INTRODUCTION

BACKGROUND

The Metropolitan Washington Council of Governments (MWCOG) includes the District of Columbia and parts of Maryland and Virginia and ranges from highly developed areas to suburbs to farms and forests (see Figure 1). MWCOG's membership comprises 300 elected officials from 22 local governments, the Maryland and Virginia state legislatures, and the U.S. Congress. The MWCOG region includes several jurisdictions that have been recognized for their leadership in smart growth planning and green building. "Region Forward" is MWCOG's vision, which sets forth goals to create a more accessible, sustainable, and prosperous region with a high quality of life.[1]

In 2010, MWCOG applied to the U.S. Environmental Protection Agency (EPA) Smart Growth Implementation Assistance program[2] for help in developing a regional strategy for climate adaptation that includes resources for its member jurisdictions. To provide the assistance, EPA hired a team of consultants led by SRA International, Inc. In addition, staff from the National Oceanic and Atmospheric Administration (NOAA) provided in-kind assistance with training to representatives from MWCOG member jurisdictions.

This project focused on finding strategies that could help MWCOG and its member jurisdictions adapt to projected climate effects and protect health, safety, and welfare while also achieving other community goals. These strategies could help local governments attract new jobs and business opportunities, encourage development that meets the community's vision for growth, maintain a high quality of life, preserve agricultural land and open space, create housing options for people with a range of incomes and at different stages in their lives, and offer transportation options that save money and reduce pollution.



Source: Metropolitan Washington Council of Governments

Figure 1: The MWCOG region and its member jurisdictions.

In September 2011, MWCOG convened meetings of land use, transportation, water, and building sector representatives to discuss the challenges facing the region and individual jurisdictions in adapting to climate change. Through these discussions and subsequent reviews with MWCOG and representatives of jurisdictions in the region, EPA and the consultant team developed and refined the strategies in this guidebook.[3]

[1] Region Forward. "Compact." Endorsed in 2010. http://www.regionforward.org/compact.
[2] For more information on the Smart Growth Implementation Assistance Program, see Appendix A.
[3] For more information on the workshops, see Appendices B and C.

Due to time and resource constraints, this project focused on policies related to land use, transportation, water, and buildings. However, many other governmental functions will be affected by climate change, including health, education, and natural resources management. In addition, energy and water utilities are crucial to engage to ensure that their services and infrastructure are prepared for climate change.[13] Further research and collaboration on these topics could be helpful to MWCOG and its member jurisdictions.

Figure 2: Definitions of key terms.

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 can result from natural factors and natural processes in the climate system, but recent climate change is largely due to human activities over the last century.[4] Effects of climate change can be exacerbated by other factors; for example, land subsidence can increase the effect of sea level rise.[5]

Recognizing that some degree of impact from climate change will occur regardless of future greenhouse gas emissions,[6] local governments are implementing *climate change adaptation* approaches that allow communities to adapt and/or become more resilient to unavoidable impacts from climate change.

Communities build resilience by determining what their vulnerabilities are and how they can make themselves less vulnerable. *Resilience* refers to "a capability to anticipate, prepare for, respond to, and recover from significant multihazard threats with minimum damage to social well-being, the economy, and the environment."[7] *Vulnerability* is "the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes."[8]

In developing resilience and adapting to climate change, communities need to pay particular attention to engaging and assisting *vulnerable populations*. These populations include "low-income communities, overburdened populations,[9] children and youth, elderly individuals, certain communities of color, households and people with limited English proficiency, immigrants, individuals with chronic medical conditions, people who are homeless or at risk of homelessness, and individuals with disabilities."[10]

This guidebook focuses on *smart growth* and *green building* approaches to help communities prepare for climate change. Smart growth strategies include using land and resources efficiently and engaging stakeholders in development decisions to help create distinctive, attractive neighborhoods with a mix of land uses and a range of housing and transportation choices.[11] Green building is "the practice of creating structures and using processes that are environmentally responsible and resource efficient throughout a building's life cycle from siting to design, construction, operation, maintenance, renovation and deconstruction."[12]

[4] EPA. "Climate Change: Basic Information." http://www.epa.gov/climatechange/basics. Accessed Jul. 12, 2013.

[5] See, for example, Boon, John D., et al. *Chesapeake Bay Land Subsidence and Sea Level Change: An Evaluation of Past and Present Trends and Future Outlook.* Virginia Institute of Marine Science. 2010. http://web.vims.edu/GreyLit/VIMS/sramsoe425.pdf.

[6] IPCC (Solomon, S., et al. (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.

[7] National Research Council of the National Academies. *Adapting to the Impacts of Climate Change*. The National Academies Press, 2010. p. 19.

[8] Ibid p. 19.

[9] In its *Plan EJ 2014*, EPA uses the term "overburdened" to describe "the minority, low-income, tribal, and indigenous populations or communities in the United States that potentially experience disproportionate environmental harms and risks as a result of greater vulnerability to environmental hazards. This increased vulnerability may be attributable to an accumulation of both negative and lack of positive environmental, health, economic, or social conditions within these populations or communities." EPA. *Plan EJ 2014*. 2011. http://www.epa.gov/environmentaljustice/resources/policy/plan-ej-2014/plan-ej-2011-09.pdf.

[10] Hurricane Sandy Rebuilding Task Force. *Hurricane Sandy Rebuilding Strategy: Stronger Communities, a Resilient Region*. 2013. p. 171. http://portal.hud.gov/hudportal/documents/huddoc?id=HSRebuildingStrategy.pdf.

[11] EPA. "About Smart Growth." http://www.epa.gov/smartgrowth/about_sg.htm. Accessed Nov. 1, 2012.

[12] EPA. "Basic Information." http://www.epa.gov/greenbuilding/pubs/about.htm. Accessed Nov. 1, 2012.

[13] See Appendix D for more information on how water utilities can prepare for climate change.

PROJECTED CLIMATE CHANGES IN THE WASHINGTON, D.C., REGION

Climate change is projected to affect the metropolitan Washington region in four major ways over the next 50 years:[14]

- Temperature: Average temperatures are projected to increase by about 2 to 4 degrees Fahrenheit (F) by 2050. By the end of the century, summer temperatures could increase by as much as 9 F and winter temperatures by 7 F. The higher temperatures will mean more frequent heat waves, more days over 90 F, fewer freezing days, and warmer nights relative to days.
- Precipitation variability: Projections suggest that precipitation could increase slightly but would be concentrated into fewer but more extreme events. This increased variability could make both droughts and heavy precipitation events more frequent.
- Severe storms: Coastal storms such as hurricanes and nor'easters are projected to become more intense.
- Sea level rise: By the end of this century, sea level rise in this region is projected to be between 2 and 3 feet but will be worsened by local land subsidence and higher storm surges.[15,16]

Potential effects on the four sectors upon which this project focused include:[17]

- Land use: The expansion of flood-prone areas, flood plains, and coastal inundation zones could put more people and property at risk. Heat waves and flooding will increase damage to natural areas.[18]
- Transportation: Extreme heat can cause pavement and rail tracks to expand and buckle, which can cause travel delays and faster deterioration. Severe weather events and flooding can cause more frequent travel disruptions and damage transportation assets. As the coastline changes from sea level rise, tunnels, roads, rail lines, and other transportation infrastructure that were not previously in harm's way will be at greater risk of flooding from storm surges. Maintenance projects could take longer and cost more because workers cannot work in extreme heat or severe weather.[19,20]
- Water: More intense rainfall can damage or overwhelm water infrastructure, potentially increasing the amount and/or frequency of sanitary sewer overflows and combined sewer overflows. As coastal storms and storm surges become more severe, drinking water and sewage treatment facilities are at greater risk of inundation, and the failure of these systems can have significant impacts on public health, the economy, and the environment. Sea level rise can put stress on wetlands that provide valuable ecological functions such as buffering storm surges and protecting water quality. Changes to the water table could affect septic fields. New flood control systems could become necessary. Increased drought could reduce water supplies.[21]
- Buildings: Structures could suffer increased damage from weather-related events. Higher temperatures can increase cooling costs and energy demand, although they would also bring a slight decrease in heating costs in winter, and can change the lifetime of roofs and other structural materials.[22,23]

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[14] The projections on this page were presented to stakeholders at the beginning of this project in September 2011. For more up-to-date projections, please see the third National Climate Assessment, which will be completed in early 2014. A draft of the assessment report is available at the National Climate Assessment Web page at http://www.globalchange.gov/what-we-do/assessment. Regional scenarios that were produced as input to the National Climate Assessment and that depict "a range of plausible future conditions" are available at the U.S. Global Change Research Program, "Scenarios for Climate Assessment and Adaptation," at http://scenarios.globalchange.gov.

[15] Boesch, Donald F. (editor). *Global Warming and the Free State: Comprehensive Assessment of Climate Change Impacts in Maryland*. Report of the Scientific and Technical Working Group of the Maryland Commission on Climate Change. University of Maryland Center for Environmental Science, Cambridge, Maryland. 2008. http://www.umces.edu/sites/default/files/pdfs/global_warming_free_state_report.pdf.

[16] U.S. Global Change Research Program. *Global Climate Change Impacts in the United States.* New York: Cambridge University Press, 2009. http://www.globalchange.gov/what-we-do/assessment/previous-assessments/global-climate-change-impacts-in-the-us-2009.

[17] For more details on the projected impacts on these sectors, see: MWCOG. "Climate Change Impacts and Adaptation." http://www.mwcog.org/environment/climate/adaptation.asp. Accessed Nov. 1, 2012.

[18] U.S. Global Change Research Program 2009.

[19] Federal Transit Administration. *Flooded Bus Barns and Buckled Rails: Public Transportation and Climate Change Adaptation*. 2011. http://www.fta.dot.gov/documents/FTA_0001_-_Flooded_Bus_Barns_and_Buckled_Rails.pdf.

[20] Federal Highway Administration. *Regional Climate Change Effects: Useful Information for Transportation Agencies*. 2010. http://www.fhwa.dot.gov/environment/climate_change/adaptation/resources_and_publications/climate_effects.

[21] U.S. Global Change Research Program 2009.

[22] U.S. Global Change Research Program 2009.

Two important threads running through the four sectors are health and social equity. EPA has found that climate change endangers "both the public health and the public welfare of current and future generations."[24] Projected climate changes could cause illness, injury, and death due to excessive heat, extreme weather, storm surges and flooding, and air pollution.[25] These health impacts, as well as the impacts of increased damage to property and disruptions to transportation networks, can hit hardest the people who are least able to adapt to them: the very young, very old, infirm, low-income, and non-English speakers. For example, low-income people and some communities of color are more likely to have existing health disparities that can make them more susceptible to health problems from extreme heat, polluted air, and other effects of climate change. The economic inequities that might have compromised their health to begin with can also make it more difficult for them to afford a safe, comfortable home or to evacuate when a flood or other disaster looms.[26] Similarly, older adults are particularly at risk in heat waves for several reasons, including their physiology and the likelihood that they have health problems or are taking medications that further increase their susceptibility to heat-related illnesses. Yet in many cases, their socioeconomic conditions, which could include living on a fixed income or living alone, hinder their ability to find a safe, affordable way to keep cool.[27]

Local governments will need to take extra measures to protect vulnerable populations and ensure that they are safe and healthy and that their homes and neighborhoods are protected. Policies that consider the particular needs of vulnerable populations, effective communication, and meaningful public participation can help ensure that climate change impacts do not worsen existing inequalities.[28]

ADAPTATION TO CLIMATE CHANGE

In the metropolitan Washington region, many jurisdictions have already recognized the need to reduce greenhouse gas emissions to mitigate human effects on the climate. MWCOG has produced a climate change plan,[29] as have Virginia,[30] Maryland,[31] and the District of Columbia.[32] Many of MWCOG's member local governments have either formal climate action plans or substantial climate change-related resources.[33] However, few of these plans address adapting to climate change beyond recognizing the need to do so; Maryland and Alexandria, Virginia, are among the few places in the region that have developed climate adaptation plans. Several other states, regions, and cities have adaptation plans that could be useful models, including the states of California, New York, and Washington; the San Diego region; Southeast Florida; Boston; Chicago; New York City; and Keene, New Hampshire.[34]

Because of the amount of greenhouse gases already in our atmosphere, continued climate change is inevitable.[35,36] Therefore, planning is necessary to adapt to the changes that are already evident, as well as those projected to happen. Climate mitigation (reducing greenhouse gas emissions) complements adaptation because it will reduce the degree of

[23] U.S. Climate Change Science Program. *Effects of Climate Change on Energy Production and Use in the United States*. 2008. http://library.globalchange.gov/products/sap-4-5-effects-of-climate-change-on-energy-production-and-use-in-the-united-states.
[24] EPA. "Endangerment and Cause or Contribute Findings for Greenhouse Gases under Section 202(a) of the Clean Air Act." 2009. http://www.epa.gov/climatechange/endangerment.
[25] American Public Health Association. *Climate Change: Mastering the Public Health Role*. 2011.
[26] Kaswan, Alice. "Domestic Climate Change Adaptation and Equity." *Environmental Law Reporter* 42.12 (2012): 11125-43.
[27] Gamble, Janet L., et al. "Climate Change and Older Americans: State of the Science." *Environmental Health Perspectives* 121.1 (2013): 15–22.
[28] Kaswan 2012.
[29] Climate Change Steering Committee. *National Capital Region Climate Change Report*. Metropolitan Washington Council of Governments. Adopted Nov. 12, 2008. http://www.mwcog.org/environment/climate/about.asp.
[30] Governor's Commission on Climate Change. *Final Report: A Climate Change Action Plan*. Commonwealth of Virginia. 2008. http://leg2.state.va.us/dls/h&sdocs.nsf/fc86c2b17a1cf388852570f9006f1299/5369104b03d766a485257440005e1c34/$FILE/RD19.pdf.
[31] Maryland Commission on Climate Change. *Climate Action Plan*. 2008; updates in 2009 and 2010. http://www.mde.state.md.us/programs/Air/ClimateChange/Pages/Air/climatechange/legislation/index.aspx.
[32] Government of the District of Columbia. *Climate of Opportunity: A Draft Climate Action Plan for the District of Columbia*. Sep. 2010 draft for public discussion. http://rrc.dc.gov/green/cwp/view,A,1231,Q,460764.asp.
[33] For links to these resources, see Appendix E.
[34] For links to more information about these plans and related resources, see Appendix E.
[35] U.S. Global Change Research Program 2009.
[36] National Research Council of the National Academies. *Adapting to the Impacts of Climate Change*. Washington, D.C.: The National Academies Press, 2010.

change over the long term, helping to reduce future risk. Many of the strategies in this publication can reduce greenhouse gas emissions as well as help communities adapt to climate change.

Responses to climate change can be either reactive or anticipatory. Reactive adaptation happens after a disaster has already taken place and attempts to reduce the damage from future, similar disasters. Robert Repetto, an expert on the intersection between economics and the environment, notes:

> "If adaptation is mainly reactive, then damages will be much greater. Unfortunately, experience shows that, in the United States, responses to disaster are mainly reactive, often characterized by inattention beforehand and over-response afterwards. In the case of climate change, reactive adaptation will be especially costly because, decade by decade, the severity of climate change impacts is likely to increase as greenhouse gas concentrations in the atmosphere rise. Reactive adaptation would be likely to lag persistently behind the emerging risks."[37]

Anticipatory adaptation looks ahead to projected changes and tries to implement policies, strategies, or other responses *before* a disaster or other weather-related impact occurs. Careful advance planning can ensure that costs are minimized by incorporating adaptation strategies into planned expenditures. Even in cases where strategies have significant additional upfront costs, they can save public funds in the long term by reducing or eliminating the recovery costs from repetitive damage by floods and storms to the same infrastructure and properties.

Source: byronpeebles via Flickr

Figure 3: Washington Harbour was flooded in April 2011 after heavy rains. The development has protective flood walls, but they were not deployed.

Climate adaptation measures for the built environment typically fall into three categories:[38]

- Protect: Adding protective measures, typically hard-engineered measures such as sea walls, dikes, reinforced buildings, or elevating land using fill or "soft" measures such as living shorelines that use vegetation and other natural elements to buffer against storm surges and sea level rise.[39]
- Accommodate: Altering buildings, infrastructure, and land use to better cope with the effects of climate change—for example, flood-proofing the first floor of a building that is in a flood-prone area.
- Relocate: Moving development out of harm's way.

This guidebook offers approaches that meet multiple community goals and can often be incorporated into existing community development processes, policies, and regulations. Therefore, most of the approaches focus on accommodation or relocation; however, communities will probably want to consider protective measures as well.

In many places, climate adaptation activities might not go by that name. They often fall under hazard mitigation or emergency management. For truly anticipatory and robust preparation, adaptation ought to be mainstreamed into building codes, zoning codes, infrastructure planning and maintenance, public health, and other regular local government functions. By incorporating climate considerations into these functions, local governments can help "buy down" risk because each element can reduce risk incrementally.

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[37] Repetto, Robert. "The Climate Crisis and the Adaptation Myth." Working Paper No. 13, Yale School of Forestry and Environmental Studies, Fall 2008. p. 2. http://environment.research.yale.edu/documents/downloads/v-z/WorkingPaper13.pdf.

[38] Dronkers, J. et al. *Strategies for Adaption to Sea Level Rise*. Report of the Intergovernmental Panel on Climate Change Coastal Zone Management Subgroup. Geneva: Intergovernmental Panel on Climate Change, 1990.

[39] EPA. *Synthesis of Adaptation Options for Coastal Areas*. 2009. http://www.epa.gov/oppeoee1/cre/downloads/CRE_Synthesis_1.09.pdf.

A stand-alone climate adaptation plan can help communities determine their risks, vulnerabilities, and action priorities. However, communities should also incorporate climate adaptation considerations into policies and processes across all their departments. Integrating climate considerations into every municipal department's budgeting and planning helps ensure that the staff most experienced in their department's activities can help develop appropriate climate responses. It also makes adaptation the responsibility of all departments, not just a single office or official.[40]

This guidebook is intended to give local governments some guidance on how to plan for and adapt to climate change in an anticipatory way. 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. These existing processes should include emerging information about projected climate changes just as they would include new projections for demographics, economics, and other relevant information. Many of the approaches described here are "no regrets," meaning they will provide benefits even if the effects of climate change turn out to be less severe or different than projected. In addition, they bring multiple benefits beyond simply adapting to climate change.

In planning for the impacts of climate change, each local government will need to assess the cost of acting versus not acting and of being anticipatory versus reactive. Uncertainty about the precise magnitude of climate impacts, even when the science about the existence of risks is strong, can make it more challenging to determine the appropriate investments to protect the community over the long term. One concern that came up in stakeholder meetings with representatives from around the MWCOG region was that some changes that local government staff believe are necessary could increase costs, and the staff sometimes find it difficult to find solid information to explain why the additional investment would be wise. Local leaders must also cope with competing priorities, some of which might be more immediate and more vocally advocated by some community members than climate adaptation actions.

In light of these issues, localities often want higher-resolution climate projections, believing that these projections would be more precise and therefore more useful. However, producing higher-resolution models can actually increase the range of climate projections and thus the range of climate impacts that have to be considered. Rather than seeing climate projections as predictions upon which to base plans, local government staff can use projections as one element in a decision-making framework that also includes the community's vulnerabilities, strengths, and resources set against a range of plausible future conditions. This kind of framework helps decision-makers determine which potential solutions would work reasonably well within this range.[41] Local governments could look for no-regrets solutions that are relatively inexpensive, bring benefits beyond adapting to climate-related impacts, and show benefits in the short term as well as over time. Solutions that meet multiple community goals and bring immediate advantages will usually garner more public and political support.

The approaches in this guidebook are already being used by communities across the country—including some in the Washington, D.C., region—to improve quality of life, encourage economic development, protect human health and the environment, conserve resources, and save money. This guidebook explains how these common approaches can be effective tools for climate adaptation planning and describes how each approach can improve resilience to climate change.

ORGANIZATION AND USE OF THIS GUIDEBOOK

The guidebook begins with a brief summary of basic climate change planning. Next, it discusses some ways regions could address climate change issues. Finally, it explores local government strategies to protect, accommodate, or relocate development while building long-term resilience to climate change. The guidebook is organized into five sections:

[40] Susskind, Lawrence. "Understanding and Responding to the Risks Associated with Climate Change." Presentation in Lincoln Institute of Land Use Policy online course, *Local Communities Adapting to Climate Change*. 2011.
[41] Weaver, Christopher P., et al. "Improving the Contribution of Climate Model Information to Decision Making: The Value and Demands of Robust Decision Frameworks." *WIREs Climate Change* 4 (2013): 39-60.

1. *Plan for Climate Change* explains how communities can conduct climate adaptation planning and/or develop a vulnerability assessment to identify vulnerable areas, risk, and priority planning areas.
2. *Consider Regional Approaches* summarizes regional land use, transportation, water, and building sector approaches that can help regions adapt to climate change.
3. *Discourage New Development in Particularly Vulnerable Areas* offers strategies local governments could consider to keep more development from moving into harm's way.
4. *Protect People and Assets in Vulnerable Areas* has strategies that can keep development already in hazardous places safer.
5. *Encourage Sustainable Growth in Appropriate, Less-Vulnerable Areas* offers strategies to encourage development that is not only in safer locations, but that also helps reduce greenhouse gas emissions.

Each approach in Sections 3 through 5 includes:

- A box summarizing the approach's adaptation planning stage (basic, intermediate, or advanced),[42] its relevance to the four major sectors discussed in this guidebook, and the hazards it addresses.
- A definition of the approach.
- The "climate connection," an explanation of how the approach can enhance climate adaptation planning.
- Examples of where the approach is being used in the Washington, D.C., region and other nearby jurisdictions.
- Benefits of using the approach.
- Implementation considerations.

Appendix E lists additional resources for each approach.

Figure 4 allows local government officials to easily find approaches that fit whatever adaptation planning stage is appropriate and address the hazard(s) most relevant to the community. For example, a planner whose community is particularly vulnerable to sea level rise can see which strategies help prepare for that hazard and would use his or her own judgment about whether the community is at a basic, intermediate, or advanced stage of planning for adaptation.

[42] The adaptation planning stage is provided as a general guide for local governments. It is a rough estimate of the stage at which a local government would be if it opts to implement this approach. For example, "evaluate development incentives provided in vulnerable areas" is a more basic step than "adopt protective regulations for vulnerable areas" and would generally come at an earlier stage in a local government's efforts to adapt to climate change.

Figure 4: This summary helps link local government approaches to adaptation planning stages and relevant hazards.

		Adaptation Planning Stage			Most Relevant Sector	Relevant Hazards		
		Basic	Intermediate	Advanced		Temperature	Precipitation/ Severe Storms[43]	Sea Level Rise
3	**Discourage New Development in Particularly Vulnerable Areas**							
3-A	Evaluate Development Incentives Provided in Particularly Vulnerable Areas	●			Land Use		●	●
3-B	Adopt Protective Regulations for Particularly Vulnerable Areas	●					●	●
3-C	Direct Development Away From Particularly Vulnerable Areas Within Individual Development Sites		●				●	●
3-D	Adopt or Adapt a Purchase or Transfer of Development Rights Program			●			●	●
3-E	Establish a Fund to Acquire or Protect Land in Particularly Vulnerable Areas			●			●	●
4	**Protect People and Assets in Vulnerable Areas**							
4-A	Improve Stormwater Management Approaches	●			Water		●	●
4-B	Adapt Zoning and Building Codes to Evolving Risks		●			●	●	●
4-C	Create Special Districts to Fund Retrofits and Upgrades for Public Buildings and Infrastructure		●		Buildings	●	●	●
4-D	Identify and Address Transportation System Vulnerabilities		●		Transportation	●	●	●
4-E	Implement Heat Island Reduction Strategies		●			●	●	
4-F	Streamline and Fund the Relocation Process			●			●	●
5	**Encourage Sustainable Growth in Appropriate, Less-Vulnerable Areas**							
5-A	Promote Compact, Mixed-Use Development	●				●	●	●
5-B	Promote Infill Development in Appropriate Locations		●				●	●
5-C	Remove Roadblocks to Appropriate Development		●				●	●
5-D	Adopt Green, Complete Streets Design Standards		●			●	●	●
5-E	Update Building Code Requirements			●		●	●	●
5-F	Incorporate Passive Survivability Into New and Existing Projects			●		●	●	

[43] Although precipitation and severe storms were initially examined separately, no approach addressed one but not the other, so they are combined here.

1 PLAN FOR CLIMATE CHANGE

Local governments are on the front lines of climate change planning. Not only are they among the immediate responders to climate changes, they are best positioned to develop tailored climate change strategies that respond to projected local impacts while meeting other community goals.

Local governments have always had to plan for a range of conditions that change over years or decades, such as projected population or economic growth or decline. Climate change is another evolving condition for which they will have to plan. With assistance from regional, state, and federal agencies; universities; or nonprofit partners, local governments can determine a range of possible impacts. Because climate change is a dynamic, long-term process that will continually change local conditions, it is important to revisit the climate planning process on a regular basis.

Tools that can help local and regional governments plan for climate change include:

- A vulnerability assessment.
- A climate readiness plan.

VULNERABILITY ASSESSMENT

A vulnerability assessment entails three key components: a sensitivity analysis of the systems associated with the planning areas (*sensitivity*); an evaluation of the exposure that these systems are likely to face (*exposure*); and the capability of a local government to address or prevent adverse outcomes from climate change or the system itself to withstand or bounce back from gradual or extreme climate changes (*adaptive capacity*). The scope and scale of a vulnerability assessment will be determined by the level of detail that meets a local government's resource and information needs. Such an assessment will help local governments determine what areas and assets are most at risk from climate change. Municipalities can use this information to prioritize where and when to take action. Several tools can help local governments with this challenge (see Figure 5). Most vulnerability assessments require similar steps, which typically include:

1. Determine potential incremental and extreme climate changes and the timeframe in which they are expected. Determine sectors and geographic areas that are or will be at increased risk and their exposure to climate change stresses (*exposure*).
2. Assess how sensitive these sectors and areas are and how critical they are to the community (*sensitivity*).
3. Determine the sector or area's ability to withstand or bounce back from climate-related impacts (*adaptive capacity*).

The local government can use this information to assess the costs of making the sectors and areas resilient to climate-related impacts and to determine whether adequate funds are available. Based on risk, importance, costs, and other factors, the government can then prioritize which sectors and geographic areas should get assistance first. A vulnerability assessment provides a community with a baseline of information that it needs as it considers options—such as the approaches described in Sections 3 through 5 of this guidebook—to prepare for and adapt to climate change. This information can be incorporated into materials that underlie the community's relevant decision-making processes, such as capital improvement plans, comprehensive plans, and emergency management plans.

Engaging representatives from all local government departments to discuss how projected changes could affect their areas of responsibility is important. While emergency management and response, land use, public works, transportation, and water might be the obvious departments to engage, the public health, social services, housing, economic development, public safety, parks, and other departments will have important contributions. Conducting a vulnerability assessment provides a good opportunity to educate as well as learn from these departments.

Figure 5: Tools for Local Adaptation Planning

EPA has toolkits to help water utilities and coastal and estuary programs plan for adaptation.

- Climate Ready Water Utilities Toolbox: *www.epa.gov/safewater/watersecurity/climate/toolbox.html*. Specific tools include:
  - CREAT, a software tool to evaluate potential impacts of climate change on water utilities and evaluate adaptation options to address these impacts using both traditional risk assessment and scenario-based decision making.
  - Preparing for Extreme Weather Events: Workshop Planner for the Water Sector, which provides materials to plan, facilitate, and conduct an adaptation planning workshop.
- Coastal Toolkit: *www.epa.gov/cre/toolkit.html*.

NOAA's Coastal Services Center lists many resources on vulnerability assessments and other elements of climate adaptation planning: *collaborate.csc.noaa.gov/climateadaptation/default.aspx*.

The U.S. Department of Transportation's Adaptation Planning page lists resources for transportation-related planning: *climate.dot.gov/impacts-adaptations/planning.html*.

ICLEI–Local Governments for Sustainability developed the ADAPT tool, available to its members, and has other resources for communities planning for climate adaptation: *www.icleiusa.org/climate_and_energy/Climate_Adaptation_Guidance*.

The Climate Impacts Group at the University of Washington published *Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments*: *cses.washington.edu/db/pdf/snoveretalgb574*.

Many other vulnerability assessment and planning tools are listed on:

- The Ecosystem-Based Management Tools Network website: *ebmtoolsdatabase.org/resource/climate-change-vulnerability-assessment-and-adaptation-tools*.
- The Climate Adaptation Knowledge Exchange website: *www.cakex.org/tools*.
- The Georgetown Climate Center's Adaptation Clearinghouse: *www.georgetownclimate.org/adaptation/clearinghouse*.

Communities could also consider using a tool such as the American Planning Association's Safe Growth Audit to determine how their current land use regulations treat particularly vulnerable and hazardous areas and to find elements that might need to be changed to ensure that development is happening where and how the community wants. The Safe Growth Audit includes questions to analyze the comprehensive plan, subdivision regulations, the capital improvement plan and infrastructure policies, and other related policies such as building codes, small area or corridor plans, economic development strategies, and emergency response strategies.[44] The results of this audit can help communities determine where they need to focus their attention as they work the results of the vulnerability assessment into their land use regulations.

Engaging residents and community organizations can help regional and local governments determine what residents' concerns are, while at the same time educating the residents about potential threats. Well-organized neighborhoods can also be better prepared for the challenges of climate change. A report from the Sandy Regional Assembly on recovery from Superstorm Sandy noted that in many places hit by the storm, community organizations and residents were the first responders and remained in the community providing crucial post-disaster assistance. The report noted that "communities that were resilient and organized before Sandy were also the most resilient after disaster hit."[45]

CLIMATE READINESS PLAN

To provide needed services and ensure the health and safety of their residents, 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. These services must be provided continuously, even when communities are affected by emergencies such as severe storms.

[44] Godschalk, David R., FAICP. *Safe Growth Audits*. Zoning Practice: Issue 10. American Planning Association. Oct. 2009.

[45] Sandy Regional Assembly. *Sandy Regional Assembly Recovery Agenda—Recovery From the Ground up: Strategies for Community-Based Resiliency in New York and New Jersey*. 2013. p. 1. http://goodjobsny.org/sites/default/files/docs/sandy_regional_assembly_recovery_agenda_final_032913-2.pdf.

As part of the vulnerability assessment process, a local government would consider the vulnerabilities of its own facilities (e.g., buildings, parks, utilities). It can then use that information to develop a climate readiness plan. A climate readiness plan can guide decision-making for long-term municipal facility planning and help ensure continuity of services.

In the vulnerability assessment, the local government will have identified all facilities (e.g., buildings, maintenance facilities, parks) for which it is directly responsible. It will also have identified which of these facilities and assets are in particularly vulnerable areas and prioritized the facilities and assets based on their community value and vulnerability.

Once this determination has been made for each facility and asset, the local government can use the climate readiness plan to identify appropriate strategies. For existing facilities in particularly vulnerable areas, the municipality would determine whether to protect the facilities where they are or relocate the activities in those facilities if they cannot be protected and are unsuitable for retrofitting due to age or design. For planned future facilities, the local government can ensure that they are located in areas that are safer but are still easily accessible to residents. The rationale for selecting the approach might depend on economic, social, or environmental factors and should be documented. The local government should also develop a cost estimate, assessment of ancillary benefits, and timeframe for completing each action.

The approaches described in Sections 4 and 5 can be useful for facilities and infrastructure that will be made more resilient. Relocation is a long-term process that involves identifying alternate, less-vulnerable locations or systems where the same system or service can be provided. While often expensive upfront and complex to plan, relocation might be the best long-term investment for critical and highly vulnerable facilities or assets.

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

- 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 safer areas that are, where possible, near a mix of uses and easy for residents and employees to access.
- Develop a sustainable reuse plan for the original facility location (e.g., return it to green space or develop as appropriate).
- Develop a service continuity plan to ensure local government services are disrupted minimally or not at all.

Finally, the actions described in the climate readiness plan can be incorporated, as appropriate, into the community capital improvement plan; the region's long-term transportation plan; and the local government's budget, emergency and/or hazard mitigation plan, and zoning codes. Mainstreaming climate adaptation actions into local and regional plans can help ensure that planning for resilience becomes part of regular government functions.

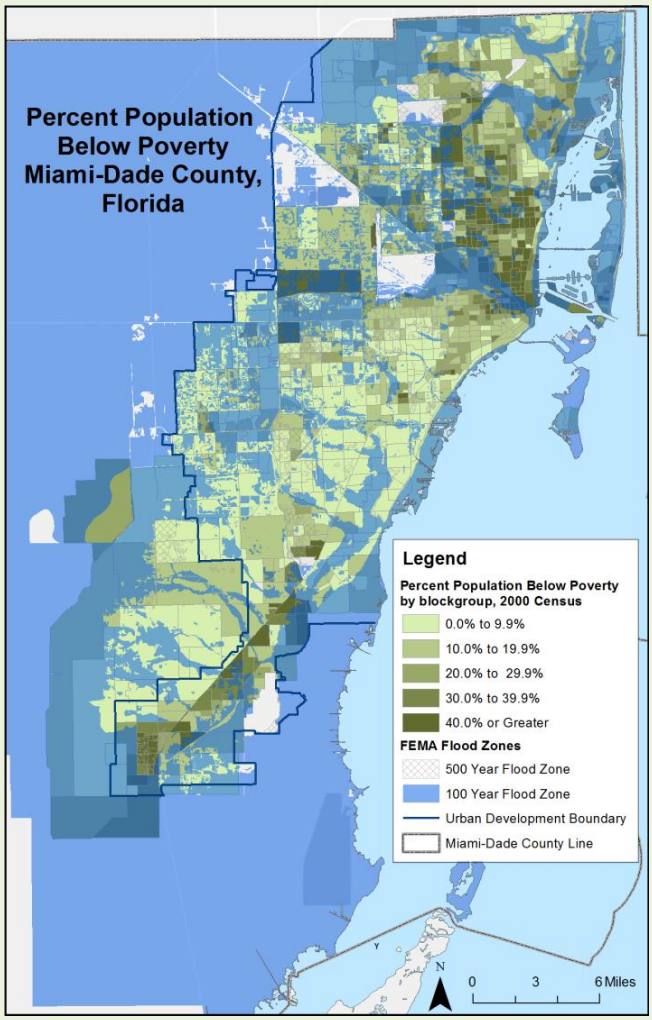
Figure 6: Roadmap for Adapting to Coastal Risk.

As part of this assistance project, NOAA trained MWCOG stakeholders on its "Roadmap for Adapting to Coastal Risk."[46] While the tool was originally developed for coastal areas, it can be used in non-coastal areas as well to better understand and plan for climate changes. It incorporates relevant hazards and climate data and information into local governments' ongoing assessment and planning processes related to water availability, stormwater management, and infrastructure maintenance and development. The tool helps communities identify how climate changes can affect these issues and explore how to reduce risks. It can also help communities work as a region to gather the information they need to conduct individual vulnerability assessments.

NOAA has resources for local governments for each of the roadmap's steps:

- Getting Started: Define community goals, build the team, identify priority issues, and prepare for the assessment.
- Hazards Profile: Explore relevant hazards and climate trends as a starting point for community vulnerabilities.
- Societal Profile: Evaluate strengths and vulnerabilities of the local population.
- Infrastructure Profile: Identify the strengths and vulnerabilities of the built environment.
- Ecosystem Profile: Consider the strengths and vulnerabilities of important natural resources.
- Risk-Wise Strategies: Explore opportunities and challenges for risk reduction through education, planning, and regulatory processes.

Preparing a regional roadmap for adapting to climate-related risks is helpful because much of the available research related to climate impacts is developed at the regional level. Working together as a region can minimize duplication of effort among individual communities, which is particularly helpful for communities that might not have the resources to do this exercise on their own.



Source: NOAA Coastal Services Center

Figure 7: As part of the roadmap process, regions can develop maps like this one from Miami-Dade County, which shows how vulnerable how-income neighborhoods are to flooding.

[46] NOAA. "Roadmap for Adapting to Coastal Risk: Overview." http://csc.noaa.gov/digitalcoast/training/roadmap. Accessed Feb. 23, 2012.

2 CONSIDER REGIONAL APPROACHES

Working on regional approaches with other nearby jurisdictions or with regional organizations such as MWCOG can help local governments more effectively plan for climate change. Regional approaches let local governments think beyond their borders about projected climate impacts (e.g., localized flooding that might be caused by conditions upstream in another community) and regional systems (e.g., water and transportation infrastructure). These approaches also use limited resources efficiently by collecting data, developing strategies, and identifying best practices that multiple jurisdictions can use.

This section highlights some regional approaches that address climate impacts in the land use, transportation, water, and building sectors. These approaches could be used by jurisdictions working together or by councils of government and similar regional or state organizations.

Source: NASA image courtesy MODIS Rapid Response Team at NASA GSFC

Figure 8: Illustrating how extreme weather can affect the entire region, the snowstorm of February 2010 blanketed the region in snow, making travel difficult or impossible and leaving hundreds of thousands of residents without power.

2-A LAND USE

Approaches to regional land use planning vary, ranging from a county that plans jointly with its constituent jurisdictions to a regional council of governments such as MWCOG that works with a larger, more diverse group of jurisdictions. Land use planning at the regional level ranges from general policy planning and goal setting to providing regional information and technical assistance. All of these approaches can be helpful in planning to protect vulnerable areas and keep people and property safe. Specific actions that regional organizations could take to incorporate climate adaptation considerations into land use include:

- Consolidating and distributing information.
- Planning regionally for climate change.

CONSOLIDATE AND DISTRIBUTE INFORMATION

Climate-related projections can be difficult to assemble. The projections often represent different geographic scales and time periods, are managed in different software, or are presented in non-standardized units of measurement. These inconsistencies can make information-sharing between government entities difficult. However, regional government organizations can be information clearinghouses, consolidating research into a single location or converting projections so they are more useful to local jurisdictions. Regional organizations can aggregate larger data sets that individual communities could not collect on their own and share the information with multiple communities.

Once the information is collected and mapped or analyzed, the regional organization can identify regional climate vulnerabilities and relay them to local governments and decision-makers through reports, meetings, maps, plans, and other means. Institutional participants such as universities or state agencies or commissions can also frequently provide assistance.

For example, in the metropolitan Washington region, the Northern Virginia Regional Commission's Sustainable Shorelines and Community Management project identified areas vulnerable to sea level rise and storm surge along Northern Virginia's tidal Potomac

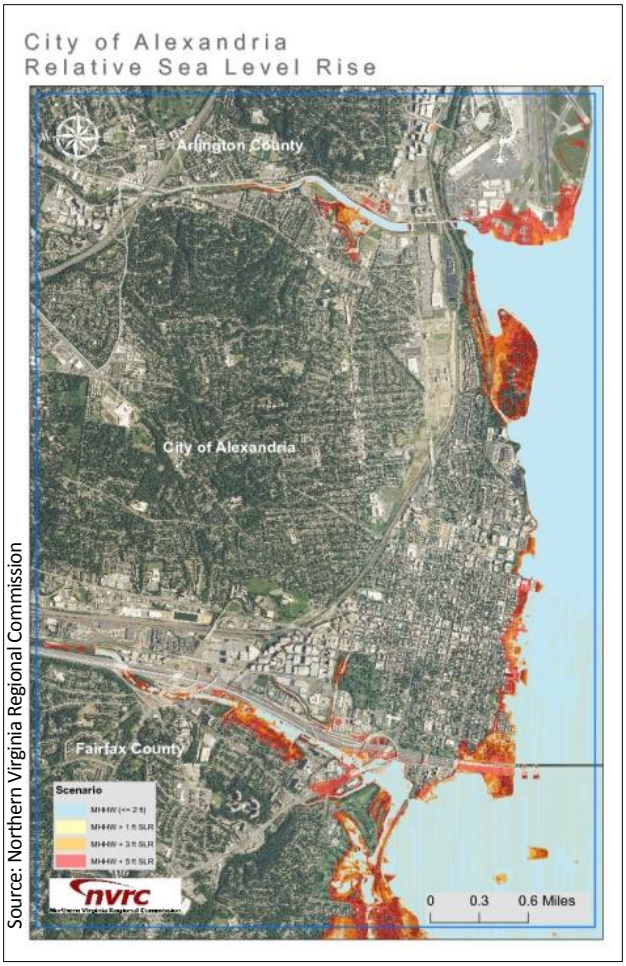


Figure 9: Sea level rise could exacerbate flooding in Alexandria, Virginia. This map shows areas that could be inundated at high tide with 1 foot (yellow), 3 feet (orange), and 5 feet (dark orange) of sea level rise.

River shoreline.[47] This inventory helps to shape local shoreline management plans and regulations. The vulnerability maps compiled during this project help the region's policy-makers with land planning and protection.

Other regional organizations that have collected and shared climate projections in their regions include:

- The Tampa Bay Regional Planning Council in Florida, which prepared a report that maps areas vulnerable to sea level rise and identifies

[47] Northern Virginia Regional Commission. *Sustainable Shorelines and Community Management Project: Phase I Report*. 2009. http://www.deq.virginia.gov/Portals/0/DEQ/CoastalZoneManagement/task12-06-08.pdf.

potential adaptation strategies for development in those areas.[48]

- The San Diego Integrated Regional Water Management Plan, which identified potential climate-related changes in the region, the state, and the Colorado River Basin.[49]
- The Wisconsin Initiative on Climate Change Impacts, which prepared a report that explores the impact of lake-level rise combined with changes in storm intensity and frequency.[50]
- Louisiana's Coastal Protection and Restoration Authority, [51] created after Hurricane Katrina. The agency prepared a coastal master plan in 2007 and updated it in 2012.[52] The plan focuses on preventing flooding and wetland loss through a range of techniques, including levees, landscape features, floodproofing, and elevating structures.

PLAN REGIONALLY FOR CLIMATE CHANGE

Regional governments can develop and adopt climate adaptation policies and priorities that start the conversation about climate adaptation and guide similar efforts by local governments. Regional governments can also lead adaptation efforts by creating model regulations and helping local governments secure funding for projects.

Regional planning that identifies and maps highly vulnerable areas, assesses projected climate-related impacts, and coordinates responses across local governments can provide more protection than single-jurisdiction planning, particularly where vulnerable areas cross local boundaries. Regional organizations can develop and suggest solutions that might be too expensive or complex for local governments to create and implement individually.

Regional organizations can help facilitate government-to-business interaction as businesses often operate in multiple localities. Regional entities can help identify local and regional funding streams for climate adaptation and can provide other support such as technical assistance and coordinating cross-jurisdictional grant applications. Regional organizations can also take a broader view of the impacts to resources that cross the boundaries of individual jurisdictions, such as a watershed or forest.

Some regional planning efforts address climate adaptation and land use in the metropolitan Washington region, including:

- The Chesapeake and Coastal Program,[53] a local, regional, and state partnership that provides assistance with coastal planning and resource protection, including sea level rise and other climate-related challenges.
- The Maryland Commission on Climate Change, which developed a *Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change*,[54] which has a section on population growth and infrastructure.

In an example outside the Washington region, the Southeast Florida Regional Climate Change Compact, adopted by Palm Beach, Broward, Miami-Dade, and Monroe counties, is a regional climate change action plan that includes specific recommendations and actions. For example, it suggests that municipal and county comprehensive plans designate Adaptation Action Areas that are vulnerable to sea level rise and other impacts. The compact developed uniform methodologies for mapping sea level rise impacts and assessing vulnerability so that all the counties and municipalities can use the same information.[55]

[48] Tampa Bay Regional Planning Council [FL]. *Sea Level Rise in the Tampa Bay Region*. 2006. http://www.tbrpc.org/mapping/sea_level_rise.shtml.
[49] San Diego Regional Water Management Group. "Integrated Regional Water Management Planning for the San Diego Region." http://sdirwmp.org. Accessed Feb. 23, 2012.
[50] Wisconsin Initiative on Climate Change Impacts. *Climate Change and Wisconsin's Great Lakes Coastal Communities: Coastal Communities Working Group Report*. 2010. http://www.wicci.wisc.edu/report/Coastal-Communities.pdf.
[51] State of Louisiana, Coastal Protection and Restoration Agency. "Louisiana's Coast: Ecosystem Restoration and Flood Protection." http://coastal.louisiana.gov. Accessed Feb. 23, 2012.
[52] Coastal Protection and Restoration Authority. "Louisiana's 2012 Coastal Master Plan." 2012. http://www.coastalmasterplan.la.gov.
[53] State of Maryland, Department of Natural Resources. "Chesapeake and Coastal Program." http://www.dnr.state.md.us/ccp/index.asp. Accessed Feb. 23, 2012.
[54] State of Maryland, Department of Natural Resources. *Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change, Phase II: Building societal, economic, and ecological resilience*. 2011. http://www.dnr.state.md.us/climatechange/climatechange_phase2_adaptation_strategy.pdf.
[55] Southeast Florida Regional Climate Change Compact. *A Region Responds to a Changing Climate*. 2012. http://southeastfloridaclimatecompact.org/compact-documents.

2-B TRANSPORTATION

Climate-related impacts that could disrupt the regional transportation network in the Washington, D.C., area include:

- Flooding of roads, tunnels, rail lines, maintenance yards, and other transportation infrastructure from increased precipitation, storm surges, and sea level rise.
- Damage from high winds and storm debris.
- Rail tracks buckling from extreme heat.
- Transit riders and transportation workers suffering health effects from excessive heat.[56]

These impacts can cause travel delays, increase regular maintenance costs, and require expensive repairs. In severe disruptions, some neighborhoods could be cut off from the region for days. Strategies that regional entities could undertake to help keep the transportation network running smoothly include:

- Increasing regional transportation resilience.
- Developing a risk-based approach to identify transportation investments.

INCREASE REGIONAL TRANSPORTATION RESILIENCE

Transportation resilience refers to a transportation system's ability to function despite disruptions. A key aspect of transportation resilience is redundancy—access to multiple transportation routes, modes, or options (e.g., the ability to walk to a store during a snowstorm when driving is dangerous or to take transit to work if roads are flooded). For example, a resilient transportation system would allow people to reroute by providing easy access to other roads or transit options. Resilient networks decrease the number of people dependent upon any given segment of the network and allow more people to continue 7to get around despite the disruption.

Redundancy in transportation systems is typically easier to achieve in areas with more compact development, where walking and biking are viable options, where enough people are close enough together to support transit, and connected road networks provide multiple routes. Smart growth strategies can help communities develop this way and, in a regional context, they can encourage growth that focuses development around transit stations and other transportation hubs that allow access to the entire region.

A regionwide strategy to encourage compact growth in well-connected areas reduces the amount of infrastructure required to serve the population and reduces dependence on regional infrastructure to meet basic mobility needs by bringing people, goods, and services closer together.

Figure 10: Bicycles can be an important element in a resilient transportation system.

Some regional approaches that could improve the resilience of the transportation sector include:

- Coordinating across jurisdictions to develop consistent strategies for ensuring that roads are well-connected, such as connectivity-scoring measures for approving new road proposals.
- Coordinating across jurisdictions and transit operators to create regional plans that link key transportation nodes and critical access routes

[56] Federal Transit Administration 2011.

and provide safe access to everyone using the transportation system.

- Working with the metropolitan planning organization (MPO) to help ensure that transit investments strengthen the regional transit network where needed and provide more transportation choices.
- Coordinating across jurisdictions and with bicycle and pedestrian advocates to identify, plan, and develop bike and trail networks and "complete streets"[57] across the region or to develop a regional bicycle and pedestrian network plan.
- Promoting the use of regional transportation performance measures that emphasize the movement of people, not vehicles, which encourages investments in more efficient and resilient modes of transportation.[58]

DEVELOP A REGIONAL RISK-BASED APPROACH TO IDENTIFY TRANSPORTATION INVESTMENTS

MPOs coordinate transportation and air quality planning among communities at the regional level. In the Washington region, the National Capital Region Transportation Planning Board at MWCOG develops long-range and short-range transportation plans and ensures that transportation plans, programs, and projects conform to the states' air quality plans.

Transportation planning processes do not typically consider climate change when weighing investment options. Analyses could incorporate a climate risk assessment into scoring future transportation investments to ensure that limited public dollars are spent where and when they can most effectively reduce vulnerabilities and improve transportation options.

To develop a regional, risk-based approach to identify appropriate transportation investments in a climate change-affected future, MPOs and regional transportation agencies could collaborate on a coordinated, comprehensive risk assessment of regional transportation networks. The Federal Highway Administration has developed a conceptual model of a risk-based, climate change vulnerability assessment that can be helpful. Five state departments of transportation and MPOs were selected to pilot the model.[59] One of the selected pilots was the Virginia Department of Transportation, which tested the model in the Hampton Roads area.[60] The model's components, which MPOs could incorporate into the Transportation Improvement Process, are:

- Develop an inventory of assets, which includes ranking the assets by their importance to the region and identifying the region's primary transportation networks and the major components of each, such as bridges, tunnels, and highway and rail line segments.
- Gather climate information to assess the likelihood and magnitude of climate impacts.
- Assess the risk to assets and the transportation system as a whole from projected climate change.

Once these steps are complete, the information can help MPOs and transportation agencies identify adaptation options and prioritize them based on the urgency, need, and opportunities for implementation as part of routine maintenance.[61]

In prioritizing adaptation investments, MPOs can consider the projected impact costs (i.e., the likely economic and social costs of each potential incident) and 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 in the District of Columbia that is critical to Virginia commuters, for example, would not necessarily be assigned a high incident cost in a Washington, D.C., vulnerability assessment and would not even be a factor in an Arlington County, Virginia,

[57] For more information on green, complete streets, see Approach 5-D.
[58] For examples of these performance measures, see: EPA. *Guide to Sustainable Transportation Performance Measures*. 2011. http://www.epa.gov/smartgrowth/transpo_performance.htm.

[59] Federal Highway Administration. "Climate Change Vulnerability Assessment Pilots." http://www.fhwa.dot.gov/environment/climate_change/adaptation/ongoing_and_current_research/vulnerability_assessment_pilots/index.cfm. Accessed Nov. 1, 2012.
[60] University of Virginia. "Scenario-Informed Multicriteria Analysis Tool." http://www.virginia.edu/crmes/fhwa_climate. Accessed Mar. 2, 2012.
[61] Federal Highway Administration. "Climate Change Vulnerability Assessment Pilots." http://www.fhwa.dot.gov/environment/climate_change/adaptation/ongoing_and_current_research/vulnerability_assessment_pilots/conceptual_model62410.cfm. Accessed Nov. 1, 2012.

assessment because Arlington has no jurisdiction over the road. A regional assessment, however, could assign an appropriate value to the cost of anticipated impacts to this road.

Other options to consider when scoring transportation investments include:

- When scoring new investments, MPOs can give weight to flexible options that can adapt to changing conditions. Weighting is generally based on total existing and potential ridership lost by the loss of an existing transportation component, compared to how much ridership would be maintained by offering the redundant service.
- MPOs and regional transportation agencies could give greater weight to investing in improvements to transportation infrastructure that is projected to be affected by multiple climate-related changes.

2-C WATER

The water sector is complex, as it includes the acquisition, delivery, collection, and treatment of water. Management of stormwater, wastewater, water quality, drinking water, and water reuse is often led by different departments in local, county, and state governments and their utility partners. Separating roles and responsibilities for water management into different departments can lead to inconsistent decisions and inefficiencies in policy-making and development, which can make the water sector more vulnerable to climate-related impacts. Regional entities can help better coordinate activities in the water sector. For example, MWCOG's Water Resources Program helps member jurisdictions and affiliated water and wastewater utilities to protect, conserve, and restore the region's water resources.

Regional organizations can help local governments better manage water resources in the face of a changing climate by:

- Using a watershed framework to enhance regional water resource management.
- Developing a regional stormwater management strategy.

USE A WATERSHED FRAMEWORK TO ENHANCE REGIONAL WATER RESOURCE MANAGEMENT

To respond to vulnerabilities related to climate change, regions can consider adopting watershed-based approaches to regional water resource management. Watershed-based approaches take a holistic view of water quality, flooding, stream degradation, and biological health in the entire watershed, not by individual jurisdictions.

Where possible given Clean Water Act regulatory constraints, a watershed framework can help communities sustainably and effectively plan for and adapt to climate changes in the water sector by:

- Establishing a coordinated, 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 would require an inventory of all water-related issues and establishing common goals and objectives through a collaborative process.
- Developing a detailed, watershed-based water resource plan to guide decision-making for all entities with regulatory powers or other control over the watershed. This plan would be a living document that changes over time and is supported by more detailed action plans.
- Ensuring the plan addresses water and land use issues. By encouraging compact development, regional smart growth strategies can reduce water infrastructure needs, help local municipalities better manage natural resources and infrastructure with limited staff and financial resources, and direct development away from natural lands that might be part of a regional green infrastructure network to protect water quality.
- Enhancing coordination among multiple levels of governments to develop appropriate, regional climate adaptation strategies for the watershed and encouraging agencies to share information about their water program planning and implementation.

Many regions use a watershed framework to enhance water resource management, including:

- The state of Washington, which passed legislation establishing a watershed-based framework that requires plans to "balance competing resource demands" and encourages citizens to "join together to assess the status of the water resources in their watershed and determine how best to manage them."[62]
- The Red River Basin watershed planning framework, which works across state and municipal boundaries in the United States and Canada to manage diverse natural resource issues and overcome political challenges.[63]

[62] State of Washington, Department of Ecology. "The Watershed Planning Act." http://www.ecy.wa.gov/watershed/misc/background.html. Accessed Nov. 1, 2012.

[63] Red River Basin Commission. *Red River Basin Natural Resources Framework Plan*. 2005. http://www.redriverbasincommission.org/Services/NRFPnonsdlstchFINAL.pdf.

Other resources for watershed planning approaches include:

- *A User's Guide to Watershed Planning in Maryland* presents a common watershed planning framework for Maryland communities, assembles planning resources, integrates regulatory actions, and presents methods to complete a watershed plan.[64]
- The Northern Virginia Regional Water Supply Plan takes a regional approach to water supply planning, allowing coordination among state-required local plans.[65]
- The Interstate Commission on the Potomac River Basin enhances, protects, and conserves the water and associated land resources of the Potomac River basin through regional and interstate cooperation. Its efforts include working with MWCOG and other partners to coordinate water resources and water supply for the region.[66]
- The state of California has a guidebook that provides statewide and regional approaches for the water sector to plan for climate change.[67]
- EPA's *Handbook for Developing Watershed Plans to Restore and Protect Our Waters* helps organizations that are undertaking watershed planning efforts. This handbook is intended to supplement existing watershed planning guides with more detailed guidance on "quantifying existing pollutant loads, developing estimates of the load reductions required to meet water quality standards, developing effective management measures, and tracking progress once the plan is implemented."[68]

DEVELOP A REGIONAL STORMWATER MANAGEMENT STRATEGY

Improperly managed stormwater can cause local or widespread flooding, leading to interruptions to traffic and businesses and threatening public safety. It can also carry pollutants from paved areas and degrade water quality.

Regional cooperation on stormwater management is important because effective management requires coordinated practices among various jurisdictions. For example, if upstream communities build additional infrastructure to channel stormwater away, it could increase flooding in downstream communities. Coordinating stormwater controls throughout the region or the watershed could help reduce stress on individual portions of the watershed.

Although engineered flood control structures such as storm sewers and cisterns are crucial in some cases, green infrastructure solutions can help reduce flooding and polluted runoff while also providing social and environmental benefits. On the regional scale, green infrastructure means the network of green spaces throughout the region that provide ecological functions such as buffering streams. These green spaces add beauty to neighborhoods and are often popular parks, greenways, or trails. Encouraging compact development helps protect these areas and maintain the regional green infrastructure network.[69]

The cost of building, operating, and maintaining improved stormwater controls can be high, and climate change might increase those costs. Climate projections indicate that heavy precipitation events are very likely to become more frequent as the climate changes.[70] A triple-bottom-line (i.e., social, economic, and environmental) analysis can account for the social and environmental benefits of green infrastructure and other multi-benefit solutions and help justify the expense in terms of the total benefits achieved. Conducting a triple-bottom-line analysis on a regional or watershed scale can make these projects more appealing to the public and political leaders, which could help secure support to establish the controls.

[64] State of Maryland, Department of Natural Resources. *A User's Guide to Watershed Planning in Maryland*. 2005. http://dnr.maryland.gov/watersheds/pubs/userguide.html.
[65] Northern Virginia Regional Commission. "Northern Virginia Regional Water Supply Plan." http://www.novaregion.org/index.aspx?NID=1214. Accessed Mar. 1, 2012.
[66] Interstate Commission on the Potomac River Basin. "Home page." http://www.potomacriver.org. Accessed Sep. 6, 2013.
[67] State of California, Department of Water Resources. *Climate Change Handbook for Regional Water Planning*. 2011. http://www.water.ca.gov/climatechange/CCHandbook.cfm.
[68] EPA. *Handbook for Developing Watershed Plans to Restore and Protect Our Waters*. 2008. http://water.epa.gov/polwaste/nps/handbook_index.cfm.

[69] For information on green infrastructure approaches at the community and site levels, see Approach 4-A.
[70] U.S. Global Change Research Program 2009.

A regional stormwater management strategy could include some of the following options:

- Assess the impact of climate change on the region's water sector. This assessment could be performed in three phases:
  1. An academic institution or a regional entity could lead research to quantify the variability and magnitude of climate change impacts in the region. Key impacts could include increases in precipitation intensity and volume, sea level rise, and increases in air and water temperatures due to the heat island effect.
  2. A regional or watershed organization could interpret these impacts at a watershed scale and integrate them into regional water supply and ecosystem vulnerability assessments. The organization could coordinate with NOAA and the Federal Emergency Management Agency (FEMA) to update indicators such as flood plain designations and design storms.
  3. The organization could develop municipality- or infrastructure-specific (e.g., wastewater treatment plants, combined sewer outfalls, or water supply intakes) vulnerability assessments that individual municipalities and utilities can undertake to develop adaptation strategies. EPA's Climate Ready Water Utilities Program has tools that could help with this effort.[71]
- Assess the potential effects of climate change on regional ground water and surface water levels. High ground water levels and impervious surfaces can increase flows into sewer systems, which overwhelms the systems. This issue is particularly relevant in urban and suburban areas, where streams might have been filled and connected to sewers, ground water levels are high due to poor infiltration through soils, or ground water is pumped into the sewer system.
- Provide information on how green infrastructure stormwater management solutions can protect water quality, particularly with projected changes in precipitation patterns. Data aggregated across many regions are available, but generating data specific to a region would be more useful. A regional entity such as MWCOG or a university could compile an inventory of stormwater control projects and their performance for regional use.
- Identify natural areas such as forests, wetlands, and water bodies that buffer against flooding and water quality impacts from climate change and that should be protected. The George Washington Regional Commission, which includes Caroline, King George, Spotsylvania, and Stafford counties and the city of Fredericksburg, completed a regional green infrastructure plan in 2011 that created a green infrastructure map of the region and offered guidance to local governments on protecting these natural areas.[72]
- Use this regional stormwater management strategy to inform waterfront development, particularly along streams and rivers that will be resilient to projected changes in the climate. If stormwater is not managed effectively in upstream areas, low-lying downstream areas could have more runoff. *Smart Growth for Coastal and Waterfront Communities*[73] and Portland, Oregon's *South Waterfront Design Guidelines*[74] discuss stormwater management and other issues pertinent to waterfront development.
- Develop regional guidance on enhanced stormwater management approaches appropriate for the projected climate in the region that could be implemented at the community level.[75]

[71] EPA. "Climate Ready Water Utilities Toolbox." http://www.epa.gov/safewater/watersecurity/climate/toolbox.html. Accessed Aug. 16, 2013.

[72] George Washington Regional Commission [VA]. *2011 Regional Green Infrastructure Plan*. 2011. http://www.gwregion.org/regional-planning/reports-and-studies/regional-green-infrastructure-plan.

[73] EPA, NOAA, Rhode Island Sea Grant, and the International City/County Management Association. *Smart Growth for Coastal and Waterfront Communities*. 2009. http://www.epa.gov/smartgrowth/sg-coastal.html.

[74] Portland, Oregon, Bureau of Planning. *South Waterfront Design Guidelines and the Greenway Design Guidelines for South Waterfront*. 2002. http://www.portlandonline.com/bps/index.cfm?&a=59773.

[75] For more information on community-level stormwater management approaches, see Approach 4-A.

2-D BUILDINGS

Green building is a familiar topic to many of MWCOG's jurisdictions, and many green building techniques can also help prepare structures for climate-related impacts such as floods, power outages, and drought. Many resources exist for green building at the national level, such as the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) rating system[76] and the International Green Construction Code,[77] which can help local governments identify green construction best practices. At the regional level, MWCOG produced a report that offers recommendations for its member jurisdictions and analyzes the benefits and costs of green building.[78]

Regional assessments of green building activities and opportunities can be helpful because developers and builders operate throughout the region, and local governments in the region frequently look to each other to learn about strategies that work. A regional entity could help local jurisdictions incorporate climate adaptation and resilience measures into building standards could be helpful for the same reasons. Useful actions that regional governments could take include:

- Identifying best practices appropriate to the region.[79]
- Educating building professionals about building for resilience.

IDENTIFY BEST PRACTICES APPROPRIATE TO THE REGION

Identifying building practices that can make structures more resilient to climate change impacts requires knowledge of not only a variety of building practices, but also local climate and market conditions. Local governments might not have the resources or expertise to do the background research necessary to find the most feasible, cost-effective, and strategically important practices for local conditions. A regional entity could gather and analyze climate and market data and make that information available to local jurisdictions. For example, a regional government could maintain a resource with information on current and projected trends in temperature, precipitation, storm surge, sea level rise, and other climate-related hazards. It could model the effects of projected changes on buildings in the area or put the projections into a format that engineering designs could easily incorporate.

With the information on projected regional impacts, the regional entity could then compile building practices that respond to current and projected hazards. It could also develop sample cost-benefit analyses of incorporating various resilience strategies. Strategies might include retrofitting existing buildings to better protect them, building new structures with

Sources: top, Fort George G. Meade via Flickr.com; bottom, Arlington County via Flickr.com

Figure 11: The damage and widespread power outages from the derecho of June 29, 2012, highlighted the need for buildings that are resilient to strong storms.

[76] U.S. Green Building Council. "LEED (Leadership in Energy and Environmental Design)." https://new.usgbc.org/leed. Accessed Nov. 16, 2012.

[77] International Code Council. "International Green Construction Code." http://www.iccsafe.org/cs/IGCC/Pages/default.aspx. Accessed Nov. 16, 2012.

[78] COG Intergovernmental Green Building Group. *Greening the Metropolitan Washington Region's Built Environment: A Report to the Metropolitan Washington Council of Governments Board of Directors*. 2007. http://www.mwcog.org/store/item.asp?PUBLICATION_ID=304.

[79] Resilience of utilities is an important issue but was outside the scope of this project. A regional effort could explore climate trends that affect utility distribution and identify best practices for making utilities more resilient to climate-related impacts.

features that keep occupants safer and minimize damage to the structure, or relocating structures to safer areas.

Techniques that improve a building's resilience and environmental performance include those that help structures use energy more efficiently and keep buildings at comfortable, safe temperatures in extreme weather.[80] Other techniques include those used to prepare for natural disasters, such as strengthening the building against strong winds; moving heating, ventilation, and air conditioning (HVAC) and electrical equipment above projected flood levels; or flood proofing the ground floor. The location of a building, relative to the region as a whole, to the surrounding neighborhood, and to highly vulnerable areas, is also important for both its resilience and its environmental performance.

As resilient building techniques become more common, the regional entity could also study what effect these techniques have on building rents and sales. Is preparing a building for projected weather impacts a selling point? What is the return on investment for either retrofitting an existing building or strengthening a new one? Knowing that they can recoup their investment when they sell the building could encourage developers, builders, and homeowners to implement these best practices.

EDUCATE BUILDING PROFESSIONALS ABOUT BUILDING FOR RESILIENCE

Architects, contractors, builders, developers, and other real estate and construction professionals work throughout the region. Therefore, a regional education effort to teach them about the climate changes that are already happening and that are projected to happen, and about specific location types and construction techniques that could better protect buildings from damage and keep occupants safe and comfortable would pay off for all the region's jurisdictions.

A regional entity could partner with trade associations or colleges and universities to develop and deliver courses and other educational materials for which professionals could get continuing education credits. Local jurisdictions could also use these materials for their own training purposes or to set guidelines that builders of municipal structures would be required or encouraged to follow.

These educational materials could extend beyond structural techniques into how to communicate about risk and market more resilient buildings and communities. People who buy or rent buildings will value resiliency measures more if they understand the potential harm and how these measures help mitigate the harm.

The green building field can provide a model for encouraging resilient building practices. Many state and local governments have developed their own green building standards; similar efforts could develop regional resilience standards for buildings based on local climate projections. These resilience standards could use green building educational materials as a template or could be incorporated into existing green building education.

[80] Some of these techniques are described in Approaches 5-E and 5-F.

3 DISCOURAGE NEW DEVELOPMENT IN PARTICULARLY VULNERABLE AREAS

A fundamental step in planning for development is to determine where it makes sense to grow—and where it does not. As the climate changes, places where growth might have made sense in the past might no longer be safe for future growth. Discouraging new development in particularly vulnerable areas is a natural extension of the smart growth approaches that many communities in the Washington, D.C., region have been using for years to protect watersheds, farmland, and natural areas.

Just as many communities have determined in their comprehensive plans where they want to direct growth, they can prepare for climate change by identifying areas that are not developed and that are more vulnerable to flooding and other climate-related impacts. Communities can limit development in these areas to ensure that people, buildings, infrastructure, and other assets are not inadvertently put at risk. Doing so is a conservative approach to an uncertain future and can help avoid significant future costs. For example, if more-vulnerable areas are developed, people and assets might be put at risk, requiring protection, evacuation, or relocation. In addition, communities might not want to invest their limited infrastructure funds in areas where that infrastructure could be repeatedly damaged by climate-related impacts over its lifetime.

For the approaches described here to be effective, communities should first complete a robust vulnerability assessment to identify the most important community assets and planning issues (e.g., stormwater management or transportation) and then identify specific geographic areas where those assets are most vulnerable to the impacts of climate change. It would also be helpful to incorporate those highly vulnerable areas into the comprehensive plan and similar land use documents, including maps. Once highly vulnerable areas are identified, communities can consider the following approaches to identify those that are most appropriate for their context and needs:

A. Evaluate development incentives provided in particularly vulnerable areas.
B. Adopt protective regulations for particularly vulnerable areas.
C. Direct development away from particularly vulnerable areas within individual development sites.
D. Adopt or adapt a purchase or transfer of development rights program.
E. Establish a fund to acquire or protect land in particularly vulnerable areas.

Figure 12: This waterfront park in Alexandria, Virginia, along the tidal part of the Potomac River, is vulnerable to flooding.

3-A EVALUATE DEVELOPMENT INCENTIVES PROVIDED IN PARTICULARLY VULNERABLE AREAS

DEFINITION

Local governments typically have regulatory and financial incentives to guide the location and design of development. Incentives can either discourage development in highly vulnerable areas or encourage proper design and placement in vulnerable areas. Local governments can review their existing incentives to ensure that they are properly addressing development in particularly vulnerable areas. Local governments can also consider conducting a fiscal impact analysis to understand the connection between development choices and local incentives.

CLIMATE CONNECTION

Property owners make development decisions based on many factors, including the possibility of leveraging their development investment with local government incentives. Financial incentives include programs such as tax abatements, tax increment financing, capital investments (e.g., sewer lines), and other programs that are authorized by state and/or federal law. Local governments can also use zoning and subdivision regulations to permit density bonuses, fast-track project approval, or waive fees. In some communities, local governments have extended infrastructure (or required private extension of infrastructure) to encourage development, without fully considering the environmental impacts.

In particularly vulnerable areas, the benefits of encouraging development would have to be balanced with the potential for climate change-related hazards to harm property and people. Local governments can review both financial and regulatory development incentives to confirm that they do not encourage development in highly vulnerable areas and, where appropriate, do encourage development in less-vulnerable areas.

ADAPTATION PLANNING STAGE

Basic

RELEVANT SECTORS

Land Use: Most relevant sector. Avoids encouraging new development in highly vulnerable areas.

Transportation: Avoids incentives to build transportation infrastructure in particularly vulnerable areas.

Water: Can avoid the inadvertent incentive of allowing water infrastructure to be built in highly vulnerable areas.

Buildings: Can prevent buildings from being built in places where they would be at high risk.

RELEVANT HAZARDS

LOCAL EXAMPLES

Examples of incentives or fiscal analysis tools that local jurisdictions use include:

- Washington, D.C., has established priority areas for tax increment financing, including the Gallery Place area. Projects must be located in a priority area to qualify for tax increment financing funds.[81]
- Counties across Maryland—including the four counties in the MWCOG region—have adequate public facilities ordinances, which require that infrastructure and services be in place before new development can be built.
- 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.

[81] District of Columbia, Office of the Chief Financial Officer. "Tax Increment Financing Program (TIF)." http://app.cfo.dc.gov/services/economic/tif_program/index.shtm. Accessed Jun. 17, 2013.

BENEFITS

- Ensuring that development incentives are tailored to protect particularly vulnerable areas and encourage development in safer areas allows a local government to effectively allocate resources such as funds and staff time.
- Eliminating development incentives in highly vulnerable areas can reduce the money and effort needed to undertake hazard mitigation or recovery in the future.
- Adding fiscal impact analysis to development application reviews would allow local governments to take a big-picture look at the assumptions and impacts underlying major development in time to adjust site impacts and uses as necessary. If local governments do not include hazard mitigation in their fiscal impact analyses, they might consider doing so.

IMPLEMENTATION

Communities can better allocate their resources if they link development incentives, including the appropriate location of infrastructure, to growth and vulnerable area protection policies in their comprehensive and capital improvement plans. Incentives work most effectively when all relevant departments coordinate so that, for example, the public works department does not approve infrastructure extension into an area that the planning department has identified as particularly vulnerable.

Where permitted by state law, communities might also consider adopting an adequate public facilities ordinance or concurrency ordinance. These ordinances place infrastructure extension costs on the private sector and require the developer to justify the location of new infrastructure. They can help prevent extension of infrastructure into undeveloped, highly vulnerable areas at taxpayer expense.

A fiscal impact analysis is another method to identify development incentives that could be encouraging growth in particularly vulnerable areas. Typically prepared to assess major projects such as subdivisions, master-planned communities, or shopping centers, a fiscal impact analysis assesses the costs and benefits associated with the project. The analysis usually examines:

- Estimated population, traffic, and growth generated by the new development.
- Public services anticipated to be required by the development (e.g., roads, water, and sewer).
- Projected tax and other revenues (e.g., property and sales taxes and impact fees).
- Development-induced costs to the community's budget (e.g., for infrastructure improvements and maintenance or new schools).

To make the fiscal impact analysis more effective, local governments could add a requirement to evaluate the potential fiscal effects of developing in a currently or potentially hazardous area—for example, needing upgraded or larger stormwater management facilities or requiring additional emergency services to be available to respond to floods or other hazards.

Some steps that local governments can consider as they revise their development incentive policies include:

- Review current funding programs and tax and fee abatement programs as well as regulatory incentives to determine whether these programs are in line with climate adaptation objectives.
- Analyze the policies governing financial tools such as tax abatement, tax increment financing, and special districts to ensure that the use of these programs has clear limits in particularly vulnerable areas.
- Require an analysis of public funding and subsidies for every project located in or encompassing a particularly vulnerable area.

3-B ADOPT PROTECTIVE REGULATIONS FOR PARTICULARLY VULNERABLE AREAS

DEFINITION

Protective regulations, in the form of development requirements that limit or prohibit specific types of development permitted in highly 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, flood plain development standards, coastal setbacks, open space requirements, and resource-specific (e.g., agriculture, wildfire) zone districts or overlay districts.

CLIMATE CONNECTION

In many communities, areas that are particularly vulnerable to impacts from climate change are also places that are attractive, economically productive, ecologically important, and important to the community's character. Protecting these areas—including low-lying coastal areas, flood plains, wildlife habitat, forested areas, aquifer recharge areas, and agricultural land—benefits both the protected land and the people who rely on the land for economic, recreational, or environmental reasons.

Restricting development in these places leaves in place natural buffers that could mitigate some of the anticipated impacts of climate change such as increased flooding. Limiting construction in these areas also reduces the structures or residents in harm's way and can save the community money on disaster preparedness, response, and recovery.

Protective regulations can be tailored to local conditions, which makes them a valuable tool for local governments planning for climate change.

LOCAL EXAMPLES

- Virginia's Chesapeake Bay Act and Regulations, which most of the Virginia localities in the MWCOG region have implemented, require a 100-foot-wide vegetated buffer adjacent to and landward of all tidal shores, tidal wetlands, and non-tidal wetlands connected to tidal wetlands, or along water bodies with perennial flow.[82] These features, including the 100-foot buffer, comprise the Resource Protection Area.
- Like many other Virginia jurisdictions in the region, 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.[83] The overlay includes buffer requirements, tree and vegetation preservation standards, and a water quality impact assessment.

ADAPTATION PLANNING STAGE

Basic

RELEVANT SECTORS

Land Use: Most relevant sector. Protects areas that are most sensitive to climate change-related impacts while reducing new construction that could put more property and lives at risk.

Water: Restricts development in or near flood-prone areas and/or environmentally sensitive areas.

Buildings: Limits construction in areas more vulnerable to hazards such as floods.

RELEVANT HAZARDS

BENEFITS

- Local governments save money by not extending public services, infrastructure, emergency management, or liabilities to highly vulnerable areas.

[82] Code of Virginia. *Chesapeake Bay Preservation Act*. Adopted 1988. http://leg1.state.va.us/cgi-bin/legp504.exe?000+cod+TOC10010000021000000000000.

[83] City of Falls Church, VA. *Code of Ordinances*, Chapter 48, Article IV, Division 16. Adopted Dec. 12, 2011. http://library.municode.com/index.aspx?clientID=14329&stateID=46&statename=Virginia.

- Keeping development out of particularly vulnerable areas can help avoid fragmentation of those areas and can create buffers that protect water supplies.
- Objective standards for particularly vulnerable areas that are uniformly applicable across all development projects provide predictability for developers.
- When well drafted, these regulations do not require a significant staff or resource commitment to administer.

IMPLEMENTATION

Communities can protect particularly vulnerable areas with different strategies depending on the information available in the community's comprehensive plan; open space, sensitive lands, or flood plain and coastal planning; and/or existing regulations.

- The first step is to identify particularly vulnerable areas through the vulnerability assessment to determine which geographic areas are critical to protect. Local comprehensive plans, state agencies, and programs for enacting land dedication and set-aside standards for new development and subdivisions can also provide information about land that should be protected. Local stakeholders should be involved in the discussion of what types of areas should be considered vulnerable and what, if any, level of development is appropriate. Mapping particularly vulnerable areas early in the process can be helpful.
- The next 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 flood plain or coastal setbacks, communities could also consider adopting development restrictions in the 500-year flood plain or large-lot zone district requirements (e.g., 1 unit per 80 acres and larger lot sizes) that do not allow significant residential development in vulnerable areas identified in comprehensive plans. A range of development restrictions could distinguish areas where no development will be permitted from areas where development can be accommodated with size, location, or construction modifications.

Figure 13: This section of the Washington and Old Dominion Railroad Regional Park runs through one of Falls Church's Resource Protection Areas designed to protect the Chesapeake Bay watershed.

- Vulnerable area protection regulations could be incorporated into an existing land use code, making them subject to review and approval processes. Vulnerable area protection regulations are relatively straightforward and generally acceptable to a wide variety of constituencies. However, they can be controversial if they are highly restrictive and severely limit development. Developing the regulations through communitywide discussion can help ensure community support.

3-C DIRECT DEVELOPMENT AWAY FROM PARTICULARLY VULNERABLE AREAS WITHIN INDIVIDUAL DEVELOPMENT SITES

DEFINITION

Where an individual development site includes both developable and particularly vulnerable areas, communities can use flexible development tools such as cluster development, planned unit development (PUD),[84] or a vulnerable area overlay to allocate development on the site to the safer area. These tools shift development within the site to allow a project to reach the permitted density while protecting the particularly vulnerable area.

CLIMATE CONNECTION

Protecting highly vulnerable areas within a site and developing that site to the maximum permitted density or square footage are not necessarily mutually exclusive. Incorporating some flexibility in the regulatory process allows local governments to protect more-vulnerable areas through site design.

Where there is sufficient room on a site, local policies can require or encourage some or all of the permitted development to be located in the safer portion. Options include allowing flexibility in lot size, building height, or setbacks to protect vulnerable areas while letting the property owner develop as permitted. This approach can be most effective where the more-vulnerable area is located on one edge of the property, such as a shoreline, stream, or forest.

Communities can use PUD to allow flexibility in site design and development standards. Climate-sensitive PUD regulations might include provisions that encourage the protection of particularly 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.

ADAPTATION PLANNING STAGE

Intermediate

RELEVANT SECTORS

Land Use: Most relevant sector. Can protect vulnerable areas while still allowing development.

Transportation: Can prevent the extension of transportation infrastructure into or through vulnerable areas.

Water: Can protect riparian areas while still allowing development on the site.

Buildings: Can allow construction in buildable areas while keeping structures out of harm's way.

RELEVANT HAZARDS

The flexibility of PUD can protect particularly vulnerable areas in several ways through the site design process, including moving development away from shorelines or streams and designating open spaces within the site. PUDs are most effective when their specifications clearly state expected density and compact development requirements in buildable areas.

In communities that promote compact development to make neighborhoods walkable and preserve open space, cluster development can protect particularly vulnerable areas. In cluster development, homes are grouped on smaller lots on a small portion of the development to preserve a larger area as open space. The open space would include the more-vulnerable areas of the parcel. To use cluster development in this context, the developer would identify the vulnerable area and design the development around that area. Because cluster design is flexible, it can be used where the vulnerable area is in the center of the parcel or in discrete areas across the site, such as low-lying, flood-prone areas. Cluster development can protect vulnerable areas in perpetuity if the protected area is

[84] A PUD is a development negotiated with a municipality to receive more flexibility in layout, design, and land use than is available under the existing land use code.

donated to the local government or a land trust as permanent open space.

However, some cluster developments create pods of homes spread so far apart that residents have no choice but to drive to most destinations, which can work against a local government's efforts to reduce excess pavement and to encourage walking, bicycling, and transit use. Cluster development ordinances can include requirements that new development be contiguous with existing development to maintain connectivity.

LOCAL EXAMPLES

Several local jurisdictions have mechanisms that protect vulnerable areas or could be adapted to protect areas that will become vulnerable as the climate changes.

- Fairfax County, Virginia's Environmental Quality Corridors are incorporated in the comprehensive plan and designed to protect habitat quality; connectedness along wildlife corridors; and pollution reduction, including vegetative filtering and steep slope protection.[85] The location of the Environmental Quality Corridor on a site is negotiated during rezoning, special exception, special permit, variance, and related review processes.
- Baltimore County, Maryland, has established "density residential" zones that do not have minimum lot sizes and are intended to protect natural features and open spaces.[86]

BENEFITS

- Allowing carefully located development on parcels with highly vulnerable areas recognizes both the property owner's development expectations and the community's climate adaptation needs.
- Vulnerable areas are identified early in project design, when the site layout can typically be changed more easily at less cost to the applicant.
- Protecting highly vulnerable areas such as stream banks can protect drinking water supplies and provide natural buffers that can absorb flood waters.

IMPLEMENTATION

Code and policy changes to locate development in a safer portion of a site can include:

- Identifying particularly vulnerable areas in comprehensive, sector, area, or master plans and cross-referencing the plan's maps in the land development regulations.
- Providing clearly written, easy-to-understand regulatory changes, including:
    - Allowing or requiring cluster development or PUD on any parcel with mapped vulnerable areas.
    - 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. As an alternative to a PUD policy, a local government could establish a vulnerable area overlay zone that designates priority protection areas and allows site design on the remainder of the site to be negotiated based on the maximum densities or square footages that would be permitted by the underlying zoning.

These approaches could 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 density across a site, amended development standards, and clustered development.[87]

[85] Fairfax County, VA. *Comprehensive Plan*, 2011 Edition, Environment Section. http://www.fairfaxcounty.gov/dpz/comprehensiveplan/policyplan/environment.pdf.

[86] Department of Planning, Baltimore County, MD. "Zoning Classifications." http://www.baltimorecountymd.gov/Agencies/planning/zoning/classifications.html. Accessed Oct. 1, 2012.

[87] City of Scottsdale, AZ, Planning and Development Services. *Citizen's Guide to Environmentally Sensitive Lands*. Effective May 21, 2004. http://www.scottsdaleaz.gov/Assets/Public+Website/codes/CitizenGuide_ESLO_06-24-04.pdf.

3-D ADOPT OR ADAPT A PURCHASE OR TRANSFER OF DEVELOPMENT RIGHTS PROGRAM

DEFINITION

Nationally, purchase of development rights (PDR) and transfer of development rights (TDR) programs have increased as communities have found them to be effective tools to protect land by combining incentives and regulations. These programs typically preserve sensitive natural areas and agricultural lands.

In a PDR program, the local government buys development rights on a parcel that it wishes to protect. Development is prohibited in or near sensitive areas, but low-impact uses can continue.

In a TDR program, environmentally sensitive lands in a designated "sending" area are zoned to 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 can be more palatable than regulations alone.

CLIMATE CONNECTION

From a climate adaptation perspective, PDR and TDR programs could be particularly useful in situations where a local government wants to restrict development in particularly vulnerable areas such as flood plains, coastal areas subject to sea level rise or tidal surges, and aquifer recharge areas. A community could either use the vulnerable areas identified and mapped in the vulnerability assessment and local comprehensive plans or create a specific vulnerable area plan and map as part of the PDR or TDR program regulations. The plans would also identify areas particularly suitable for development in already-developed areas or newly designated growth areas. Under a TDR program, the vulnerable areas would be designated as sending areas and rezoned to limit development to an appropriate level. The landowners would be granted development credits to help offset any loss in value. They could sell those credits to developers in approved receiving areas.

ADAPTATION PLANNING STAGE

Advanced

RELEVANT SECTORS

Land Use: Most relevant sector. Protects particularly vulnerable areas while providing compensation to the property owner.

Water: Can be used to protect areas vulnerable to flooding or increased runoff, as well as buffers to protect water quality.

RELEVANT HAZARDS

Creating a PDR or TDR program typically requires intensive public involvement. This public engagement in developing the program helps the local government explore the relative value of vulnerable areas. The purchase or transfer calculations can be tailored to reflect the community's acceptance of the program and the value of limiting development in the particularly vulnerable areas to improve the community's resilience to climate change. For example, a coastal community could decide that the transfer of beachfront development rights is quite valuable and might be equal to double or triple the same development rights for an inland lot.

LOCAL EXAMPLES

Existing local PDR and TDR programs preserve land for its resource, scenic, recreational, or agricultural value, not for climate adaptation. However, the basics of these programs could be adapted to help protect against the weather-related impacts of climate change.

- The Virginia legislature authorized TDRs in 2006 and amended that legislation in 2009 to make

TDRs easier. Virginia has a model TDR ordinance for localities[88] as well as a model PDR program outline.[89] While several Virginia jurisdictions have PDR programs, few have TDR programs.
- In Maryland, a dozen counties have PDR programs, and several well-established and successful TDR programs, like the one in Montgomery County, could provide useful guidance to local governments considering using these tools.

BENEFITS

- PDR and TDR programs can protect areas potentially vulnerable to climate change impacts such as flooding, rising sea levels, and stronger storms.
- Landowners are compensated for the change in development rights, making it easier for local governments to protect highly vulnerable areas.
- TDR programs focus development in designated growth areas, supporting community efforts to channel future development into safer areas.
- Preserving open space helps reduce fragmentation of sensitive natural areas that provide ecological functions like protecting water quality.

IMPLEMENTATION

Successful PDR and TDR programs are grounded in a solid understanding of which areas in a community should have less or no development.

- In communities that already have PDR or TDR programs, local governments can analyze the results of their vulnerability assessment to determine if they need to adjust the areas designated for restricted development. For example, some areas identified in the vulnerability assessment as vulnerable to flooding or other impacts might not currently be designated as areas to preserve under the TDR or PDR program.
- If a PDR program already exists, the local government could consider the fee purchase of vulnerable lands and resale of those lands with conservation restrictions. This type of program needs more upfront funding and has longer carrying periods but can be more effective because land can be resold to recoup most of the sales price and will still be protected.
- If a TDR program already exists, the local government can also consider the vulnerabilities associated with the designated receiving areas to ensure it is encouraging development in the most appropriate places.
- For communities that want to initiate a PDR program, PDR programs can be funded annually out of general fund revenues, through a bond issuance, or through adoption of a dedicated funding source such as an earmarked sales tax. The adopting jurisdiction can also work with special districts (e.g., water supply or drainage districts) to use utility and other targeted fees or taxes to acquire properties that meet the goals of both the municipality and the special district, such as vulnerable areas that, if developed, would be expensive to serve and likely to suffer infrastructure damage in a flood or strong storm.
- To establish a TDR program, the local government would consider the mechanics of the process (e.g., how to determine how many development rights are assigned to a particular property and how to document the transfer) and how large the sending and receiving areas should be in relationship to one another to create a viable market for development rights.

Local governments could start by adopting a voluntary TDR program covering designated vulnerable areas. For greater impact, the local government could adopt a TDR program combined with downzoning vulnerable (sending) areas and increasing the density of the receiving area.

[88] Virginia Department of Agriculture and Consumer Services. *A Model Transfer of Development Rights Ordinance for Virginia Localities*. 2010. http://www.vdacs.virginia.gov/preservation/pdf/Model%20TDR%20Ordinance.pdf.
[89] Virginia Department of Agriculture and Consumer Services. *A Model Purchase of Development Rights (PDR) Program for Virginia*. 2005. http://www.vdacs.virginia.gov/preservation/pdf/pdfprogram.pdf.

3-E ESTABLISH A FUND TO ACQUIRE OR PROTECT LAND IN PARTICULARLY VULNERABLE AREAS

DEFINITION

In addition to, or as an alternative to, adopting regulations to protect particularly vulnerable areas as described in Approach 3-B, local governments could establish a fund to purchase land or acquire an interest (e.g., an easement) in highly vulnerable land. This approach permits the local government to place appropriate limits on development in that area.

CLIMATE CONNECTION

In some cases, for long-term protection of particularly vulnerable areas, it could be appropriate for a local government to buy and manage the area. Such a case might occur where development pressure influences local economic and policy choices, such as allowing resort development in a coastal area susceptible to sea level rise and storm surges. It could be because private-sector action to protect a vulnerable area would be difficult to coordinate, such as creating a wetland buffer across several individually owned parcels. Or it could be because local government ownership would benefit both the community and the current property owner. For example, the local government could buy a property that regularly floods and convert it to a park. The property owner would no longer have to deal with floods, and the community would get more park land.

Where local government ownership or long-term oversight is a good investment for the community and can create an appropriate use in particularly vulnerable areas, the local government would need to establish a funding source to buy the land outright or to purchase an easement to restrict development. Funding sources can vary, and each can have restrictions on its activation and use. Because of these requirements, local governments might need significant lead time to establish an acquisition program.

Some types of easements, such as rolling easements, are designed to change as the landscape changes.

ADAPTATION PLANNING STAGE

Advanced

RELEVANT SECTORS

Land Use: Most relevant sector. Allows restriction of development while compensating the property owner.

Water: Can be used to protect particularly vulnerable areas affected by flooding or increased runoff.

Buildings: Can be used to buy and demolish structures in particularly vulnerable areas.

RELEVANT HAZARDS

Rolling easements allow owners to use the land, but they are prohibited from implementing measures to harden the shoreline. As the shoreline changes—for example, due to sea level rise—the easement automatically "rolls" inland.[90]

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 reforest those areas if necessary.[91] The authority for this activity is Maryland's Forest Conservation Act. The act requires developers to mitigate forest losses, with the rate of allowed clearing and required replacement depending on the land use category. Riparian areas are priority areas for protection and mitigation and can be transferred to public ownership as an easement.

[90] NOAA. "Erosion Control Easements." http://coastalmanagement.noaa.gov/initiatives/shoreline_ppr_easements.html. Accessed Nov. 6, 2012.

[91] Frederick County, MD. "Fee-in-Lieu Program." http://frederickcountymd.gov/index.aspx?NID=1631. Accessed Mar. 2, 2012.

- Land trusts can often be valuable partners in acquiring or protecting land. For example, the Northern Virginia Conservation Trust is working with the city of Alexandria, Virginia, to protect land in a "Green Crescent" that would link disconnected green spaces by protecting land along rivers and streams. Both the city and the trust acquire land to complete the crescent as described in the city's open space plan.[92]

BENEFITS

- Acquiring land lets local governments manage particularly vulnerable areas in a more comprehensive, long-term way.
- Acquiring land or an easement is likely to be less controversial than regulatory action.
- Having control over particularly vulnerable areas could eliminate the need to change regulations if conditions change. For example, if flooding is greater than anticipated, the local government would not need another round of regulatory changes to establish new setbacks to protect property owners because it would own the land.
- Protected land can contribute to local economies by attracting tourism, recreation, hunting, or fishing.
- Local governments save money by reducing or eliminating the need to extend public services and infrastructure to highly vulnerable areas.

IMPLEMENTATION

For some communities, establishing a fund to purchase particularly vulnerable areas or acquire partial title will be a new program. To ensure that they are using their funds on the most critical areas, communities can closely coordinate the purchase of vulnerable lands with the goals and policies in the comprehensive plan or other appropriate plans, such as open space and recreational plans. Because land acquisition is not a regulatory program, the local government might need to determine a specific enabling authority for the purchase program and funding beyond the state statutory authority relied upon for land use regulations. Depending on the jurisdiction and funding source, the funds might need to be accounted for in the capital improvements program.

The first step in an acquisition program is generally preparing a methodology report that examines the goals of the program, the potential funding sources, and the anticipated outcomes. The methodology report would provide detailed estimates of each potential funding source's revenue stream.

Examples of funding sources that communities might choose include sales taxes, general obligation or revenue bond issuances, gaming or lottery revenues, excise or transfer taxes, general fund appropriations, and special districts (taxing or self-funded). Once the local government has selected a funding source, it would need to be established and maintained as required by state or local law or through home rule authority.

Once funding is available, the local government will need to determine how it wishes to acquire vulnerable areas. Options include purchasing properties as they come on the market, offering to purchase property through a willing seller/willing buyer program, or acquiring land at fair market value through eminent domain when justifiable and endorsed by community consensus. The actions taken will depend on both available funds and how the community chooses to protect vulnerable areas.

Based on the community's comprehensive, open space, or recreational plans and the methodology report, the local government can establish policies that identify the properties to be purchased, the method of purchase, and how the properties will be managed in the long term. A separate oversight body or advisory board could help provide consistent guidance.

[92] Washington Smart Growth Alliance. "Alexandria's Green Crescent." *2009 Conservation Priorities*. 2009. http://www.sgalliance.org/documents/RCPL_2009.Alexandria.pdf.

4 PROTECT PEOPLE AND ASSETS IN VULNERABLE AREAS

When thinking about how to protect people and property in vulnerable areas from hazards such as storm surges or flooding, many communities think of engineered protective structures like sea walls or dikes. These approaches have their place and can be part of a community's overall hazard mitigation or climate adaptation strategy, but they often achieve only one goal—blocking the hazard—and sometimes can be expensive or cause inadvertent harm to other areas, like a flood barrier that channels floodwaters downstream and increases flooding in other communities. And although they tend to perform well up to their performance limit, once they reach that limit, the failure can be catastrophic.

The approaches described here are intended to meet multiple goals—not only protecting property and lives, but also saving local governments or residents money, reducing pollution, adding attractive amenities to a community, or improving residents' quality of life.

A. Improve stormwater management approaches.
B. Adapt zoning and building codes to evolving risks.
C. Create special districts to fund retrofits and upgrades for public buildings and infrastructure.
D. Identify and address transportation system vulnerabilities.
E. Implement heat island reduction strategies.
F. Streamline and fund the relocation process.

Figure 14: Washington Canal Park in Washington, D.C., uses rain gardens and permeable paving materials to capture rainfall and store it for reuse. Its light-colored surfaces and vegetation help reduce ambient air temperatures.

4-A IMPROVE STORMWATER MANAGEMENT APPROACHES

DEFINITION

Stormwater management is the practice of managing the quantity and quality of runoff from precipitation. Stormwater systems are designed to protect property and ensure public safety by carrying excess water away from structures, preventing flooding, and controlling pollution entering waterways.

CLIMATE CONNECTION

In the metropolitan Washington region, climate change is projected to cause stronger storms and to concentrate more precipitation in fewer events.[93] These changes in the timing and quantity of precipitation will likely increase stormwater runoff, especially when soil is already saturated or when precipitation exceeds the design capacity of the stormwater management system. Intense rainfall can overwhelm stormwater infrastructure, leading to localized flooding. Studies have suggested that historical data alone are no longer sufficient for calculating stormwater infrastructure requirements because of climate change. If communities continue to use historical data, they might need to update the data more frequently to capture recent climate trends.[94]

Many communities in the United States have stormwater systems that are separate from sewage conveyances. However, over 750 communities in the United States, including Washington, D.C., and Alexandria, Virginia, have combined sewer systems that collect rainwater runoff, domestic sewage, and/or industrial watewater in the same pipe to convey it to a wastewater treatment plant. During rare periods of extremely heavy precipitation, the sewer system or wastewater treatment plant might not have enough capacity to accommodate the added water volume. In these cases, the systems can overflow into nearby streams, rivers, or other water bodies. This overflow causes raw sewage to enter waterways, which harms water quality and threatens public health, and also causes high rates of stream flow, which erodes stream banks and deposits sediment, nutrients, and other pollution downstream.[95]

In addition, areas with more impervious surfaces such as roads and parking lots (through which water cannot naturally infiltrate) can have higher volumes of stormwater runoff. During intense precipitation events, watersheds with a significant proportion of impervious surface can experience higher peak flows, exacerbating local flooding and damaging stream banks. Increases in high-intensity rainfall events associated with climate change can exacerbate this problem, as can increases in the amount of impervious surface in a watershed.[96] These factors highlight the importance of managing the amount of paved area as a critical strategy for addressing some of the impacts of climate change.

ADAPTATION PLANNING STAGE

Basic

RELEVANT SECTORS

Transportation: Can reduce runoff from and flooding of roads.

Water: Most relevant sector. Can increase ground water infiltration, reduce the volume of runoff, and reduce demands on potable water by reusing captured stormwater for nonpotable uses.

Buildings: Adds elements such as trees, rain gardens, and other vegetation around buildings to slow, filter, and collect stormwater runoff with additional benefits such as reduced cooling needs and increased property values.

RELEVANT HAZARDS

[93] U.S. Global Change Research Program 2009.

[94] Forsee, William Joel, and Sajjad Ahmad. "Evaluating Urban Storm-Water Infrastructure Design in Response to Projected Climate Change." *Journal of Hydrologic Engineering* 16.11 (2011): 865-873.

[95] EPA. "Combined Sewer Overflows." http://cfpub.epa.gov/npdes/home.cfm?program_id=5. Accessed Nov. 5, 2012.

[96] Denault, Catherine, Robert G. Millar, and Barbara J. Lence. "Assessment of Possible Impacts of Climate Change in an Urban Catchment." *Journal of the American Water Resources Association* 42.3 (2006): 685–697.

In areas facing water shortages due to increased demand as well as increased periods of dry weather, stormwater management practices can be designed to help retain water in the watershed to recharge ground water, augment base stream flow during dry periods, and capture and store water for later use, all of which help to build resilience to climate variability.

Understanding how vulnerable a system is to the changing climate requires an assessment of a wider range of variability than has been used in the past. The community's vulnerability assessment should help the local government understand the factors that affect stormwater management under various scenarios.

Municipal governments and states have historically implemented state and federal regulations and local development ordinances to reduce peak stormwater runoff. Water quality-based regulations, such as combined sewer overflow or municipal separate storm sewer permits, impose specific requirements that guide stormwater management. Hard engineering solutions have often been used to meet these requirements. However, many communities are now using green infrastructure measures.

Green infrastructure at the site level includes features that slow, capture, filter, and/or absorb stormwater runoff in ways that mimic natural processes. Some approaches include:

- Reducing the amount of impervious surface by using pervious concrete, pavement, or pavers or replacing unneeded pavement with green space.
- Using elements such as cisterns, rain barrels, and rain gardens on small lots.
- Adding to public rights-of-way elements such as bioswales (vegetated swales that capture and filter runoff) and enhanced tree pits (tree planting areas that include specially engineered soils and native plants to absorb and filter runoff).
- Capturing and reusing rainwater for irrigation in large industrial, institutional, commercial, and residential lots.
- Using green roofs or other rooftop retention elements to store rainfall and let it drain gradually.
- Adding large-scale stormwater management facilities, including constructed or natural wetlands.
- Creating storage underneath parking lots, streets, and sidewalks that can be designed to drain gradually into the sewer system or infiltrate into the ground.

Figure 15: The retrofit of Decatur Street in Edmonston added rain gardens that capture and filter stormwater.

LOCAL EXAMPLES

- Edmonston, Maryland, retrofitted its main street with green infrastructure, including bike lanes with pervious pavement and rain gardens. The street had frequently flooded during storms and dumped polluted stormwater directly into a Chesapeake Bay tributary. The new green street is designed to capture the runoff from 90 percent of storms in a typical year.[97]
- Maryland's Stormwater Management Act of 2007 requires that all new development implement environmental site design practices so that stormwater at the site will mimic runoff

[97] Town of Edmonston, MD. "Project Green Street." http://edmonstonmd.gov/GoingGreen.html. Accessed Feb. 2, 2012.

quantities that were present prior to development.[98]

- Alexandria had a consultant assess its storm sewer capacity and how the city might update its stormwater design criteria based on historical data and a range of climate change scenarios.[99]

BENEFITS

- Rainwater can be captured for nonpotable uses or allowed to replenish ground water instead of being discharged into combined sewers. When designed to capture the first 1 to 1.5 inches of rainfall, green infrastructure can reduce flooding from even large storm events.
- Above-ground stormwater management systems such as swales and vegetated buffers offer flexibility and scalability to respond to future changes in conditions (e.g., climate changes) or requirements (e.g., regulations).
- Adding green infrastructure elements makes streets more pleasant for all users and can encourage walking and bicycling.
- Some green infrastructure strategies can also reduce the heat island effect by adding shade from trees, replacing asphalt and concrete with planted areas where appropriate, or using light-colored, pervious pavement for paved areas.[100]

IMPLEMENTATION

Although many of these implementation steps are more appropriate for urban and suburban drainage areas, they can also be effective for many rural areas that need to control erosion and runoff.

Communities can use voluntary programs and incentives in the beginning of a phased implementation program and could eventually require controls to meet regulatory targets. Implementation can be challenging in highly developed areas due to limited available land and high costs. In suburban and rural areas, the benefits from some of the practices might be marginal, but because more land is available, the facilities can be larger, which can improve results. Each community will need to determine whether or how to adopt these practices based on the ease of implementation, cost (including maintenance, which can be critical to the selected practice's ability to manage stormwater), and anticipated benefits.

- Local governments could amend ordinances and codes to:
  - Require stormwater controls and rainwater capture and reuse at the site and neighborhood scales, in addition to existing pre- and post-development runoff regulations.
  - Include criteria aimed at protecting water quality and controlling erosion. For example, development permits could require site-scale detention to achieve a lower discharge limit from each acre of impervious area.
  - In a combined sewer system, require developers to achieve a no-net-increase in combined sewer overflow volumes or frequencies after construction within a watershed.
  - Include a criterion to capture and infiltrate up to 1 or 1.5 inches of rain generated from the impervious portion of a development site. Green infrastructure techniques such as rain gardens, rain barrels, and bioretention could achieve this requirement.
- Localities can create stormwater utilities or districts to fund areawide stormwater improvements. Such districts could include a fee based on property size and amount of impervious surface.
- Enhanced building standards could be required for new and redevelopment projects, while existing buildings could be encouraged to adopt them through incentives. Describing standards in simple terms will make it more likely that developers' permit applications will be consistent and will achieve community goals.

[98] Maryland Department of the Environment. "Facts About Stormwater Management Act of 2007." May 7, 2007. http://www.mde.state.md.us/assets/document/Stormwater%20Act%202007%20Update.pdf.

[99] van der Tak, Laurens. "Build Smart: CH2M Hill: Climate Change & Innovative Urban Planning." *livebetter* e-magazine. Issue No. 12, 2011. http://livebettermagazine.com/eng/magazine/print_article.lasso?id=209&-session=user_pref:42F947961dc9b11BFCMUHI1092DD.

[100] See Approach 4-E for more on strategies to reduce the heat island effect.

  - Green building standards can support stormwater capture through green roofs, infiltration practices, or capturing and reusing rainwater for nonpotable uses. Financial incentives to reduce potable water demand, reuse graywater,[101] or install green roofs can encourage these practices. This reuse might require modification of plumbing codes and treatment requirements, which would have to happen at the state level for Virginia.

- Municipalities can encourage households and small businesses to use small-scale stormwater management practices (e.g., rain barrels, rain gardens, swales, or planting trees) to achieve watershed-wide benefits. Public outreach and community involvement can help people learn about available techniques, encourage neighborhood-scale projects, and share information on operation and maintenance. Community involvement can be a low-cost, high-impact technique, but projects can take longer to implement.
- Roads, parking lots, and other transportation-related paved areas represent a large proportion of ground cover in most communities. This land usually has more pollutants such as oil, particulates, and other contaminants. Communities can develop guidelines for green infrastructure strategies along streets that can capture stormwater to prevent flooding and irrigate street trees and landscaping. In large parking lots, communities could allow pervious pavement or pavers and other green infrastructure techniques to minimize stormwater runoff and add greenery.
- Resizing or reconfiguring existing stormwater controls can be particularly useful for places with existing detention ponds sized and built based on historical data that might no longer be valid given projected precipitation changes. For example, detention ponds originally designed for controlling a 10-year design storm[102] (based on historical data) might not be adequate to control peak flow from a new design storm (based on projections) with increased volume. Where allowed by state law, communities could adjust their design standards periodically based on new climate projections and, where feasible, resize existing stormwater ponds. However, there might be some resistance to changing standards based on projected changes rather than historical data. In addition, some communities rely on state agencies to update guidance on design storms and might not be able to change the requirements on their own.
- Local agencies responsible for parks, transportation, and wastewater have their own green infrastructure programs. Coordinating and streamlining technical and financial resources can facilitate implementation at all scales.

[101] "Graywater" is water that has been used in washing machines, showers, and baths and is collected for nonpotable uses such as watering lawns or flushing toilets.

[102] A design storm is the largest amount of rain expected over a 24-hour period within a specified interval such as 10 years. Design storms are used to plan stormwater management structures and features.

4-B ADAPT ZONING AND BUILDING CODES TO EVOLVING RISKS

DEFINITION

Many communities rely on zoning and building codes to protect health and safety. Zoning codes include specifications such as setback (or set-to) lines, lot sizes, building heights, amount of impervious surface area, and permitted uses, while building codes specify ventilation, insulation, fireproofing, structural integrity, and other design aspects.

Greenfield development on the rural edge of the metropolitan Washington region is more likely to happen "by right," meaning that once the development has met the zoning code requirements, no further review is needed. However, infill and redevelopment are often more complex, in part because they need to be carefully stitched into the existing community fabric.

Communities have a range of development review processes, including public input processes, planning review boards, and site design standards, among others. Many of the region's jurisdictions give planning boards and county councils discretion when approving development proposals.

CLIMATE CONNECTION

Most communities' land use and building codes were established based on historical weather patterns and their associated risks. Some communities have allowed development in areas that are already known to be hazardous. For example, some communities permit development in or very near flood plains as long as the structures are elevated above the projected flood level. These flood plains could flood at higher levels in the future, threatening property and residents who might now consider themselves safe.

In communities where developed areas could become increasingly vulnerable to climate change or are on land that provides valuable ecosystem services such as protecting water supply watersheds, more anticipatory, dynamic, flexible land use and building codes and approval processes can help ensure that development in particularly hazardous areas protects assets and human health and safety as much as possible.

ADAPTATION PLANNING STAGE

Intermediate

RELEVANT SECTORS

Land Use: Most relevant sector. Adjusts development standards based on risk to make development in vulnerable areas safer.

Buildings: Most relevant sector. Updates building standards to help buildings better withstand climate-related impacts.

RELEVANT HAZARDS

LOCAL EXAMPLES

No communities in the region appear to have changed zoning and building codes in response to increasing risks related to climate change.

BENEFITS

- Periodically reviewing and updating zoning, building, and other development regulations can help ensure that new development is occurring in the most suitable locations and that new development in particularly vulnerable areas follows measures to be safe. This regular review process can allow a community to consider climate-related zoning changes in a way that aligns with its overall climate adaptation planning.
- Incorporating evolving, rather than static, predictions of climate-related stresses on structures into building codes helps make buildings more resilient and durable throughout their lifetimes and can lower operating costs by using energy and water more efficiently. More climate-resilient buildings will better protect their inhabitants and help reduce economic

losses and societal disruption from extreme weather events.

- Allowing development and redevelopment in hazard-prone areas, done in a safer way and subject to a risk-based review, continues to bring property tax revenue to the community and can prevent these areas from becoming blighted in the wake of a disaster.

IMPLEMENTATION

The challenges that typically accompany updates and changes to codes, standards, and policies include real and perceived increased uncertainty for those seeking approvals, the time it takes everyone to become familiar with the new rules, and resistance to change. Although some developers might see the changes as tightening building and development codes, the local government could emphasize how the changes create more flexible and responsive policies and requirements that are more open to innovative solutions to evolving risks. In the process of addressing these emerging risks, the community can more clearly define its goals and aspirations, rather than focusing only on preventing undesirable outcomes.

Most local governments would need to do an initial review of their codes to determine which parts of the codes are allowing development that is not appropriate for changing climate conditions or which parts could become more dynamic or flexible. Subsequent reviews of the climate-related elements of land use regulation and building codes could be done as part of a regular code review process. Local governments could establish regular intervals—for example, every three years—to review how development is proceeding in hazardous and potentially hazardous areas and use updated climate projections to change the codes if needed.

Local governments could also engage developers to help create standards for development in areas that have frequent flooding or other hazards that are not yet severe enough for the government to consider restricting development in those areas. As the risks change over time, keeping developers involved in adjusting these standards can help keep mitigation options cost-effective.

In states with statewide codes, localities are allowed to incorporate local climate and other conditions. Communities can develop stricter requirements for buildings in areas vulnerable to flooding, high winds, wind-driven rain, extreme temperatures, drought, and wildfires, as well as areas predicted to become more vulnerable to extended utility outages. In Virginia, however, localities cannot adopt a code that is more stringent than the Virginia Uniform Statewide Building Code, with the exception that in flood plains, a locality can increase its freeboard requirements.[103,104]

Communities could consider adopting "stretch" codes, which are more stringent, voluntary codes that incorporate innovative practices. These codes ease the design and approvals process for more energy-efficient buildings and can be accompanied by incentives. The International Green Construction Code incorporates many provisions to increase resilience.[105] Communities could consider adopting this code as either a mandatory or voluntary code.

To encourage upgrading existing buildings, communities could tie changes and increased requirements to changes in occupancy, ownership, and significant renovations or additions to minimize hardship on owners and occupants.

If these existing buildings are out of compliance with codes, they are known as nonconforming structures. To encourage nonconforming structures or uses to be replaced or removed over time, most communities have zoning and building code controls on their expansion or renovation. These regulations usually require full compliance with all current standards, such as setbacks, height, or 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 structure's value). Moreover, these regulations rarely

[103] Freeboard means elevating a building's lowest level by a small additional amount over the predicted high-water mark from a flood.
[104] Personal communication with Emory Rogers, director, Division of Building and Fire Codes, Department of Housing and Community Development, Commonwealth of Virginia, on May 9, 2013.
[105] International Code Council. "International Green Construction Code." http://www.iccsafe.org/cs/igcc/pages/default.aspx. Accessed Nov. 1, 2012.

allow any type of expansion (e.g., elevating a building to reduce the chances that it will flood).

While these regulations make sense in many circumstances, they can have serious unintended consequences in areas that have suffered or could suffer major storm damage. Because of the potential cost of full compliance with current standards, property owners could be tempted to undertake only minor repairs to make their structures habitable and avoid major upgrades—which could make the structures more hazard resilient—for fear of triggering the nonconformity provisions. This disincentive could actually render a property less safe. Some property owners might choose to abandon rather than rebuild their properties, leading to long-term neighborhood blight and loss of local government tax revenues. Local governments also often have 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, some communities implement development standards that require or provide incentives to redevelop or rebuild nonconforming structures to make them more hazard resilient. Incentives for redevelopment of nonconforming structures, when coupled with requirements for greater hazard resilience, could help ensure that existing development in hazard-prone areas such as coastlines and flood plains becomes more capable of withstanding adverse weather events that could be worsened by climate change.

Communities could amend the nonconforming use and structure standards of the zoning regulations to allow these structures or uses to expand their floor area with administrative approval, provided they also comply with hazard resilience standards. Communities could consider using special or conditional use permits for changes that affect a larger geographical area.

4-C CREATE SPECIAL DISTRICTS TO FUND RETROFITS AND UPGRADES FOR PUBLIC BUILDINGS AND INFRASTRUCTURE

DEFINITION

Public structures and infrastructure might 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, communities might need special taxing or assessment districts to accomplish changes beyond the scope of typical capital improvement programming.

CLIMATE CONNECTION

Public buildings and infrastructure often need to function continuously through weather emergencies such as hurricanes or major storms and through periods of extreme temperatures and drought. Frequently, however, they either were not constructed with these extremes in mind or they and their attendant mechanical systems have aged since their original construction. An example is the combined sanitary and stormwater sewer system that can still be found in many communities, including some in the metropolitan Washington region. More frequent flooding with higher volumes of water causes stormwater and sanitary sewer loads to combine and be discharged into water bodies together. In another example, the electrical grid can strain to provide the electricity needed for air conditioning during prolonged heat waves.

By retrofitting these facilities before stress or disaster hits, local governments might be able to save money by not having to undertake expensive reconstruction, by using a well-managed bid and construction process, and from the updated and potentially more efficient structures. In addition, they will ensure smoother functioning in an emergency.

To pay for these changes, local governments can create special taxing or assessment districts that disperse tax or fee payment across all of the users of the public building or infrastructure. The monies that are collected from the special tax or assessment can be used to fund upgrades on a pay-as-you-go basis, to support the issuance of bonds, or, particularly with respect to transportation infrastructure, to create a public-private partnership for upgrades.

The assessment could be augmented with state emergency preparedness funds, a FEMA Pre-Disaster Mitigation Grant,[106] and/or U.S. Department of Housing and Urban Development Community Development Block Grants.[107]

ADAPTATION PLANNING STAGE

Intermediate

RELEVANT SECTORS

Transportation: Could upgrade transportation infrastructure.

Water: Could upgrade water, sewer, and stormwater infrastructure.

Buildings: Most relevant sector. Can fund upgrades of structures in anticipation of future climate change-induced stresses.

RELEVANT HAZARDS

LOCAL EXAMPLES

Special taxing or financing districts are commonly used across the United States. Examples of special districts in the metropolitan Washington region include:

- In Virginia, community development authorities are authorized to establish, finance, and operate infrastructure projects paid for through

[106] FEMA. "Pre-Disaster Mitigation Grant Program." http://www.fema.gov/pre-disaster-mitigation-grant-program. Accessed Feb. 15, 2012.

[107] HUD. "Community Development Block Grant Program – CDBG." http://portal.hud.gov/hudportal/HUD?src=/program_offices/comm_planning/communitydevelopment/programs. Accessed Feb. 15, 2012.

special assessment, tax increment financing, or both.[108]

- 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 property acquisition and maintenance.[109]
- Property owners in the Downtown D.C. Business Improvement District agreed to a special assessment tax that is used in part to fund programs to increase energy efficiency and encourage neighborhood-scale environmental sustainability.[110]

BENEFITS

- Anticipatory upgrades to public structures and infrastructure can be more cost-effective than reactive upgrades because they can use the usual bid processes instead of having to seek bids quickly for emergency rebuilding. They can allocate the costs to the structure's users and avoid having to pay for emergency reconstruction out of the general fund.
- Energy-saving upgrades can help local governments save money on building maintenance and operations over time.
- Improved building materials and technology such as green roofs can manage stormwater and reduce cooling loads.
- With upgraded infrastructure, businesses and residents should experience less weather-related disruption of public utilities, and buildings and infrastructure should perform more reliably even outside of emergencies.

IMPLEMENTATION

The local government's vulnerability assessment should have identified structures and infrastructure that are in or near particularly vulnerable areas and could be damaged by climate-related weather impacts. Using this information, the local government can assess which structures need retrofits or upgrades. With these facilities identified, the municipality can determine how to draw the boundaries for districts that would benefit from upgrading infrastructure.

Special districts can fund infrastructure improvements by raising bonds or through a tax assessment. For example, using an ad valorem tax, the Lee County, Florida, All-Hazards Protection Fund funds projects such as hurricane shelter improvements and public safety infrastructure upgrades.[111] In planning for retrofits and upgrades, the special district can also consider how these projects could bring multiple benefits beyond resiliency, such as adding attractive and functional features such as rain gardens that absorb stormwater, providing new public space for the community, or improving energy efficiency to save money and conserve natural resources.

While a local government and property owners might want to form a special district specifically to prepare for climate change impacts, forming a new special district can take a long time, depending on the jurisdiction. In the meantime, local governments could work with existing special districts that currently fund infrastructure to help them identify vulnerable structures and infrastructure and incorporate projected climate change impacts into plans for new infrastructure.

[108] Painter, Andrew. "Community Development Authorities." *University of Richmond Law Review* 45.1 (2010). http://lawreview.richmond.edu/wp/wp-content/uploads/2010/12/Painter-451.pdf.

[109] Anne Arundel County, MD. *Anne Arundel County Code*. Section 4-7-204(d), Special Community Benefit Districts: Arundel-on-the-Bay Special Community Benefit District. Adopted Nov. 9, 2005. http://www.aacounty.org/CountyCode/index.cfm.

[110] Downtown D.C. Business Improvement District. "EcoDistrict." http://www.downtowndc.org/programs/ecodistrict. Accessed Oct. 15, 2012.

[111] Lee County, FL, Public Safety and Florida Division of Forestry. *Lee County Community Wildfire Protection Plan*. 2011. http://www.lee-county.com/gov/dept/dcd/Planning/Amendments/Documents/RA2012/CPA2011-17/CPA201117A1.pdf.

4-D IDENTIFY AND ADDRESS TRANSPORTATION SYSTEM VULNERABILITIES

DEFINITION

The metropolitan Washington regional transportation system is managed by federal, state, regional, and local agencies depending on the jurisdiction and the transportation mode. For example, the commonwealth of Virginia controls and maintains most public roads, while in Maryland, local governments own local roads. Regardless of ownership, local governments are often best able to identify weaknesses in their community's transportation system and have an important role to play in maintaining and enhancing transportation infrastructure.

Nearly all local governments perform near-term (e.g., three to six years) capital improvement planning. Some jurisdictions incorporate long-range transportation planning into their comprehensive plans. In the Washington region, local transportation planning is coordinated through the National Capital Region Transportation Planning Board, the region's MPO. MPOs and the U.S. Department of Transportation provide critical guidance, coordination, and oversight to the local transportation planning process. The MPO also coordinates local transportation planning activities with the region's Transportation Improvement Program and long-range transportation plan.[112]

A region's Transportation Improvement Plan and long-range transportation plan analyze economic growth, changing development patterns, and a list of priority projects for funding. Currently, few transportation plans explicitly address projected climate change impacts. By including these considerations in transportation planning, local governments can identify transportation system vulnerabilities that they or the regional transportation planning process can address.

ADAPTATION PLANNING STAGE

Intermediate

RELEVANT SECTORS

Land Use: Affects land uses around transportation facilities; can encourage compact development to make transportation options more feasible.

Transportation: Most relevant sector. Informs transportation programming, location, and facility design for reliable operations during disruptions.

RELEVANT HAZARDS

CLIMATE CONNECTION

Climate changes such as increased temperatures, more precipitation, more severe storms, and sea level rise can cause severe disruptions to transportation systems by buckling pavement and rail tracks and damaging or blocking roads and rail lines with flooding or debris from storms. Flooding, extreme heat, ice, and other weather events cost the country millions of dollars annually in delayed freight deliveries, lost productivity, wasted fuel, physical repairs, and other delays. These costs can weaken regional economic competitiveness, quality of life, and health and safety.

Working within the existing transportation planning process, local governments can analyze potential transportation vulnerabilities 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 to protect vulnerable assets.

Local governments have both the authority and responsibility to determine how they want to adapt their assets to the potential hazards of climate change through protecting, retrofitting, or relocating infrastructure.

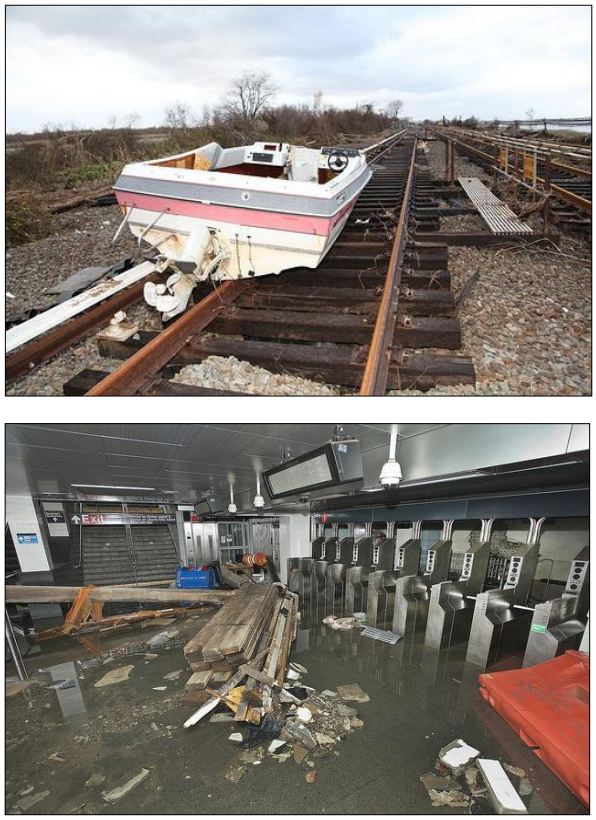
[112] For more on regional transportation planning for climate adaptation, see Section 2-B.

LOCAL EXAMPLES

- The state of Maryland began to analyze the state's transportation vulnerabilities in the Maryland Climate Action Plan released in August 2008.[113] According to the Maryland Department of Transportation, "[The State Highway Administration] has established goals to identify vulnerable infrastructure and develop risk assessments for short- and long-term investments to protect coastal communities, environmental assets, and infrastructure from the potential impacts of climate change-induced storm surges and sea-level rise."[114]
- In 2011, the District of Columbia Department of Transportation adopted a new way to develop its Transportation Improvement Plan. Using a software program, the agency weighed and prioritized investments, taking into account typical factors such as maintenance and safety, but also enhanced mobility, system redundancy, and environmental performance. The agency was able to evaluate each proposed project against its level of environmental risk and its ability to achieve climate change objectives.

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 can strengthen the region's transportation system, helping to maintain regional transportation continuity.
- Coordinating land use and transportation planning ensures that investments in development and transportation support and reinforce each other. Identifying and addressing climate-related vulnerabilities helps make sure that the transportation system will continue to support the community's plans for growth.
- 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.



Source: Metropolitan Transportation Authority of the State of New York via Flickr

Figure 16: Superstorm Sandy in October 2012 showed how powerful storms can damage both aboveground and underground transit facilities.

IMPLEMENTATION

Local governments and transportation asset owners can begin by identifying the assets that are in particularly vulnerable areas and determining the probability and cost of a debilitating event. A good starting point for planning for potential future system vulnerabilities is to know which transportation assets are already affected by weather events that are expected to become more severe and/or frequent due to climate change, the impact to the asset and the transportation system as a whole, and the estimated cost of that impact. While historical data about

[113] Maryland Commission on Climate Change. *Maryland Climate Action Plan: Appendix E*. 2008. http://www.mde.state.md.us/assets/document/Air/ClimateChange/AppendixE_Adaptation_Response.pdf.

[114] Maryland Department of Transportation. *2012 Annual Attainment Report on Transportation System Performance*. 2012. p. 36. http://www.mdot.maryland.gov/Office%20of%20Planning%20and%20Capital%20Programming/CTP/CTP_12_17/Final_CTP/2012_Attainment_Report.pdf.

transportation system impacts from past weather events can be helpful, it will not be sufficient to plan for climate change. Local governments should recognize that climate projections are constantly being refined and improved, and they should periodically reevaluate data to ensure that they are using the best possible information. The vulnerability assessment process, described in Section 1, is another critical information source for projected climate risks.

To develop a transportation vulnerability assessment, which could be done in conjunction with the community vulnerability assessment, local governments can consider:

- Potential hazards and their impacts (how, which, and where climate changes are likely to affect assets and modes).
- Inventory of critical assets in areas affected by climate change-related weather hazards and how those areas are likely to change over time (e.g., an area that used to be in a 100-year flood plain is now in a 50-year flood plain).
- Estimated vulnerability of the asset, the probability of impact from a major weather event, and assessment of the system's resilience to losing that asset.
- Estimated social and economic costs of probable incidents.
- Inventory of planned capital projects.

Using this assessment, localities can prioritize already-planned projects based on vulnerability, determine whether to change the project plans to incorporate the results of the vulnerability assessment, and determine how to proceed with assets that are vulnerable but not currently programmed for investment.

A major challenge for transportation asset owners is determining the most appropriate adaptation strategies. Often, protection or retrofit strategies are less expensive and more acceptable to communities than relocation. However, communities should at least consider all options, especially for more vulnerable assets. In addition to preserving the asset and/or its function, adaptation strategies ideally should enhance the system's overall resilience and performance by providing more mobility options or redundancies, addressing other network challenges such as congestion, enhancing safety, and/or encouraging and supporting the development patterns that the community wants.

To evaluate potential adaptation strategies, a local government could consider:

- Evaluating adaptation options and the trade-offs among them.
- Selecting a preferred adaptation strategy, estimating its cost, and proposing programming.
- Setting deadlines to implement adaptation actions.
- Choosing an evaluation methodology and a cycle for reassessing strategies.
- When scoring transportation infrastructure and service investments, giving preference to options that add redundancy to at-risk infrastructure (e.g., a bus rapid transit line that could handle service from a rail line expected to become vulnerable to storm surges).

While funding determinations and adaptation strategies are generally the responsibility of the individual owners, the MPO and other regional transportation agencies can take the lead in ensuring that facilities of regional importance are included in the regional Transportation Improvement Plan and that separate adaptation investments work together as a whole (e.g., on a road that passes through two jurisdictions, ensuring that one jurisdiction is not planning to move a segment of the road while the other is planning to retrofit its portion of the corridor). Therefore, results from local government transportation vulnerability assessments can be valuable inputs to the regional transportation planning process.

4-E IMPLEMENT HEAT ISLAND REDUCTION STRATEGIES

DEFINITION

A "heat island" is an area with manmade infrastructure that has warmer air and surface temperatures than nearby areas. Heat islands form because natural land cover is replaced with pavements and buildings. On hot, sunny days, heat islands can result in temperatures as high as 22 F warmer than the surrounding land, causing stress on people and infrastructure.[115] High temperatures can also contribute to poor air quality in urban areas by increasing ground-level ozone.[116] Low-income and some communities of color are particularly at risk from the heat island effect because they often have more impervious surfaces. Residents of these communities often do not have air conditioning or opt not to use it because of its cost.[117]

CLIMATE CONNECTION

Climate change is expected to bring higher temperatures to many communities, which will likely exacerbate the heat island effect. The higher temperatures could pose a significant health and safety threat to people and could damage transportation infrastructure (e.g., deform rail lines, expand bridge joints, or degrade pavement). Reducing the heat island effect will help communities facing increased temperatures to be more resilient to those changes. Some strategies that reduce the heat island effect can also help manage stormwater to protect water quality and make communities more resilient to expected increases in precipitation or severe storm events.

Actions that reduce the heat island effect can also help use energy more efficiently, reduce air pollution, lower greenhouse gas emissions, and improve conditions for children and other people whose health is particularly affected by heat and the effects of smog. Key heat island reduction strategies include increasing tree canopies or vegetative cover, installing green or cool roofs,[118] and using cool pavements.[119] These techniques can reduce summertime cooling costs, which saves energy and reduces 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 impacts of climate change.

ADAPTATION PLANNING STAGE

Intermediate

RELEVANT SECTORS

Transportation: Can protect transportation infrastructure from heat-related impacts and can provide shade and cooling for pedestrians and bicyclists.

Water: Reduces polluted runoff that would otherwise flow into streams, rivers, and lakes.

Buildings: Most relevant sector. Reduces cooling loads and energy use.

RELEVANT HAZARDS

LOCAL EXAMPLES

- Arlington, Virginia, has a "Policy for Integrated Facility Sustainability" that requires county facilities to meet LEED Silver criteria and cites five specific LEED credits to pursue, two of which are Heat Island and Stormwater Management.[120]
- Montgomery County, Maryland, has a RainScapes Rebate Rewards program, funded by a water quality protection fee, which rebates property owners who use techniques to reduce

[115] EPA. "Heat Island Effect." http://www.epa.gov/hiri. Accessed Feb. 28, 2012.
[116] U.S. Global Change Research Program 2009.
[117] Kaswan 2012.
[118] A cool roof is one that has a high albedo, meaning it reflects more heat and sunlight away from the building.
[119] Cool pavements are "paving materials that reflect more solar energy, enhance water evaporation, or have been otherwise modified to remain cooler than conventional pavements." EPA. "Cool Pavements." http://www.epa.gov/hiri/mitigation/pavements.htm. Accessed Feb. 28, 2012.
[120] Arlington County, VA. "Policy for Integrated Facility Sustainability." Aug. 19, 2008. http://freshaireva.us/wp-content/uploads/2012/01/file699501.pdf.

stormwater runoff and the heat island effect.[121] For example, property owners can get rebates for planting trees, with priority given to trees that shade existing impervious surfaces, buildings, or air-conditioning units.[122] Gaithersburg and Rockville, Maryland, have similar programs.

- Washington, D.C., has a green roof rebate program that provides base funding of $5 per square foot. Properties of all sizes and types are eligible.[123]

BENEFITS

- Trees, vegetation, and green roofs can reduce ambient air temperatures, which can reduce energy used for cooling and associated air pollution and greenhouse gas emissions.[124]
- Trees and vegetation can:
  - Remove air pollutants.
  - Sequester and store carbon.
  - Slow, absorb, and filter stormwater.
  - Help protect water quality.
  - Reduce noise levels.
  - Create wildlife habitats.
  - Improve the aesthetics of streets, parking lots, public spaces, and other properties.
  - Increase outdoor social interaction and physical activity.
  - Increase property values.
  - Improve ground water recharge and increase soil water storage.[125]
- Strategically planted deciduous trees can provide shade for buildings during summer months without significantly reducing passive solar gain in winter.
- Cool roofs can reflect heat from buildings, meaning less heat is transferred into the building. Cool roofs can reduce the amount of cooling needed while lowering energy use, peak electricity demand, air pollution, greenhouse gas emissions, and the onset of heat-related illnesses.[126]
- Cool pavements help reduce surface and air temperatures by reflecting solar energy or enhancing water evaporation. These pavements can indirectly help reduce energy consumption, air pollution, and greenhouse gas emissions and can keep paved areas like parking lots cooler, which keeps the people who use these areas more comfortable. Additional benefits from the range of cool pavement technologies include absorbing stormwater, reducing the temperature of stormwater to protect water quality, making the pavement surface more durable, enhancing nighttime illumination, and even potentially reducing tire noise.[127]
- Reducing urban temperatures in a warming climate can benefit public health by reducing the incidence of heat stress, particularly for the very young, elderly, sick, or disabled. Low-income people who fall into one of these categories are particularly vulnerable because they often cannot afford to cool their homes. Lower ambient air temperatures mean less need for cooling, which saves residents money.

Source: Payton Chung via Flickr.com

Figure 17: The Watha T. Daniel/Shaw Library in Washington, D.C., a LEED Gold building, has a roof that is part vegetated, which absorbs rainfall, and part reflective, which keeps the building cooler.

[121] Montgomery County, MD. "RainScapes Rewards Rebates Program." http://www6.montgomerycountymd.gov/dectmpl.asp?url=/content/dep/water/rainrebate.asp. Accessed Jan. 17, 2013.
[122] Montgomery County, MD. "RainScapes Rewards Rebate: Tree Canopy." Revised Jul. 2010. http://www6.montgomerycountymd.gov/Content/dep/downloads/Rainscapes/helpguide_TreeCanopy.pdf.
[123] District Department of the Environment. "Green Roofs in the District." http://ddoe.dc.gov/greenroofs. Accessed Nov. 6, 2012.
[124] EPA. *Reducing Urban Heat Islands: Compendium of Strategies—Trees and Vegetation*. 2008. http://www.epa.gov/heatisld/resources/pdf/TreesandVegCompendium.pdf.
[125] EPA, *Reducing Urban Heat Islands—Trees and Vegetation* 2008.
[126] EPA. *Reducing Urban Heat Islands: Compendium of Strategies—Cool Roofs*. 2008. http://www.epa.gov/heatisld/resources/pdf/CoolRoofsCompendium.pdf.
[127] EPA. "Cool Pavements." http://www.epa.gov/heatisld/mitigation/pavements.htm. Accessed Mar. 2, 2012.

- As summer temperatures rise, the rate of ground-level ozone formation, or smog, increases. This ozone can irritate the respiratory system, reduce lung function, and aggravate asthma.[128] By lowering temperatures, urban heat island strategies can help reduce ground-level ozone concentrations.[129]

IMPLEMENTATION

Local governments can use publicly available screening tools to estimate potential benefits of different heat island mitigation strategies in their region, such as EPA's Mitigation Impact Screening Tool,[130] the Center for Neighborhood Technology's Green Values® Stormwater Toolbox,[131] or the U.S. Forest Service's i-Tree tools.[132] Based on this initial information, communities can analyze mitigation options for their environment to develop a comprehensive plan for implementation that might include:

- Urban forestry: A local government can develop an urban forestry master plan or community tree canopy plan by inventorying the number and types of trees and forests, identifying areas affected by stormwater-related issues such as flooding or stream bank erosion, and setting priorities to expand and improve trees and forests to reduce heat island impacts and stormwater runoff. These plans typically include planting, protection, maintenance, and management of trees and other appropriate vegetation; encouraging green (vegetated) roofs, walls, and building terraces; and taking into consideration the projected effects of climate change on the types of trees and vegetation that will be appropriate to plant.
- Procurement: Local governments can require cool technologies (e.g., cool and green roofs, pervious and light-colored pavement) for government buildings, roads, and projects.
- Green building standards: Green building standards can include heat island reduction strategies, such as cool and green roofs and preserving trees and vegetation.
- Building codes: Local governments can include green and cool roofs in their building codes as voluntary measures, perhaps with incentives attached, even in jurisdictions where these measures cannot be mandated.
- Community involvement: Stakeholders can work together on implementing heat island mitigation strategies, developing neighborhood programs to maintain plantings, and implementing volunteer programs.
- Street design: Street standards can include cool pavements and vegetation that reduce air and surface temperatures and minimize stormwater flows by diverting stormwater to irrigate street trees and landscaping, roadside infiltration beds, and rain gardens.[133]
- Maintenance plans: A comprehensive inspection and maintenance program can ensure heat island and stormwater control strategies function as designed.

Engaging agencies, nonprofits, or community-based organizations focused on related issues such as air quality, urban forestry, energy efficiency, health care, green jobs, and walking and biking can strengthen the plan and ensure that the solutions the community chooses meet multiple goals.

[128] EPA. "Smog—Who Does It Hurt?" 1999. http://airnow.gov/index.cfm?action=smog.index.
[129] EPA. *Reducing Urban Heat Islands: Compendium of Strategies—Green Roofs*. 2008. p. 7. http://www.epa.gov/heatisland/resources/pdf/GreenRoofsCompendium.pdf.
[130] EPA. "Mitigation Impact Screening Tool." http://www.heatislandmitigationtool.com/Introduction.aspx. Accessed Nov. 2, 2012.
[131] Center for Neighborhood Technology. "Green Values® Stormwater Toolbox." http://greenvalues.cnt.org. Accessed Nov. 2, 2012.
[132] U.S. Department of Agriculture, Forest Service. "i-Tree." http://www.itreetools.org. Accessed Nov. 2, 2012.

[133] For more information on green, complete streets, see Approach 5-D.

4-F STREAMLINE AND FUND THE RELOCATION PROCESS

DEFINITION

In response to a climate change vulnerability assessment, a community might determine that certain areas are so potentially hazardous that, over the long term, it would be preferable to relocate the structures located in these areas to ensure their safety. Whether before or after a disaster strikes, the decision to relocate is often difficult and emotional. People are reluctant to leave their homes or to give up a business location they have enjoyed for many years. In many places, neighborhoods that will be at risk have great cultural and historical significance as well as deep emotional attachments for their residents. Relocation is almost always a last resort.

Where this decision has been made, the local government can make the process easier and faster for those who choose to relocate by streamlining relocation processes and providing quick and efficient review of zoning and building code issues. Streamlining could mean creating a coordinated package of relocation services and resources involving all relevant government agencies in both the vacated and receiving jurisdictions.

CLIMATE CONNECTION

It is an incredibly difficult decision to relocate residents and businesses from any neighborhood. However, in extreme cases, it might be in the best interests of the community and its residents to reduce the number of structures located in particularly vulnerable areas, most likely low-lying areas where flooding is projected to become more frequent because of increased precipitation or storm surges exacerbated by sea level rise. Where the likelihood of harm to the public is great or where it would be difficult to safely rescue people during a storm event, communities might want to consider voluntary, anticipatory relocation.

Many areas have already dealt with damage from flooding but allowed reconstruction on the original site—perhaps many times. The projected increase in flooding due to climate change might tip the cost-benefit balance—for either the local government or for the individual residents or businesses—toward relocation rather than reconstruction. Changes in FEMA or National Flood Insurance Program maps or requirements might also trigger this change; people might prefer to relocate rather than rebuild if they know they will pay for more insurance or perhaps not be able to obtain insurance at all.

ADAPTATION PLANNING STAGE

Advanced

RELEVANT SECTORS

Land Use: Can start or speed up relocation to safer areas.

Transportation: Can move transportation infrastructure out of hazardous areas.

Water: Can move water infrastructure out of hazardous areas to preserve safe, reliable water service.

Buildings: Most relevant sector. Can encourage households and businesses to move from structures in vulnerable areas to safer locations, reducing property damage and protecting health and safety.

RELEVANT HAZARDS

To make relocation easier, local governments can make changes to building, zoning, and subdivision regulations that encourage relocation; incorporate relocation across several development decisions; and streamline relocation procedures.

Communities might also want to establish a dedicated fund to defray the costs of moving structures and infrastructure to less-vulnerable areas. A local relocation fund can be targeted to the specific climate changes anticipated in the region. For example, coastal communities could establish a road relocation fund that would be used to build new roads outside of areas highly vulnerable to storm surges or sea level rise.

LOCAL EXAMPLES

No communities appear to have streamlined the relocation process for climate change adaptation purposes. However, there are examples of community relocations out of flood-prone areas, such as Grundy and Clinchport, Virginia.[134]

BENEFITS

- Putting funding, policies, and processes in place now can make it easier for local governments to help residents and businesses relocate if and when the time comes.
- Planning ahead can help local governments avoid the costs of rescuing people or rebuilding buildings and infrastructure by giving people the option to relocate before an emergency happens.
- The public review and discussion required to amend zoning regulations can give the local government a chance to explain the importance of the issue to residents.
- Anticipatory relocation is a good investment for local governments where the cost and impact of road, sewer, and other infrastructure repair following a damaging event or erosion would be significantly more expensive than relocating facilities and services before problems occur. Local governments can address infrastructure priorities through the normal capital improvements process, and they can move infrastructure in an orderly but expedited manner that allows normal design and bidding processes.

IMPLEMENTATION

After completing a climate vulnerability assessment, the local government will have some idea of which areas will become more vulnerable to hazardous events over time. Many communities have designated in their comprehensive plans where they want new development to occur. These two pieces of information can help communities determine how many structures might need to move and at what time, along with where new development might be built to accommodate those families and businesses. Major implementation steps include outreach, funding, and streamlining the relocation process.

- Outreach: A local government that decides to consider relocation should have a public discussion about the reasons to move structures out of particularly vulnerable areas, the costs and benefits of doing so, the options available to those who live or work in the affected areas, and how the process will be funded. Identifying highly vulnerable and buildable areas on a map will help public discussion, as will a publicly available assessment of the costs and benefits of streamlining the relocation process and creating a relocation fund. Outreach should start early and continue throughout the process to ensure that the local government understands and responds to affected residents and business owners' concerns.

  Low-income people often live or own businesses in particularly vulnerable areas. The mere suggestion of relocation can trigger fears that a nefarious motive is behind the relocation or that people will be forced from their homes. Making a special effort to engage low-income, minority, and overburdened residents early and often in any discussion of relocation can help ensure that their concerns are well-understood and that everyone gets the same information about their neighborhood's vulnerability. Education about the risks, a clear process outlined ahead of time with public review, and specific safer locations to which the relocated residents and businesses could move can help quell their fears. These residents might need additional financial or logistical help to relocate; the local government will need to determine how it will provide that assistance. Community-based organizations can be valuable partners in working with both residents and the local government to ensure that, if people choose to relocate, the process is fair and residents get the help they need.

[134] Mullins, Amanda. "Flood Hazard Mitigation from a Grundy, Virginia, Perspective." *Virginia Water Central*. Jun. 2006. http://vwrrc.vt.edu/pdfs/newsletter/038Jun2006onecol.pdf.

- Funding: Communities considering voluntary, anticipatory relocation can prepare a relocation assessment to identify:
    - The range of uses, services, and facilities eligible for funding.
    - Priorities for protecting particularly vulnerable areas.
    - Potential impacts of the projected event (e.g., hurricane or flooding) to people and structures.
    - Cost of various relocation options.
    - Potential funding sources and the potential total funding from each source.

  Local governments can prepare a cost-benefit analysis for structures and infrastructure that compares anticipatory relocation, post-impact relocation, repair and replacement of damaged structures with no relocation, and, where applicable, status quo with no further action needed for the damaged service or infrastructure (e.g., a utility substation that will not be replaced).

  To be successful, a relocation fund would have to be backed by a long-term, reliable funding source such as a dedicated sales tax. Other funding sources could include annual appropriations from the general fund; bond issuance; and, where the funding will be used to relocate infrastructure, a tap fee for water and sewer hookups or a utility fee. If the vulnerable areas will eventually be converted to natural or open spaces, funding might also be available from foundations, land preservation nonprofits, or government grants. In addition to local funding, federal assistance, such as FEMA Pre-Disaster Mitigation grants and CDBG funds, might be available.

  Depending on restrictions from the funding source, the funds collected as part of the relocation fund could be provided directly to recipients as grants or could be used to underwrite low-interest loans. Funding could also be used to cover site development costs in safer areas to encourage new development.

- Streamlining: Packaging government services and streamlining approvals can remove inter- and intra-departmental or -jurisdictional conflicts and delays while ensuring that the process incorporates short- and long-term community goals. The aims should be to ease the challenges associated with relocation and ensure that all resulting new construction and development make the community more resilient.

  Approaches to streamlining the relocation process can be grouped into three categories:

  1. Changes that save time and money, which could include:
     - Establishing a priority permitting process for development projects that house relocated households or businesses by coordinating among approving entities, or establishing a “relocation permit” that has a fast turn-around and requires priority review from all applicable departments, such as planning, building, public works, water and wastewater, and transportation.
     - Reducing or waiving permit application fees.
     - Setting priorities for public-sector funding or construction of infrastructure such as roads, sewer, or transit.
     - 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.
  2. Creative approaches that encourage development innovation, which could include:
     - Establishing a process to develop non-contiguous PUDs that link particularly vulnerable areas subject to relocation with buildable areas. A PUD would allow the vulnerable area to be used to meet open space or park dedication requirements while increasing the density in the buildable areas. Boulder County, Colorado, uses this method to protect environmentally sensitive areas. Structures in the vulnerable area would have to be

removed in an environmentally responsible way.
    - Establishing a comprehensive permitting process that allows integrated responses to risk across traditional regulatory boundaries (such as land use, building safety, water, wastewater, stormwater, and transportation) to be approved at least as easily and quickly as standard projects. Comparative risk analysis has not typically been part of development approvals, and those in the approvals process will need clear signals that they have the authority to consider a broader array of risks and work with regulatory authorities other than those usually involved.
3. Changes to standards to make redevelopment easier, which could include:
    - Allowing more compact development—for example, with alternative setback and height (dimensional) standards—and increased density for projects that include sites for relocated structures and/or infrastructure.
    - Creating a relocation zone district that allows by-right development of small lots, a mix of densities and uses, and accessory dwelling units and has priority development approval processing.
    - Authorizing the building department to use flexible, performance-based reviews to enable innovative, climate-responsive designs to be used cost-effectively. This can be achieved by either updating codes or allowing reviews to incorporate emerging risks when determining whether proposed alternative designs are as safe and effective as current practice.

5 ENCOURAGE SUSTAINABLE GROWTH IN APPROPRIATE, LESS-VULNERABLE AREAS

By using smart growth development and green building strategies, local governments can accommodate population growth, improve air quality by offering less-polluting transportation options, reduce greenhouse gas emissions by making household and transportation energy use more efficient, improve water quality by better managing stormwater, and foster vibrant communities with a mix of uses and a diverse tax base. By doing so in safer areas, local governments can also reduce long-term costs associated with responding to climate change-related weather impacts and increase their community's resilience and ability to adapt to climate changes.

As a first step before considering any of these approaches, communities would review their vulnerability assessment, which should have identified specific geographic areas that are likely to be less vulnerable to impacts from a changing climate. The highly vulnerable and less-vulnerable areas would also be identified in the community's comprehensive plan. Once the less-vulnerable areas are identified, local governments can align these safer areas with areas designated for future growth and determine whether any changes are required in planning for future development. Next, communities can consider the following approaches to identify those that are most appropriate to encourage safe, resilient growth while meeting other community goals:

A. Promote compact, mixed-use development.
B. Promote infill development in appropriate locations.
C. Remove roadblocks to appropriate development.
D. Adopt green, complete streets design standards.
E. Update building code requirements.
F. Incorporate passive survivability into new and existing projects.

Figure 18: Rockville Town Square in Rockville, Maryland, is an infill project with a mix of uses.

5-A PROMOTE COMPACT, MIXED-USE DEVELOPMENT

DEFINITION

Compact, mixed-use development has less environmental impact because it reduces impervious surfaces, which reduces stormwater runoff that can harm water quality; requires less energy to build and operate structures; and reduces air pollution and greenhouse gas emissions by offering less-polluting, more energy-efficient transportation options.

Many jurisdictions in the metropolitan Washington region already have policies supporting compact, mixed-use development. In addition, all of MWCOG's member jurisdictions endorsed the Region Forward vision, which includes as one of its goals: "We seek transit-oriented and mixed-use communities emerging in regional activity centers that will capture new employment and household growth."[135]

ADAPTATION PLANNING STAGE

Basic

RELEVANT SECTORS

Land Use: Most relevant sector. Uses land more efficiently.

Transportation: Reduces driving distances and makes less-polluting transportation options like transit, walking, and bicycling more feasible.

Water: Can protect critical open space to absorb stormwater and flood waters.

RELEVANT HAZARDS

CLIMATE CONNECTION

As development is discouraged in highly vulnerable areas and people and businesses relocate from these areas, local governments will need to consider the most appropriate location for new growth in their jurisdictions. And because less total land area will be available for development, they will also need to consider how additional population could be accommodated in designated growth areas that are less likely to be affected by climate change.

Amending local comprehensive and area plans and using zoning tools that support compact, mixed-use development can be important elements in local governments' efforts to implement climate adaptation plans. Encouraging more compact, mixed-use development in less-vulnerable areas shifts development pressure off undeveloped farmland and open space, as well as areas currently or projected to be particularly vulnerable to climate-related risks.

Compact development, particularly when built on or adjacent to already-developed land, can reduce the amount of new infrastructure required to support growth. However, in many already-developed areas of the Washington region, existing infrastructure is old and needs to be upgraded or replaced to handle the development it already has, much less new development. In addition, temperature extremes—which are projected to become more extreme as the climate changes—can make water mains fail,[136] so maintaining and improving infrastructure will be important to support compact development.

The 1995 heat wave in Chicago, which caused hundreds of deaths, illustrates how neighborhood context can affect how people cope with extreme weather events. The victims were overwhelmingly elderly and low-income people who either did not have air conditioning in their homes or could not afford to run it. A groundbreaking study that examined the physical and social features of neighborhoods and the rates at which people in those neighborhoods died during the heat wave found that neighborhoods that had suffered commercial decline had higher-than-average mortality rates. In fact, the study found, the rate of

[135] Region Forward. "Compact." Endorsed in 2010. http://www.regionforward.org/compact.

[136] New York City Office of Emergency Management. "NYC Hazards: Water Supply Disruptions." http://www.nyc.gov/html/oem/html/hazards/utilities_water.shtml. Accessed Nov. 1, 2012.

commercial decline in a neighborhood explained virtually all of the difference in death rates between neighborhoods. Elderly people were likely afraid to leave their homes in neighborhoods that had visibly deteriorated and had few or no commercial enterprises besides bars and liquor stores. In low-income neighborhoods that had suffered less commercial decline, elderly people had safe places such as grocery stores where they could go to get out of the heat. The study also suggested that people might have the same reaction in the face of other disasters, noting, "When one's own community is perceived to pose a known danger, the more uncertain hazard presented by potential disaster may be discounted."[137]

Neighborhoods with a mix of uses can encourage people who cannot afford to or do not want to run their air conditioning to leave their homes and find a safe, cool place to spend hot days. In everyday life, having a mix of uses near homes lets people travel shorter distances to reach their daily destinations, which makes walking, bicycling, and transit more convenient and appealing and shortens driving distances for people who choose to drive.

In addition to the weather-related impacts of climate change, communities might also want to consider preparing for economic risks. Gas and energy prices have fluctuated severely and sometimes unexpectedly due to real or perceived supply problems. Prices are likely to be unpredictable in the future as well because of the many global variables that affect energy prices. Compact, mixed-use development can help ensure that the community and its residents can continue to thrive even in the face of gas or energy price spikes by making it easier for residents to get around without driving and putting everyday uses within easy reach.

LOCAL EXAMPLES

Many jurisdictions across the metropolitan Washington region have adopted zoning tools and development incentives that encourage compact, mixed-use development. Examples include:

- The Rosslyn-Ballston corridor in Arlington, Virginia, is a nationally recognized example of how compact, mixed-use development concentrated at transit stations can strengthen neighborhoods, improve economic and fiscal performance, and reduce traffic congestion. Although the corridor covers only 2 square miles, less than 8 percent of the county's land area, it provides about 31 percent of the county's assessed land value.[138] The corridor was not planned explicitly to be resilient to climate change, but it lies well outside the 500-year flood plain, and it is projected to absorb more than one-third of the county's population growth and more than half its job growth by 2040.
- A flood-control project along Carroll Creek in Frederick, Maryland, has sparked revitalization in the city's center with new compact, mixed-use development. The city estimated that the public investment in the park will bring more than $150 million in private investment, 1,500 new jobs, 300 housing units, over 500,000 square feet of commercial space, and more than $2.5 million in local tax revenue.[139]

Figure 19: Carroll Creek Park in downtown Frederick, a flood control project, removed much of the downtown from the 100-year flood plain, and the attractive design of the park and the new amenities it brought spurred new investment.

[137] Browning, Christopher R., et al. "Neighborhood Social Processes, Physical Conditions, and Disaster-Related Mortality: The Case of the 1995 Chicago Heat Wave." *American Sociological Review* 71.4 (2006): 661-678.

[138] Arlington County, VA, Dept. of Community Planning, Housing and Development, Planning Division. "40 Years of Smart Growth: Arlington County's Experience with Transit Oriented Development in the Rosslyn-Ballston Metro Corridor." Presentation. Dec. 6, 2012. http://www.arlingtonva.us/departments/CPHD/planning/powerpoint/rbpresentation/rbpresentation_060107.pdf.

[139] City of Frederick, MD. "Carroll Creek Park Overview." https://www.cityoffrederick.com/DocumentCenter/Home/View/1100. Accessed Jan. 15, 2013.

BENEFITS

- Compact, mixed-use development can make local economies less vulnerable to disruptions in regional transportation networks.
- Increasing the number of people who live within walking, bicycling, or transit distance of daily goods, services, and jobs reduces stress on regional roads and transit networks during service disruptions.
- Mixed-use neighborhoods can bring local economic benefits, including higher public revenues, new businesses and investment, and infrastructure cost savings.
- These neighborhoods can save residents money on transportation and energy, give them easier access to a wider range of jobs, and put more services and amenities close at hand.[140]
- Compact, mixed-use development can reduce stormwater runoff per household. More compact development produces less impervious cover per household, which creates less runoff.[141]
- Compact development could reduce transportation-related greenhouse gas emissions by anywhere from 1 to 15 percent in 2050, depending on assumptions about the amount of new development that is compact and other variables.[142,143,144]
- Developing compactly can help reduce pressure to develop on critical natural lands.
- Many communities might find the costs of retrofitting, relocating, or making redundant their key transportation assets to be daunting. Encouraging growth near existing transportation infrastructure in safe areas can help communities get more mobility per dollar spent, which can help keep adaptation economically feasible.

IMPLEMENTATION

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

- Identifying and rezoning activity centers where mixed-use development will be permitted and promoted.
- Removing zoning barriers by tailoring parking, landscaping, and open space regulations for more compact projects.
- Creating transit-oriented development zoning districts around Metro stations and other major transit stops, within which development is encouraged through higher permitted densities and heights and development potential is maintained through minimum density requirements. This strategy takes advantage of market forces by making development more profitable in these areas.
- Creating by-right mixed-use zones in which the combination of commercial and residential uses is allowed without special hearings or lengthy review processes.
- Retrofitting aging strip malls and commercial centers to become mixed-use centers, as White Flint Mall in Rockville, Maryland, is doing.[145]
- Using form-based codes, which rely on physical form rather than type of use as the organizing principle. Because the code concentrates on the form, communities can encourage development that accommodates a mix of uses and can allow some flexibility of uses. Form-based codes are intended to help the community achieve its vision for development and work well with compact development.

[140] Kooshian, Chuck, and Steve Winkelman. *Growing Wealthier: Smart Growth, Climate Change and Prosperity*. Center for Clean Air Policy. 2011.
[141] EPA. *Protecting Water Resources With Higher-Density Development*. 2006. http://www.epa.gov/smartgrowth/water_density.htm.
[142] Ewing, Reid, et al. *Growing Cooler: The Evidence on Urban Development and Climate Change*. Urban Land Institute. 2008. Estimates 7 to 10 percent reduction in greenhouse gas emissions.
[143] Cambridge Systematics, Inc. *Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions*. Urban Land Institute. 2009. Estimates 9 to 15 percent reduction.
[144] Transportation Research Board. *Driving and the Built Environment: The Effects of Compact Development on Motorized Travel, Energy Use, and CO2 Emissions*. Transportation Research Board Special Report 298. National Research Council. 2009. Estimates 1 to 11 percent reduction.
[145] O'Connell, Jonathan. "In White Flint, the mall is being turned into a town." *washingtonpost.com Capital Business Blog*, Nov. 17, 2011.

5-B PROMOTE INFILL DEVELOPMENT IN APPROPRIATE LOCATIONS

DEFINITION

Infill development is the carefully planned, compatible use or reuse of property located in already-developed areas. It includes reusing and/or redeveloping underused or vacant property, cleaning up and reusing brownfields, or allowing higher-density development at an existing site. Infill development is typically in areas already served by infrastructure.

CLIMATE CONNECTION

Local governments can improve their community's long-term resilience to climate change by encouraging development in less-vulnerable areas. Where neighborhoods already exist in safer areas, continued investment can strengthen them and help them attract future growth. If there are properties that are underused, vacant, or otherwise not contributing to 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, or affordable homes).

Where development exists in highly vulnerable areas, local governments might want to consider whether it is appropriate to encourage infill development there, even if that development is designed to be resilient to natural hazards. The public often assumes that if a local government allows development in a location, that location must be safe. Allowing new development in particularly vulnerable areas can create a false sense of security among both new and current residents and businesses. Decisions about infill in vulnerable areas are not easy; in some cases, the only other land available for development might need new infrastructure or might be far from existing development. Each community will need to weigh the pros and cons of encouraging infill development in areas that are or will become particularly vulnerable.

In addition to strengthening neighborhoods in less-vulnerable areas to enhance resilience, infill development can reduce greenhouse gas emissions. When a well-planned infill project is constructed in lieu of a greenfield development project, the more efficient location allows people to drive less, which reduces greenhouse gas emissions. For example, Eugene, Oregon, encourages infill to meet community greenhouse gas emission goals.[146]

ADAPTATION PLANNING STAGE

Intermediate

RELEVANT SECTORS

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

Transportation: Makes transportation more efficient by aligning land use and future population growth with areas that already have transportation infrastructure.

Buildings: Can raise the value of surrounding properties and preserve the neighborhood's fabric and character.

RELEVANT HAZARDS

LOCAL EXAMPLES

- Fairfax County, Virginia, is encouraging infill development near the Dunn Loring Metro station in Merrifield, a designated "suburban center" where the county wants to encourage more compact development with a mix of uses, walkability, and transportation options.[147] The area south of the station was primarily commercial and industrial development. The redevelopment is creating a new town center where none existed before and is bringing thousands of new apartments, townhouses,

[146] City of Eugene, OR. *A Community Climate and Energy Action Plan for Eugene.* 2010. http://www.eugene-or.gov/DocumentCenter/Home/View/565.

[147] Fairfax County, VA. *Fairfax County Comprehensive Plan, 2011 Edition*. Area Plan Overview. Amended through Jun. 19, 2012. http://www.fairfaxcounty.gov/dpz/comprehensiveplan/area1/overview.pdf.

and other housing options within walking distance of the Metro station.[148]

- Prince George's County, Maryland, projects that it will capture more of the region's growth in future decades because it has a large amount of relatively affordable land, including sites near Metro stations and in existing communities. The county's 2010 visioning process found strong support for infill development, particularly around transit stations.[149] The county council passed a bill in June 2013 that aims to make it easier and faster for developers to build near Metro and MARC stations.[150]

BENEFITS

- Done thoughtfully, infill development can preserve the fabric and character of the existing neighborhood and create a more appealing alternative to developing on greenfields.
- Building in already-developed areas makes better use of existing infrastructure.
- Infill development can strengthen property values and revitalize declining communities by improving access to services, jobs, and affordable homes.

IMPLEMENTATION

A community can prioritize areas where it wants infill based on specific criteria. In the highest priority areas, the local government can develop an inventory of vacant, abandoned, or underused properties using desktop data (e.g., property records, zoning, aerial photos, postal service tracking, utility data, tax receipt data, and state and local brownfield inventories) and windshield surveys (observations made by visiting the area). For each site, the local government can gather information on site size and configuration, current ownership, tax status, zoning, soils, flood plains, wetlands, availability and condition of infrastructure, potential contamination, and site access. Sites that are near existing infrastructure, particularly transit stations, can be highlighted. A geographic information system can easily map this information, which can help identify opportunities for consolidating multiple parcels.

Figure 20: Halstead Square, about one block from the Dunn Loring Metro station, offers more than 1,000 apartments and lofts and over 100,000 square feet of commercial space.

In addition to the quantitative site characteristics, the community can consider qualitative characteristics such as local market dynamics, character of the neighborhood or block, area vacancy rate, nearby amenities, and community needs. With this information, the community can develop concepts for redevelopment of infill sites based on its preferences.

To encourage redevelopment, the local government can identify potential barriers to redevelopment of the infill sites, such as lack of developer interest, cost of development, community concerns, and regulatory barriers.

For each priority area, a detailed infill development strategy could identify the community's preferences for reuse, potential barriers to development, and ways to

[148] Fairfax County, VA, Office of Community Revitalization. "Merrifield: Development Projects." http://www.fcrevit.org/merrifield/development.htm. Accessed Jan. 14, 2013.
[149] Maryland-National Capital Park and Planning Commission. *Envision Prince George's Phase I: Final Report*. 2010. http://envisionprincegeorges.org/wp-content/uploads/2010/06/EPG_Phase-I-Final-Report_web.pdf.
[150] Spivack, Miranda S. "Prince George's Council approves plan to speed development around transit stations." *Washington Post*, Jun. 4, 2013.

facilitate reuse. Some techniques that communities have used to encourage infill development include:

- Offering density bonuses in priority infill areas.
- Providing financial incentives for brownfield redevelopment.
- Creating a local land bank to manage property acquisition and disposition through the tax foreclosure process, voluntary conveyance, or purchase.
- Reducing barriers to reusing 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.
- Reaching out to developers.
- Upgrading infrastructure.
- Reducing development costs (e.g., land write-downs, providing infrastructure upgrades, loan guarantees, or tax abatement).
- Implementing interim uses before a more permanent, long-term use is implemented. Interim uses (e.g., allowing food trucks to park in a vacant lot) are a way to use a vacant property while waiting for market conditions for new development to improve. They tend to require minimal investment or construction of buildings or infrastructure.

5-C REMOVE ROADBLOCKS TO APPROPRIATE DEVELOPMENT

DEFINITION

While most communities use zoning and subdivision regulations to ensure development is appropriate, these regulations can sometimes be unintended roadblocks to getting the development a community envisions. "Appropriate development" in this context means development that is outside of particularly vulnerable areas, uses resources efficiently, protects the environment, and fulfills the community's vision. Regulatory roadblocks that might inadvertently prevent communities from getting this type of development include:

- Prohibitions on compact, mixed-use development.
- Requirements for suburban-style 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 flood plains, wetlands, or unbuildable areas.
- Inflexible yard and setback encroachment provisions that prohibit any construction in required yards or setbacks.
- Complicated permitting procedures in less-vulnerable infill and redevelopment areas.

Development codes can incorporate various flexibility and "safety valve" provisions to minimize the impacts of these unintended consequences. For example, administrative adjustments can be minor deviations from dimensional requirements (e.g., reducing yard requirements or allowing fewer parking spaces) that can be approved administratively or can allow development to move to a more appropriate area of the site. Incentives like density bonuses or height increases can encourage developers to build more compact projects. Zoning district standards can be revised or new districts created that allow a mix of uses by right instead of through a process that requires extensive review.

ADAPTATION PLANNING STAGE

Intermediate

RELEVANT SECTORS

Land Use: Most relevant sector. Makes the type of development the community wants the easiest and least complicated option for developers.

Water: Can remove roadblocks to allowing green infrastructure techniques and protecting water resources on a site.

Buildings: Ensures that communities get buildings that fit with community character and meet neighborhood needs.

RELEVANT HAZARDS

CLIMATE CONNECTION

Flexibility and safety valve provisions like administrative adjustments and incentives for appropriate development can help promote climate adaptation. For example:

- An administrative adjustment procedure could allow development to encroach into a required yard or setback on one side of a lot to retain a mature tree or avoid a sensitive area on the other side of the lot.
- 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 site's overall impervious footprint.

- Incentives such as additional density or building height could promote green roofs and rainwater harvesting devices that can significantly reduce stormwater runoff from a site.

Modifications to zoning district provisions that allow mixing uses or types of housing by right foster development in preferred locations, reducing some pressure to develop in particularly vulnerable areas. They also help to reduce greenhouse gas emissions by giving people transportation options besides driving.

LOCAL EXAMPLES

- Portsmouth, Virginia, has updated its zoning ordinance to allow administrative review and approval of requests for minor deviations (up to 15 percent) from any numeric or dimensional standard in the ordinance. 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), and compensating public benefits provisions that allow applicants to seek a waiver from one or more code requirements (such as required design standards) by providing a compensating public benefit (e.g., 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 require mixed-use development. The code includes a density bonus system that allows additional residential density, additional building height, reduced parking requirements, and increased lot coverage if the development includes green features such as LEED certification, green roofs, recycled building materials, or other elements.[151]
- In downtown Silver Spring, Maryland, redevelopment efforts near the Metrorail station got a boost from Montgomery County's Green Tape Program.[152] The county department of permitting services created a Green Tape review team to provide priority review to development applications in the project area, typically issuing permits within two weeks. The initial $400-million town center project stimulated $1.37 billion in private investment in new residences, office space, and retail.[153]

Figure 21: Downtown Silver Spring was revitalized in part due to the county's efforts to streamline development approvals and encourage investment in the area.

BENEFITS

- Removing roadblocks to appropriate development makes development regulations more flexible and helps the community get the type of development it wants.
- Encouraging development that offers transportation options or uses energy-efficiency technology can reduce greenhouse gas emissions.

[151] City of Portsmouth, VA. *Zoning Ordinance*. Revised Jul. 24, 2012. http://www.portsmouthva.gov/planning/docs/municodefinalJuly242012.pdf.

[152] Montgomery County, MD. "Green Tape Program." http://permittingservices.montgomerycountymd.gov/DPS/customerservice/GreenTape.aspx. Accessed Nov. 1, 2012.

[153] Iams, Alex, and Pearl Kaplan. *Economic Development and Smart Growth*. International Economic Development Council. 2006. http://www.iedconline.org/clientuploads/Downloads/edrp/IEDC_Smart_Growth.pdf.

IMPLEMENTATION

The regulatory tools described here are most effective when local plans and land use regulations direct development into buildable areas. The effective removal of roadblocks in the land development regulations depends, in part, on the community's comfort level with allowing staff to handle minor modifications and alternative approvals for development proposals.

Implementation measures could include:

- Incorporating administrative adjustment procedures for modifications to some dimensional standards such as setbacks or yard requirements.
- Establishing clear approval criteria for all administrative waivers, adjustments, and means of alternative compliance so that outcomes are predictable.
- Ensuring that approval criteria are measurable and objective.
- 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.
- Tailoring development standards for compact areas, including allowing closer building spacing, using structural screens instead of landscaped buffers, reducing parking requirements, or substituting streetscaping (e.g., green infrastructure features, plazas, benches, pedestrian-scale lamps, art, or water features) for required open space.
- Incorporating standards that protect local character and adjoining neighborhoods from potentially incompatible mixed-use development.
- Providing menus of climate adaptation features to help make these incentives practical.

5-D ADOPT GREEN, COMPLETE STREETS DESIGN STANDARDS

DEFINITION

Complete streets allow pedestrians, bicyclists, transit users, and drivers to travel safely. They are typically designed for areas with a well-connected street network, which further encourages walking and bicycling. Incorporating green infrastructure elements within the right-of-way absorbs polluted runoff and helps manage stormwater. Complete, green streets make the street's stormwater system part of the community's landscape as well as its stormwater management strategy.

CLIMATE CONNECTION

Complete streets design, including better connectivity within local and regional street networks, can help maintain mobility and access in the event of regional network disruptions. Better connectivity means that the road network provides more alternative routes that can be used if a major route is blocked by flooding or some other weather-related disruption. Complete streets also create beneficial redundancy by making more transportation options viable for many trips, including daily trips to jobs, stores, schools, and services.

Complete streets can help a community cope with unpredictable gas prices. In neighborhoods where walking, biking, or taking transit is easy or where driving distances are shorter, residents can opt to drive less and shift trips to other modes if gas prices rise. In neighborhoods with fewer transportation options, residents faced with high gas prices must either reduce their trips or cut other spending to pay for gas. In everyday life, complete streets help reduce greenhouse gas emissions by making walking and bicycling more appealing.

Many communities incorporate green infrastructure elements into complete streets. Features like street trees, rain gardens, and planters not only capture, slow, filter, and absorb stormwater, they also make the street more pleasant, provide shade, and calm traffic.

ADAPTATION PLANNING STAGE

Intermediate

RELEVANT SECTORS

Land Use: Can reduce cost of providing parking by improving pedestrian, bicycle, and transit access.

Transportation: Most relevant sector. Creates more options to access goods, services, jobs, and recreation, reducing effects from service disruptions.

Water: Reduces runoff from streets if the design incorporates natural stormwater management features.

Buildings: Can reduce the amount of lot space dedicated to parking, providing more room for buildings or green uses.

RELEVANT HAZARDS

LOCAL EXAMPLES

Many jurisdictions in the metropolitan Washington region have complete streets policies, and in 2012, the National Capital Region Transportation Planning Board passed a resolution supporting complete streets.[154] Maryland and Virginia have statewide policies, and Arlington County and Alexandria, Virginia; Montgomery County, Prince George's County, and Rockville, Maryland; and Washington, D.C., have policies as well.

- Montgomery County's policy incorporates green streets measures, providing standards for "public roads that are planned, designed, and constructed to:
  - Provide for the safety and convenience of all users of the roadway system …
  - Facilitate multi-modal use

[154] National Capital Region Transportation Planning Board. "Complete Streets Policy for the National Capital Region." Adopted May 16, 2012. http://www.mwcog.org/uploads/committee-documents/bF1dXlpX20120517141002.pdf.

  - Provide for the treatment of stormwater using Vegetated Integrated Management Practices in the road right-of-way
  - Accommodate, to the greatest extent possible, streets trees as an important environmental and community character element of the right-of-way and associated easements."[155]
- Washington, D.C.'s policy notes: "Improvements to the right of way shall consider environmental enhancements including, but not limited to: reducing right-of-way storm water run-off, improving water quality, prioritizing and allocating sustainable tree space and planting areas (both surface and subsurface), reusing materials and/or using recycled materials, and promoting energy conservation and efficiency wherever possible."[156]
- Arlington County's Master Transportation Plan includes a policy to "Reduce storm-water runoff by minimizing the creation of additional impermeable areas and increasing the infiltration of storm water in street-side collection areas and through permeable pavement."[157]

BENEFITS

- Making walking, bicycling, and transit use safe and convenient reduces greenhouse gas emissions and other pollution and makes it easier for people who cannot or choose not to drive to get around.
- More redundant street networks can offset or minimize traffic delays and other direct impacts from flooding that would be more acute in a less-connected, automobile-only road system.

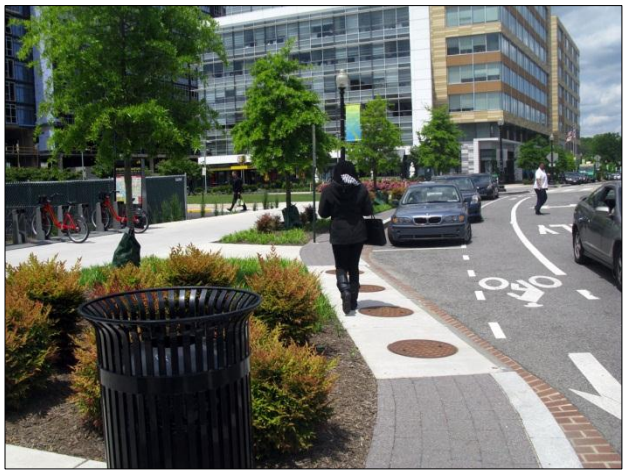


Figure 22: In front of the Waterfront Metro Station in Washington, D.C., Fourth Street Southwest has bike lanes, wide sidewalks, planting areas, and a Capital Bikeshare station.

- Streets that are safer and more pleasant for bicyclists and pedestrians can encourage more people to be physically active, which can improve their health.[158]
- Green infrastructure elements provide shade and reduce the heat island effect while also helping to reduce flooding and protect water quality.
- Studies have found that walkable neighborhoods have higher property values than less walkable ones.[159]

IMPLEMENTATION

Local governments could adopt complete streets design standards that also incorporate green infrastructure features. A complete streets policy requires consideration of all modes when constructing or reconstructing any street. It sets a vision for what the community wants from its streets, promotes connectivity, sets a high burden of proof for seeking exceptions, and would be adopted by all agencies involved in street design and construction.

Policies are generally more effective when complemented by implementation steps such as:

[155] County Council for Montgomery County, MD. "Resolution 16-809 (Approval of Executive Regulation 31-08 AM, Context Sensitive Road Design Standards)." Adopted Dec. 9, 2008. p. 20. http://www6.montgomerycountymd.gov/content/council/pdf/res/20081209_16-809.pdf.

[156] District Department of Transportation. "DDOT Issues Complete Streets Policy." Oct. 21, 2010. http://ddot.dc.gov/DC/DDOT/About+DDOT/News+Room/Public+Notices/DDOT+Issues+Complete+Streets+Policy.

[157] Arlington County, VA. *Arlington Master Transportation Plan Streets Element*. Adopted Feb. 12, 2011. p. 18. http://www.arlingtonva.us/departments/EnvironmentalServices/dot/planning/mplan/mtp/images/file77496.pdf.

[158] Heath, Gregory W., et al. "The Effectiveness of Urban Design and Land Use and Transport Policies and Practices to Increase Physical Activity: A Systematic Review." *Journal of Physical Activity and Health* 3, Suppl 1 (2006): S55-S76.

[159] Kooshian and Winkelman 2011.

- Street design guides that establish or update official guidelines for "completing" different types of streets. Communities could produce their own street design manual or endorse design standards such as the Institute of Transportation Engineers' *Designing Walkable Urban Thoroughfares*.[160] Design guides that show what is expected and acceptable are important, as demonstrated by a 1996 Massachusetts law that called for "reasonable provisions" for bicycles and pedestrians, which was ineffective in changing the Massachusetts Department of Transportation's road-design approach until its highway design manual was rewritten in 2006.[161]
- Workshops and training can help agency staff understand what they are implementing and why. For example, Chicago developed training sessions for project managers, planners, engineers, elected officials, and community stakeholders.[162]
- Performance measures can demonstrate the need for complete streets by tracking crash data and stormwater runoff, prioritize spending by determining where investment would maximize impacts, and assess the effects of complete streets by tracking conditions before and after implementation. Arlington County's Master Transportation Plan Streets Element includes performance measures for each policy.

[160] Institute of Transportation Engineers. *Designing Walkable Urban Thoroughfares: A Context-Sensitive Approach*. 2010. http://www.ite.org/emodules/scriptcontent/Orders/ProductDetail.cfm?pc=RP-036A-E.

[161] McCann, Barbara, and Suzanne Rynne. *Complete Streets: Best Policy and Implementation Practices*. American Planning Association. 2010.

[162] Ibid.

5-E UPDATE BUILDING CODE REQUIREMENTS

DEFINITION

Building codes are designed to ensure that buildings are safe for people to use and operate. Building codes are reviewed and updated periodically to reflect industry and technology changes.

CLIMATE CONNECTION

Buildings both affect the climate and are affected by it. Because buildings last a long time, their design and construction have both short- and long-term consequences.

However, most building codes were not developed for the changing temperature extremes, weather events, droughts, flooding, and extended weather-caused utility disruptions projected to increase with climate change. Current codes do not require buildings to maintain safe temperatures during heat waves, requiring them to maintain only minimum temperatures in cold weather, and typically assume that utility services will be uninterrupted. Provisions that address many climate-related hazards are based on historical weather and flood data, not projected changes in storms, temperature, or sea level rise.

Local governments can implement design and construction standards for all new buildings and substantial work on existing buildings that consider the increasing levels and types of risk and climate stress that are projected for the building's lifespan. Building to these higher standards and performance levels can protect health, lives, and property while reducing operating expenses and helping meet both climate mitigation and adaptation goals. These standards can be particularly helpful in helping low-income people cope with heat waves, storms, and other emergencies. People who cannot afford to cool their homes or who will not leave their homes during an emergency because of a lack of transportation or distrust of authorities need a safe place to ride out the emergency.

Many of these design standards are covered in green building codes. For example, the International Green Construction Code and the Standard for the Design of High-Performance Green Buildings (known as ASHRAE 189.1) as amended in 2013 both contain provisions that encourage site development practices that simulate the pre-development hydrology of the site, thus minimizing the site's impact on flood levels and local water quality. In the absence of adaptation-specific building codes, communities can use green building codes to meet many of the same objectives while also achieving other environmental and economic benefits.

ADAPTATION PLANNING STAGE

Advanced

RELEVANT SECTORS

Land Use: Could tie building requirements for vulnerable areas to specific changes in zoning and land use.

Transportation: Can incorporate options that encourage less-polluting transportation modes, such as showers in non-residential projects, bike racks, or electric-vehicle charging stations.

Water: Can incorporate provisions related to water supply, use, and reuse; wastewater; stormwater; and flooding.

Buildings: Most relevant sector. Encourage more resilient and energy-efficient buildings.

RELEVANT HAZARDS

LOCAL EXAMPLES

- Virginia communities must use the statewide building code, but they can adopt policies to encourage building practices that encourage better environmental performance. For example, in 2009, the city of Alexandria adopted a green building policy that says all new development requiring a development site plan or development special use permit should achieve a LEED Silver or equivalent rating for non-residential development and LEED certified

or equivalent rating for residential development.[163]

- The Washington, D.C., Green Building Act of 2006 established high-performance building standards and a green building incentives program.[164] The city is revising its building code to incorporate green building standards and hopes to finalize the new code in 2013.[165]

BENEFITS

- Codes that prepare for the projected impacts of climate change better protect life and property and reduce strain on emergency responders, 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, residents, and businesses will be.
- Local governments, businesses, and individuals can see lower operating, repair, rebuilding, utility, and maintenance costs, as well as lower insurance premiums because communities with the most current codes and the best enforcement pay the lowest insurance rates.[166]

IMPLEMENTATION

Building codes require local governments to establish local climatic and geographic conditions and criteria that buildings must be designed to meet. Codes typically contain climate, wind, flood, soil, and other maps used to establish building requirements according to expected conditions. Local governments could use projected vulnerabilities or risks identified through the community vulnerability assessment as the basis for using higher-than-historical requirements to deal with higher-than-historical risks.

Different states and localities have 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.

Even in Dillon Rule states with state-mandated codes, local governments have the authority to create building codes[167] and zoning districts[168] with specific provisions to address health and safety concerns, which can include increasing climate-related risks. Local governments can often use incentives and higher voluntary building standards if they cannot vary from state-mandated building codes.

In addition, the International Building Code and International Residential Code, which most state building codes either adopt directly or use as a foundation, reference FEMA and the National Flood Insurance Program, their maps and information, and the American Society of Civil Engineers (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 vulnerability assessments and require higher performance levels for buildings according to their predicted level of risk.

Local governments can also consider using the International Green Construction Code[169] or ASHRAE

[163] City of Alexandria, VA, Planning and Zoning. "Green Building in Alexandria." http://alexandriava.gov/GreenBuilding. Accessed Jan. 7, 2013.

[164] Council of the District of Columbia. *Green Building Act of 2006*. 1-206.02(c)(1). Enacted 2006. http://rrc.dc.gov/green/lib/green/pdfs/GreenBuilding_act06.pdf.

[165] Neibauer, Michael. "D.C.'s proposed building codes take 'green' requirements to another level." *Washington Business Journal*, Dec. 7, 2012.

[166] The Building Code Effectiveness Grading Schedule of the Insurance Services Office (ISO) grades communities on their codes and enforcement and sets insurance rates accordingly. ISO Mitigation Online. "ISO's Building Code Effectiveness Grading Schedule (BCEGS®)." http://www.isomitigation.com/bcegs/0000/bcegs0001.html#.TuDgFko771A. Accessed Nov. 5, 2012.

[167] Commonwealth of Virginia. *Virginia Construction Code: Part I of the Virginia Uniform Statewide Building Code.* 103.10. Effective Mar. 1, 2011. http://www.dhcd.virginia.gov/StateBuildingCodesandRegulations/PDFs/2009/Code%20-%20VCC.pdf. Section 103.10, Use of Certain Provisions of Referenced Codes, notes that "Section R301.2 of the International Residential Code authorizing localities to determine climatic and geographic design criteria" is considered a valid provision of the code.

[168] Silton, Andrew C., and Jessica Grannis. *Virginia Case Study: Stemming the Tide: How Local Governments Can Manage Rising Flood Risk*. Georgetown Climate Center. 2013. http://www.georgetownclimate.org/sites/default/files/Va%20Case%20Study%20Jan.%202013%20update.pdf.

[169] The International Green Construction Code is an overlay code for the International Building Code. International Code Council. "International Green Construction Code." http://www.iccsafe.org/cs/IGCC/Pages/default.aspx. Accessed Nov. 6, 2012.

189.1[170] to establish higher requirements tied to incentives. Another option is to adopt ordinances that give building and zoning departments the flexibility to approve projects pursuing certification under a third-party system even if they are using techniques that might otherwise be prohibited. For example, the city of Seattle[171] and Clark County, Washington,[172] allow buildings designed under the Living Building Challenge[173] to vary from certain code requirements such as mandated amounts of parking.

[170] ASHRAE. "Standard 189.1." https://www.ashrae.org/resources--publications/bookstore/standard-189-1. Accessed Jun. 26, 2013.
[171] Seattle Department of Planning and Development. "Priority Green." http://www.seattle.gov/dpd/permits/greenbuildingincentives/livingbuildingpilot/default.htm. Accessed Nov. 6, 2012.
[172] Clark County, WA. "Sustainable Communities." http://www.clark.wa.gov/environment/sustainability/communities.html. Accessed Nov. 6, 2012.
[173] The Living Building Challenge is a certification program for projects striving to meet or exceed net-zero performance for energy and water and to achieve other environmental benefits. International Living Future Institute. "Living Building Challenge." http://living-future.org/lbc. Accessed Nov. 6, 2012.

5-F INCORPORATE PASSIVE SURVIVABILITY INTO NEW AND EXISTING PROJECTS

DEFINITION

Passive survivability is a building's ability 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, and temperature extremes. Survivability 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 means, such as on-site renewable energy; rainwater harvesting, treatment, and storage; and wastewater systems.

CLIMATE CONNECTION

More frequent and longer utility service disruptions can reasonably be expected to accompany climate-related increases in storm intensity, flooding, and temperature extremes. Climate-related utility outages could result from increased electric power demands during periods of high temperatures. Power generation could be jeopardized if sufficiently cool water is not available for coal- and gas-fired power plants or nuclear power generation, which has already been a problem in some parts of the United States during summertime droughts.[174] The flooding and high winds accompanying severe storms frequently cause extensive damage, and it can take days or even weeks to restore services.

Current building codes do not require buildings to provide adequate health and safety to occupants beyond very short utility service disruptions, and many 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 would also help meet climate adaptation and resilience goals while reducing greenhouse gas emissions.

ADAPTATION PLANNING STAGE

Advanced

RELEVANT SECTORS

Land Use: Could require reviewing land use regulations for issues such as solar access and approvals for cisterns and renewable energy systems.

Water: Encourages water conservation.

Buildings: Most relevant sector. Ensures that buildings remain safe and habitable during natural disasters and extended utility service disruptions.

RELEVANT HAZARDS

While all buildings can benefit from these strategies, passive survivability could be particularly important for police and fire stations, critical infrastructure support facilities, hospitals, schools, and buildings designated as emergency shelters.

LOCAL EXAMPLE

- The Langston High School and Langston-Brown Community Center in Arlington, Virginia, incorporates passive solar and cooling-load avoidance strategies, operable windows for ventilation in the event of power failures, and large rainwater cisterns.

BENEFITS

- Local governments can continue to provide emergency services from critical facilities during extended utility service disruptions, extreme weather, and other events.
- Having public or private buildings that can be safely occupied during these events reduces demands on emergency responders and utility repair crews and reduces damage—and financial losses—to buildings and property

[174] EPA. "Energy Impacts & Adaptation." http://www.epa.gov/climatechange/impacts-adaptation/energy.html. Accessed Nov. 6, 2012.

typically resulting from extended power outages.

- Passive survivability can reduce direct and longer-term health impacts by ensuring that people have clean water and safe living conditions. This aspect is particularly important for people who cannot easily move to a safer location because of physical disability, a lack of transportation options, or a distrust of authorities.
- High-efficiency and passive-solar building envelopes and renewable energy systems reduce greenhouse gas emissions from operating buildings.
- Communities save money on everyday energy and water operating costs. If the approach includes measures such as conserving water or reusing collected stormwater, it can even reduce the pressure to expand water treatment facilities.

IMPLEMENTATION

In the vulnerability assessment, the local government will have identified critical buildings and facilities related to emergency services, including command and communication facilities; emergency shelters; hospitals; and infrastructure support buildings for power, water, sewer, and communications utilities. Once the local government has identified critical facilities, it can develop plans to improve their survivability, prioritized by the importance of the building, the level and type of vulnerability, the willingness of the facility's owner to make changes, and available resources.

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. If a community's

Figure 23: The Langston High School and Langston-Brown Community Center's passive survivability features include shades over windows and two 11,000-gallon cisterns, one of which is behind the white screen.

regulations allow net-zero-energy building, passive survivability will likely also be allowed because many of the energy-efficiency, renewable energy, ventilation, passive solar, daylighting, and other techniques used in net-zero-energy projects will also provide passive survivability. In addition, because of the other benefits these technologies bring, like saving money on energy costs, they are no-regrets strategies.

Once local governments are more familiar with the strategies and benefits, they can develop informational, technical, and incentive programs for privately owned buildings. Facilitating the process could involve removing regulatory barriers in building and land use codes and standards and offering incentives or technical assistance to help residents retrofit their homes or incorporate passive survivability measures into new homes.

Communities might also consider requiring or providing incentives for passive survivability for projects in areas currently or projected to be more vulnerable to service disruptions.

6 CONCLUSION

The strategies in this guidebook can help communities prepare for future risks in ways that generate benefits now and in the long term. They can help local governments meet multiple environmental, economic, and community goals to create healthy, thriving neighborhoods that can better withstand the hazards that are increasing as the climate changes.

This guidebook is presented to MWCOG's member jurisdictions as a resource that they can use not only to inform climate adaptation planning, but also to incorporate climate considerations into regular land use and transportation planning. It is a starting point for discussion. It will be up to each jurisdiction to determine if and how to implement any of the ideas presented in this report based on their needs, circumstances, and priorities. MWCOG provides a good forum for jurisdictions in the region to learn from each other as their climate adaptation efforts evolve.

Similar work could be useful on other topics that this guidebook was not able to address, such as how utilities and government entities such as public health departments, wildlife and natural resources management agencies, and school districts can prepare for and adapt to climate change.

Many other regions and localities around the country are planning for climate adaptation, and this report can be a resource for them as well. Incorporating smart growth and green building strategies into adaptation planning, and vice versa, helps both public and private entities to make communities safer, healthier, and stronger.

Figure 24: Satellite image of the Washington, D.C., region.

APPENDIX A: EPA SMART GROWTH IMPLEMENTATION ASSISTANCE PROGRAM

Communities around the country are looking to get the most from new development and to maximize their investments. Frustrated by development that gives residents no choice but to drive long distances between jobs and housing, many communities are bringing workplaces, homes, and services closer together. Communities are examining and changing zoning codes that make it impossible to build neighborhoods with a variety of housing types. They are questioning the fiscal wisdom of neglecting existing infrastructure while expanding new sewers, roads, and services into the fringe. Many places that have been successful in ensuring that development improves their community, economy, public health, and environment have used smart growth principles to do so (see box). Smart growth describes development patterns that create attractive, distinctive, and walkable communities that give people of varying age, wealth, and physical ability a range of safe, convenient choices in where they live and how they get around. Growing smart also means that we use our existing resources efficiently and preserve the lands, buildings, and environmental features that shape our neighborhoods, towns, and cities.

However, communities often need additional tools, resources, or information to achieve these goals. In response to this need, EPA launched the Smart Growth Implementation Assistance (SGIA) program to provide technical assistance through contractor services to selected communities.

The goals of this assistance are to improve the overall climate for infill, brownfields redevelopment, and the revitalization of non-brownfield sites, as well as to promote development that meets economic, community, public health, and environmental goals. EPA and its contractor assemble teams whose members have expertise that meets community needs. While engaging community participants on their aspirations for development, the team can bring their experiences from working in other parts of the country to provide best practices for the community to consider.

Smart Growth Principles

In 1996, based on the experience of communities around the nation, the Smart Growth Network developed a set of 10 basic principles:

- Mix land uses.
- Take advantage of compact building design.
- Create a range of housing opportunities and choices.
- Create walkable neighborhoods.
- Foster distinctive, attractive communities with a strong sense of place.
- Preserve open space, farmland, natural beauty, and critical environmental areas.
- Strengthen and direct development towards existing communities.
- Provide a variety of transportation choices.
- Make development decisions predictable, fair, and cost effective.
- Encourage community and stakeholder collaboration in development decisions.

Source: *www.smartgrowth.org/about/principles/default.asp*

For more information on the SGIA program, including reports from communities that have received assistance, see *www.epa.gov/smartgrowth/sgia.htm*.

APPENDIX B: ABOUT THE SITE VISIT

In 2010, MWCOG applied to EPA's SGIA program asking for help with identifying smart growth strategies that could improve the region's capacity to adapt to climate change and disseminating those strategies to local decision-makers. To provide the assistance, EPA contracted with SRA International. The contractor team included:

- Kate Marshall, SRA International (project lead)
- Chris Duerksen, Clarion Associates
- David Eisenberg, Clarion Associates/ Development Center for Appropriate Technology
- David Fields, Nelson Nygaard
- Sri Rangarajan, HDR
- Link Walther, Clarion Associates/Continental Shelf Associates

Kevin Nelson, AICP (project lead), and Megan Susman from the Office of Sustainable Communities were the EPA staff for this project. The MWCOG team included Joan Rohlfs, Maia Davis, Amanda Campbell, Jeannine Altavilla, and Anne Mariani.

MWCOG, EPA, and SRA chose to focus on four sectors—land use, transportation, water, and buildings—because they are the most relevant to using smart growth strategies to adapt to climate change and because MWCOG has committees set up around these sectors.

While a vulnerability assessment is a crucial early step in planning for adaptation, EPA's resources for this project could not include a full-fledged assessment. Instead, NOAA provided in-kind assistance by offering a session of its "Roadmap for Adapting to Risks Training" on March 3, 2011. Attendees at this training included local government staff from various MWCOG jurisdictions as well as federal and nonprofit partners. This training was not a vulnerability assessment for the MWCOG region; rather, it trained attendees in using the roadmap process to conduct a vulnerability assessment in their own communities. The training also was an early step to engage interested local staff in connecting risks and vulnerabilities to community development issues while the SGIA project was still in the planning phase.

In September 2011, MWCOG held stakeholder meetings for the four sectors. In each meeting, MWCOG staff presented an overview of how projected climate changes might affect the region, and the contractor team presented some examples of how other places around the country were addressing these issues. The stakeholders then identified data gaps and brainstormed potential approaches. Their suggestions are listed in Appendix C.

This guidebook used these stakeholder discussions, as well as best practices from around the country, to develop ideas for how jurisdictions in the region could prepare for climate change while meeting other goals. A draft of the guidebook was sent to stakeholders in the National Capital Region for review. Comments from those stakeholders helped refine the guidebook.

Other EPA staff reviewed part or all of the guidebook, including staff from the Office of Air and Radiation, Office of Enforcement and Compliance Assurance, Office of Environmental Justice, Office of Policy, Office of Research and Development, Office of Solid Waste and Emergency Response, Office of Water, and Region 3. NOAA staff Sarah van der Schalie and Tashya Allen also reviewed parts of the publication.

For more information about MWCOG's adaptation-related efforts, information developed as part of this SGIA project, and updates on dissemination of this guidebook, see *www.mwcog.org/environment/climate/adaptation.asp*.

APPENDIX C: STAKEHOLDER INPUT FROM SECTOR MEETINGS

In September 2011, MWCOG members met to discuss climate changes affecting the land use, transportation, water, and building sectors. In these meetings, participants were asked to identify gaps in the available information and resources and suggest approaches that could help them prepare for and adapt to climate change. This appendix lists the ideas collected from these meetings. The EPA team was not able to incorporate or address all of these ideas but provides them here for MWCOG, other Washington, D.C., area organizations and governments, and regional governments around the country as examples of the type of help communities are asking for.

LAND USE SECTOR

- Identify approaches for local governments to adapt to multiple impacts simultaneously (e.g., best practices for climate adaptation that maximize investment and impact or provide greater "bang for the buck").
- Demonstrate the financial benefits of preparing for climate change by developing cost-benefit analyses of "business as usual" compared with more sustainable land use that would prepare communities for worst-case climate scenarios (i.e., demonstrate that the upfront investment reduces long-term costs).
- Assist in cross-jurisdiction coordination to improve communication to the public related to climate adaptation issues.
- Help build political support for long-term climate adaptation planning activities.
- Identify funding sources for climate adaptation planning at the regional or local levels.
- Provide guidance to communities to focus mixed-use development in areas with access to transit.
- Provide examples or model ordinance language to prohibit development on steep slopes, stream valleys, and other vulnerable areas (e.g., flexible zoning).
- Encourage conservation of farmland and rural areas across the region.
- Across the region, encourage site planning that is sensitive to natural features and that incorporates green infrastructure strategies.
- Provide guidance on how to change existing land use patterns in flood-prone areas across the region.
- Assist with coordination to help communities manage development in areas that are at risk of flooding or higher storm surges due to sea level rise.
- Provide improved data projections for precipitation, stormwater management, and sea level rise; help identify the "new normal" for which communities can plan.
- Map non-tidal flooding areas across the region.
- Provide regional mapping that integrates natural systems and climate change adaptation approaches into local land use planning (e.g., develop geographic information system (GIS) layers related to habitat and migration shifts due to the changing climate).

TRANSPORTATION SECTOR

- Define expected climate impacts across the region (e.g., develop enhanced GIS data to identify sea level rise in feet, average seasonal changes in temperature, or stormwater projections) to provide a regional consensus on transportation system design parameters.
- Collect and share street elevation data to better understand which streets are most vulnerable to flooding and identify areas where underground stormwater storage systems can be constructed.
- Document expected impacts from long-term effects of climate change on transportation system components such as stop locations, materials, coverings, and fuel.
- Provide a mechanism (e.g., web portal or regional data workgroup) for sharing GIS and other climate-related data across the region to

reduce redundant data collection efforts and mapping activities.
- Identify regional transportation demand management strategies.
- Provide guidance on how to incorporate adaptation into long- and short-range transportation plans and capital improvement plans.
- Identify on a regional scale less-vulnerable areas targeted for smart growth development that should be prioritized for transportation investments.
- Develop local case studies of successful integrated transportation and land use development that prepares for projected climate change impacts.
- Develop case studies on what other agencies or municipalities are doing to adapt transportation systems to climate change.
- Provide best practices for transportation infrastructure design that is resilient to climate changes (e.g., flooding).
- Provide guidance on using street or tunnel infrastructure to temporarily store stormwater for reuse in landscaping irrigation.
- Develop best practices or model codes to reduce parking requirements in mixed-use, compact development areas.
- Provide guidance on how to develop areas around existing, underused Metro transportation infrastructure to encourage people to use transit, offer more housing and transportation options, better connect people to jobs in the region, and encourage compact development.
- Educate the public and elected officials about the consequences of cumulative transportation and land use decisions.
- Enhance communication among state and regional planning organizations and districts.
- Work with the federal government to encourage its coordination with regional and local governments and to improve federal workers' access to public transit.

WATER SECTOR

- Develop better estimates of the magnitude of climate change impacts to support better water sector planning (e.g., more accurate estimates of expected changes in precipitation, sea level, and temperature). Provide better modeling tools and/or more accurate modeling results. Identify ways to fund downscaled modeling.[175]
- Provide assistance in gathering data regarding the changing nature of 15-, 100-, and 200-year storm events; water demand; sea level rise (which is particularly important for water treatment plants); and temperature (which will affect infrastructure integrity and water quality).
- Provide improved modeling tools for regional stormwater planning (e.g., vulnerability assessment tools and design criteria for stormwater management and infrastructure).
- Establish region-specific guidance on how to integrate climate change considerations into broader decision-making.
- Provide assistance in developing a more coordinated and integrated approach to regional or watershed water policy (instead of a system that separately plans for drinking water, wastewater, stormwater, or Chesapeake Bay water quality).
- Provide regional guidance on source water and flood plain protection.
- Develop a regional plan to reduce stormwater volumes and pollutant loads from transportation corridors.
- Provide regional guidance on how to integrate improved stormwater practices in development projects.
- Develop guidance for local governments to encourage reuse of rainwater for nonpotable uses.
- Identify low-cost, no-regrets actions that local governments could undertake despite uncertainty in climate change predictions.

[175] Downscaling models means performing additional work to convert the global-scale projections that most climate models produce into finer-grained, locally specific information.

Identify water sector approaches that have the best cost-benefit ratio.

- Develop best practices and credible data on effective stormwater management approaches to meet regulatory requirements. Track performance of rain gardens, rain barrels, and other features that capture and filter stormwater.
- Conduct outreach and help build public and political support for changes needed to prepare for climate change.
- Identify locations for new reservoirs to capture storm surges or heavy rainfall and save the water for drought periods or nonpotable use.
- Identify fill locations that could be converted back to a wetland or shoreline environment.

BUILDING SECTOR

- Educate the public, elected officials, and municipal employees about the climate changes that are happening and that are projected to happen and about how to prepare for these changes.
- Have a clear plan that links to the National Flood Insurance Program. Adopt higher standards and apply design and construction standards beyond development in mapped flood plain. Encourage relocating buildings from risky areas and limiting certain types and uses of buildings in vulnerable areas.
- Establish baselines and metrics to measure progress.
- Produce data that are comprehensible to political leadership. Have a centralized database with information on increasing temperatures and precipitation patterns. Model the effects of projected changes on the built environment.
- Enable low- or no-cost upgrades from property owners and support them with assessment incentives.
- Map areas vulnerable to heat, flooding, and other impacts to prioritize outreach and funding.
- Pay more attention to reduced public revenues for enforcement of codes and to the perception that immediate emergency management is a higher priority.
- Refine and improve projections for temperature and precipitation changes and put them in a format that can be incorporated into engineering designs.
- Help develop approaches that address retrofitting.
- Develop standards or best practices for utility distribution system resiliency. Provide information on climate trends related to utilities. Get utilities on board to help with energy efficiency and on-site energy generation.
- Conduct modeling on heat island effects in compact communities with multiple buildings.
- Benchmark energy use per square foot against the best performing buildings in the region.
- Improve data on storm surges, including cost-benefit analyses of hardening existing buildings.
- Develop a regional GIS layer for inundation for use in planning.

APPENDIX D: CLIMATE ADAPTATION

The provision of clean and safe water is essential to the economy viability and the public health of all communities. Drinking water treatment systems remove contaminants from raw water supplies and provide safe drinking water for over 300 million people across the United States. Wastewater treatment systems treat sewage from urban areas with a population of over 160 million and remove pollutants for discharges to receiving waters. This appendix gives a very brief introduction to why it is important for water systems to plan for climate change and offers resources that give more detailed and comprehensive information.

Drinking water and wastewater systems are vulnerable to the changes in weather and hydrologic conditions that are expected to result from a changing climate. Extreme weather events intensified by climate change pose serious challenges for drinking water and wastewater systems. Drinking water and wastewater treatment plants are often located in low-lying areas are subject to flooding and, in coastal areas, inundation as a result of storm surges. Flooding and storm surges can disrupt operation at water treatment systems, leading to human health and environmental problems and costly repairs and renovations. Sea level rise poses a long term risk of inundation and damage to water systems in coastal areas. Changes in rainfall patterns and in the intensity of rainfall can reduce the reliability of drinking water supplies and make it more difficult to meet pollution discharge limits for wastewater treatment systems.

To continue to meet their public health and environmental missions, drinking water and wastewater systems need to understand their vulnerabilities to a changing climate and implement actions to reduce these risks.

A study by the Interstate Commission on the Potomac River Basin concluded that by 2040, the Potomac River basin could experience:

- Average temperature increases of 1.3 to 4.1 F (0.7 to 2.3 degrees Celsius).
- Precipitation increases or decreases (the models projections were evenly split).
- Increased average evapotranspiration rates, causing stream flows to decrease as much as 34 percent.
- Higher summertime water demand.[176]

In the worst-case scenario, if no changes are made to the water supply system, a moderate drought in 2040 could cause mandatory restrictions on water use, depleted reservoirs, and very low flows in the Potomac River.[177]

Some of the benefits of planning for climate change impacts on water systems include:

- Improved reliability of drinking water and wastewater systems during extreme weather events helps avoid or reduce service disruptions that can have significant environmental, human health, and economic consequences.
- Understanding the potential impacts of climate change on water supplies will encourage long-range planning to identify and develop alternative sources and to implement a range of non-structural practices to help reduce demand for water and to increase water efficiency.
- Developing vulnerability assessments for water systems can help anticipate treatment and discharge issues related to changing water availability and changes in flows in waters receiving discharges.

[176] Ahmed, S.N., K.R. Bencala, and C.L. Schultz. *2010 Washington Metropolitan Area Water Supply Reliability Study: Part 2: Potential Impacts of Climate Change*. Interstate Commission on the Potomac River Basin. 2013. http://www.potomacriver.org/publicationspdf/ICPRB13-07.pdf.
[177] Ibid.

RESOURCES

- Water systems can participate in the EPA WaterSense Program as a "partner" as a key step toward supporting water use efficiency in the community. DC Water is a program partner and will offer consumers useful water-saving techniques and encourage them to look for WaterSense-labeled products when making product choices. These products use about 20 percent less water and perform as well as, or better than, conventional models. See *www.epa.gov/watersense/partners/index.html* for more information about becoming a partner.
- DC-area water and wastewater utilities of all sizes can join the Water/Wastewater Agency Response Network (WARN) for the National Capital Region to better respond to and recover from extreme weather events. WARNs are networks of "utilities helping utilities" to support the sharing of water and wastewater utility resources during emergencies. Several National Capital Region (NCR) utilities are already members of NCR WARN, including DC Water, the city of Fairfax, Virginia; the city of Rockville, Maryland; Arlington County, Virginia; and Loudoun Water in Virginia. See *www.ncrwarn.org* for more information about NCR WARN and *www.awwa.org/resources-tools/water-knowledge/emergency-preparedness/water-wastewater-agency-response-network.aspx* for more information about WARNs in general.
- Water systems interested in reviewing the range of climate adaptation challenges and evaluating priority actions can draw on the Adaptation Strategies Guide developed by the EPA Climate Ready Water Utilities Program, available at *water.epa.gov/infrastructure/watersecurity/climate/upload/epa817k11003.pdf*.
- Water systems interested in focusing on extreme weather events can use the EPA Extreme Events Workshop Planner, available at *yosemite.epa.gov/ow/SReg.nsf/WorkshopRegistraton?OpenForm&Download=WORKSHOP*.
- Water systems interested in a more extensive and structured climate change adaptation planning process can consider using the Climate Resilience Evaluation and Awareness Tool (CREAT). CREAT is a software tool to assist drinking water and wastewater utility owners and operators in understanding potential climate change threats and in assessing the related risks at their individual utilities. CREAT provides users with access to the most recent national assessment of climate change impacts for use in considering how these changes will affect utility operations and missions. It is available for download free of charge at *water.epa.gov/infrastructure/watersecurity/climate/creat.cfm*.
- Water systems can also gather a range of information for climate change-related planning from the Climate Ready Water Utilities Toolbox. The toolbox is organized into categories to help guide the user to the most relevant information. Hundreds of resources in the toolbox can be searched by geographic region, water utility type and size, water resources, climate change impact, and climate change response strategies. See *www.epa.gov/safewater/watersecurity/climate/toolbox.html*.
- Several approaches that water systems can use to address the various hazards to water infrastructure are described in *Adapting to Climate Change: The Public Policy Response – Public Infrastructure*, by James E. Neumann and Jason C. Price, published by Resources for the Future in 2009, available at *www.rff.org/News/Features/Pages/Climate-Threats-to-Infrastructure.aspx*.
- American Water, which owns water systems in over 30 states, including Alexandria Water in Virginia, recognizes the implications of a changing climate for water systems and developed a white paper on climate change to guide future planning. See *files.shareholder.com/downloads/AMERPR/2644891801x0x262681/2A25899A-F0A6-4CA3-95D5-215946CC3064/WP081216_ClimateChange.final.pdf*.

APPENDIX E: RESOURCES

This appendix includes:

- General smart growth and climate adaptation resources.
- MWCOG member jurisdictions' climate change resources.
- Other climate adaptation plans.
- Resources and more information for each approach in Sections 3-5.

GENERAL SMART GROWTH AND CLIMATE ADAPTATION RESOURCES

Climate Adaptation Knowledge Exchange houses resources on managing natural resources in the face of a rapidly changing climate and includes case studies and tools. http://www.cakex.org.

The U.S. Department of Transportation's Transportation and Climate Change Clearinghouse contains resources on climate impacts on transportation, including roads and transit. http://www.climate.dot.gov/index.html.

EPA's smart growth website includes research, publications, and tools to help communities learn about and implement smart growth approaches. http://www.epa.gov/smartgrowth.

EPA. *Creating Equitable, Healthy, and Sustainable Communities: Strategies for Advancing Smart Growth, Environmental Justice, and Equitable Development*. 2013. http://www.epa.gov/smartgrowth/equitable_development_report.htm. Provides land use and community design strategies that bring together smart growth, environmental justice, and equitable development principles and that community-based organizations, local and regional decision-makers, developers, and others can use to revitalize their communities.

EPA. *Essential Smart Growth Fixes for Urban and Suburban Zoning Codes*. 2009.
EPA. *Essential Smart Growth Fixes for Rural Planning, Zoning, and Development Codes*. 2012. http://www.epa.gov/smartgrowth/essential_fixes.htm. Specific changes local governments in urban, suburban, and rural places could make to their codes and ordinances to promote more sustainable communities.

International City/County Management Association and Smart Growth Network. *Getting to Smart Growth*, Volumes I (2002) and II (2003). http://www.epa.gov/smartgrowth/getting_to_sg2.htm. Each volume contains 100 policies, many of which can help create compact, mixed-use communities. Also available in Spanish.

International City/County Management Association and Smart Growth Network. *This Is Smart Growth*. 2006. http://www.epa.gov/smartgrowth/tisg.htm. Also available in Spanish.

MWCOG MEMBER JURISDICTIONS' CLIMATE CHANGE RESOURCES

District of Columbia

Climate of Opportunity: A Draft Climate Action Plan for the District of Columbia: http://rrc.dc.gov/green/cwp/view,A,1231,Q,460764.asp.

Maryland

Maryland Department of the Environment—Climate Change: http://www.mde.state.md.us/programs/Air/ClimateChange/Pages/Air/climatechange/index.aspx.

City of Bowie—Green Bowie: http://www.cityofbowie.org/index.aspx?NID=98.

Going Green in Charles County: http://www.charlescounty.org/green.

Sustainable Frederick County: http://frederickcountymd.gov/index.aspx?NID=3530.

City of Gaithersburg—Environmental Services: http://www.gaithersburgmd.gov/poi/default.asp?POI_ID=388&TOC=107;83;388.

City of Greenbelt—Green Steps: http://www.greenbeltmd.gov/green_steps/index.html.

Montgomery County Department of Environmental Protection—Climate Change: http://www.montgomerycountymd.gov/dectmpl.asp?url=/Content/dep/climatechange/climateL2.asp.

Prince George's County—Air Quality and Climate Program: http://www.co.pg.md.us/Government/AgencyIndex/DER/ESG/about-air-quality.asp.

City of Rockville—Energy and Climate Protection: http://www.rockvillemd.gov/index.aspx?NID=288.

Virginia

Commonwealth of Virginia: http://www.deq.virginia.gov/Programs/CoastalZoneManagement/CZMIssuesInitiatives/ClimateChange.aspx.

Eco-City Alexandria: http://alexandriava.gov/Eco-City.

Arlington Initiative to Rethink Energy: http://freshaireva.us.

Fairfax County—Cool Counties: http://www.fairfaxcounty.gov/living/environment/coolcounties.

City of Falls Church—Climate Change and Energy Efficiency: http://www.fallschurchva.gov/Content/Government/Departments/PublicUtilities/Environment/climatechange.aspx?cnlid=4396.

OTHER CLIMATE ADAPTATION PLANS

Several states, regions, and local governments have developed climate adaptation plans, including:

- California (2009): http://www.climatechange.ca.gov/adaptation.
- Washington (interim report in 2011): http://www.ecy.wa.gov/climatechange/ipa_responsestrategy.htm.
- San Diego (2012): http://www.icleiusa.org/climate_and_energy/Climate_Adaptation_Guidance/san-diego-bay-sea-level-rise-adaptation-strategy-1/san-diego-bay-sea-level-rise-adaptation-strategy.
- Southeast Florida (2012): http://www.southeastfloridaclimatecompact.org.
- Boston (2011): http://www.cityofboston.gov/climate/bostonsplan/default.asp.
- Chicago (2008): http://www.chicagoclimateaction.org/pages/adaptation/11.php.
- New York City (2010): http://www3.interscience.wiley.com/journal/123443047/issue.
- Keene, NH (2007): http://www.ci.keene.nh.us/sustainability/climate-change.

For more information on state climate adaptation planning, see the Center for Climate and Energy Solutions' regularly updated map of states with climate adaptation plans completed or in progress at http://www.pewclimate.org/what_s_being_done/in_the_states/adaptation_map.cfm.

For more information on local climate adaptation planning, see ICLEI's resources at http://www.icleiusa.org/climate_and_energy/Climate_Adaptation_Guidance.

RESOURCES AND MORE INFORMATION FOR EACH APPROACH IN SECTIONS 3-5

Approach 3-A: Evaluate development incentives provided in particularly vulnerable areas

Georgia Institute of Technology. WebLOCI™ Local Fiscal Impact Analysis. http://weblociusers.org. Web-based version of the local fiscal impact tool LOCI™ designed to provide decision-makers with insight into the fiscal and economic impacts of new or expanding businesses. Uses include helping a community understand what appropriate incentives might be.

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Approach 3-B: Adopt protective regulations for particularly vulnerable areas

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County of Maui, Hawaii. "Shoreline Setback Assessment Application." http://www.co.maui.hi.us/index.aspx?NID=1269. Accessed Sep. 19, 2012. The county 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.

FEMA Region 10. *Higher Floodplain Management Regulatory Standards*. 2002. http://www.oregon.gov/LCD/HAZ/docs/floods/floodplain_mgmt_higher_reg_standards.pdf?ga=t. Describes approaches to flood plain management in the Pacific Northwest and identifies approaches for local governments that exceed the minimum requirements of the National Flood Insurance Program.

Frederick County, Virginia, Department of Planning and Development. "Memorandum on Riparian Buffers." Oct. 3, 2011. Example of how a Virginia locality incorporated the Chesapeake Bay Act and Regulations into local codes.

Jefferson County, Colorado. "Section 52: W-H Wildfire Hazard Overlay District." Adopted Feb. 8, 2011. Wildfire hazard overlay district that prohibits the construction, reconstruction, or expansion of structures until the property owner receives approval of a wildfire mitigation site plan that maintains defensible space and fuel breaks thinnings.

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Virginia Institute of Marine Science. *Recurrent Flooding Study for Tidewater Virginia (SJR 76, 2012)*. Report to the Governor and General Assembly of Virginia. Senate Document No. 3. 2013. http://leg2.state.va.us/dls/h&sdocs.nsf/By+Year/SD32013/$file/SD3.pdf. Section 2.3, Viability of Management/ Retreat Options in Virginia's Political Climate, outlines planning authorities, financial incentives, investment and infrastructure decisions, and regulatory authorities that Virginia localities can use to plan for flooding and sea level rise.

Approach 3-C: Direct development away from particularly vulnerable areas within individual development sites

Arendt, Randall. *Rural by Design: Maintaining Small Town Character*. American Planning Association. 1994.

Maiolo, John R., et al (editors). *Facing Our Future: Hurricane Floyd and Recovery in the Coastal Plain*. Coastal Carolina Press. 2001. See "Natural Hazards, Smart Growth, and Creating Resilient and Sustainable Communities in Eastern North Carolina" on pp. 271-282.

North Shore Land Alliance [Long Island, New York]. Local Ordinance Guide. http://www.northshorelandalliance.org/modelorid.htm. Accessed Sep. 19, 2012. Provides model regulations to preserve sensitive lands.

Park City, Utah. *Park City Municipal Code*. Title 15: Land Management Code – Chapter 2.21. Adopted Aug. 2008. http://www.parkcity.org/Modules/ShowDocument.aspx?documentid=217. The Sensitive Area Overlay Zone Ordinance addresses wetland and stream protection as well as wildfire regulations. In applying the overlay, staff and the applicant delineate sensitive lands and those available for development. The overlay specifies how much density can be transferred out of the sensitive areas onto the remainder of the site.

Approach 3-D: Adopt or adapt a purchase or transfer of development rights program

King County, Washington. "Farmland Preservation Program." Updated Nov. 23, 2011. http://www.kingcounty.gov/environment/wlr/sections-programs/rural-regional-services-section/agriculture-program/farmland-preservation-program.aspx.

Maryland AgPrint. "Local Purchase of Development Rights (PDR) /Transfer of Development Rights (TDR) Programs." http://www.agprint.maryland.gov/programs.html. Accessed Sep. 19, 2012.

Pruetz, Rick. *Beyond Takings and Givings*. American Planning Association Planners Book Service, Aerie Press. 2003. http://www.beyondtakingsandgivings.com/beyond.htm.

Virginia Department of Agriculture and Consumer Services, Office of Farmland Preservation. "Farmland Preservation Tools." http://www.vdacs.virginia.gov/preservation/tools.shtml. Accessed Jan. 7, 2013.

Approach 3-E: Establish a fund to acquire or protect land in particularly vulnerable areas

Baltimore County, Maryland. "Easement Programs and Applications." Revised Nov. 8, 2011. http://www.baltimorecountymd.gov/Agencies/environment/landpreservation/agpres.html.

Duerksen, Chris and Cara Snyder. *Nature-Friendly Communities: Habitat Protection and Land Use Planning, Key Elements and Best Tools.* Island Press. 2005.

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Titus, James G. "Rising Seas, Coastal Erosion, and the Takings Clause: How to Save Wetlands and Beaches Without Hurting Property Owners." *Maryland Law Review* 57.4 (1998): 1279-1399. http://papers.risingsea.net/downloads/takings.pdf.

Approach 4-A: Improve stormwater management approaches

Committee on Reducing Stormwater Discharge Contributions to Water Pollution, National Research Council. *Urban Stormwater Management in the United States*. The National Academies Press. 2008. http://www.nap.edu/catalog.php?record_id=12465. Suggests municipal-level actions to reduce stormwater runoff.

Commonwealth of Virginia Department of Conservation and Recreation. *Virginia Stormwater Management Handbook, First Edition*. 1999. Chapter 2: Stormwater Management and Urban Best Management Practices. http://www.dcr.virginia.gov/stormwater_management/documents/Chapter_2.pdf.

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EPA. "Green Infrastructure." http://water.epa.gov/infrastructure/greeninfrastructure/index.cfm. Accessed Sep. 19, 2012. Includes tools and case studies that can help communities implement green infrastructure approaches.

EPA. "National Stormwater Calculator." http://www.epa.gov/nrmrl/wswrd/wq/models/swc. Accessed Sep. 3, 2013. Estimates the annual amount of rainwater and frequency of runoff from a specific site anywhere in the United States.

EPA. *Water Quality Scorecard: Incorporating Green Infrastructure Practices at the Municipal, Neighborhood, and Site Scale*. 2009. http://www.epa.gov/smartgrowth/water_scorecard.htm. Guides municipal staff through a review of codes and ordinances to ensure that codes support a green infrastructure approach.

Maryland Department of the Environment. *Maryland Model Stormwater Management Ordinance*. 2002 and 2007 supplement. http://www.mde.state.md.us/programs/ResearchCenter/ReportsandPublications/WaterPublications/Documents/www.mde.state.md.us/assets/document/sedimentStormwater/model_ordinance.pdf.

Maryland Smart, Green and Growing. "Stormwater: Slow It Down, Spread It Out, Soak It In." http://www.green.maryland.gov/greendowntown/Storm_Water.asp. Accessed Sep. 19, 2012.

Northern Virginia Regional Commission. "BMP Handbooks." http://www.novaregion.org/index.aspx?nid=250. Accessed Feb. 24, 2012.

Virginia Department of Conservation and Recreation. *Stormwater Management Enforcement Manual*. 2006.

Approach 4-B: Adapt zoning and building codes to evolving risks

In two communities that suffered severe damage from Hurricane Katrina, Biloxi and Pascagoula, Mississippi, nonconforming structures in special flood hazard areas can expand their footprints by up to 15 percent through approval of a special or conditional use permit—provided the expanded structure incorporates features that better comply with flood damage prevention standards—without requiring full compliance with all zoning and flood plain standards.

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- City of Pascagoula, Mississippi. *Unified Development Ordinance*, Article 8: Nonconformities. Feb. 2011. http://cityofpascagoula.com/wp-content/uploads/2011/06/Final-Unified-Development-Ordinance-5.pdf.

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City of Chula Vista, California. *Climate Adaptation Strategies: Implementation Plans*. 2011. http://www.chulavistaca.gov/clean/conservation/Climate/ccwg1.asp. Includes code changes for cool roofs, water reuse, cool paving, sea level rise, and land development codes and detailed plans and budgeting projections.

Georgetown Climate Center. *Adaptation Tool Kit: Sea-Level Rise and Coastal Land Use*. 2011. http://www.georgetownclimate.org/resources/adaptation-tool-kit-sea-level-rise-and-coastal-land-use. Lists materials from some states that have recommended implementing building code changes and developing resilient design guidance.

Ientilucci, Arthur. "Pigs in the Parlor or Diamonds in the Rough? A New Vision for Nonconformity Regulation." *Zoning News*. American Planning Association, Feb. 2003.

Massachusetts Executive Office of Energy and Environmental Affairs. "Building Energy Codes." http://www.mass.gov/eea/energy-utilities-clean-tech/energy-efficiency/policies-regs-for-ee/building-energy-codes.html. Accessed Sep. 19, 2012. Includes information about Massachusetts' "stretch code" for better energy performance for buildings.

Oregon Department of Consumer and Business Services, Building Code Division. "Oregon Reach Code." http://www.bcd.oregon.gov/programs/reach.html. Accessed Sep. 19, 2012. Optional energy-efficiency standards that exceed the state's mandatory codes.

Santa Barbara County, California. *County Land Use and Development Code*, Chapter 35, Nonconforming Uses, Structures, and Lots. 2008. http://longrange.sbcountyplanning.org/planareas/gaviota/documents/GavPAC%20Materials/GavPAC%20Meeting%2031/NonConformingUsesLUDC.pdf. Permits the reconstruction, alteration, and relocation of structures housing nonconforming uses in coastal erosion areas provided they meet certain standards, such as compliance with setback and height requirements. Seismic retrofits are allowed for all nonconforming structures.

Approach 4-C: Create special districts to fund retrofits and upgrades for public buildings and infrastructure

Wang, Yumei and Bill Burns. "Case History on the Oregon GO Bond Task Force: Promoting Earthquake Safety in Public Schools and Emergency Facilities." Presented at 8th National Earthquake Conference, Apr. 18-21, 2006, San Francisco. http://www.oregongeology.org/sub/projects/rvs/EERI-GO-Bond-text.pdf. Describes how a task force developed recommendations to permit local governments to issue general obligation bonds to pay for seismic rehabilitation of schools and emergency facilities. A similar method could fund building upgrades in vulnerable areas.

Approach 4-D: Identify and address transportation system vulnerabilities

District Department of Transportation. *Climate Change Adaptation Plan*. Undated. http://dc.gov/DC/DDOT/Publication%20Files/Projects%20and%20Planning/Environment/Climate%20Change/DDOT_Climate-Adaptation-Plan.pdf. Accessed Sep. 3, 2013.

TRB Special Task Force on Climate Change and Energy. *Adapting Transportation to the Impacts of Climate Change: State of the Practice 2011*. Transportation Research Board of the National Academies. 2011. http://www.trb.org/Main/Blurbs/165529.aspx.

U.S. Department of Transportation. "Climate Change Impacts." Transportation and Climate Change Clearinghouse. http://climate.dot.gov/impacts-adaptations/forcasts.html. Accessed Nov. 2, 2012.

U.S. Department of Transportation, Federal Highway Administration. *Integrating Climate Change into the Transportation Planning Process*. 2008. http://www.fhwa.dot.gov/environment/climate_change/adaptation/resources_and_publications/integrating_climate_change/index.cfm.

Wilmington Area Planning Council. *Sea-Level Rise: A Transportation Vulnerability Assessment of the Wilmington, Delaware, Region*. 2011. http://www.wilmapco.org/slr.

Approach 4-E: Implement heat island reduction strategies

Center for Neighborhood Technology and American Rivers. *The Value of Green Infrastructure: A Guide to Recognizing Its Economic, Environmental and Social Benefits.* 2010. http://www.cnt.org/repository/gi-values-guide.pdf.

EPA's Heat Island Effect website (http://www.epa.gov/hiri/index.htm) has several helpful resources, including:

- *Reducing Urban Heat Islands: Compendium of Strategies*. 2008. http://www.epa.gov/hiri/resources/compendium.htm.
- Mitigation Impact Screening Tool (MIST). Accessed Sep. 19, 2012. http://www.heatislandmitigationtool.com/Introduction.aspx.
- *Excessive Heat Events Guidebook*. 2006. http://www.epa.gov/heatisld/about/heatguidebook.html.
- *Community Actions Database*. Accessed Sep. 19, 2012. http://yosemite.epa.gov/gw/heatisland.nsf/webpages/HIRI_Initiatives.html.
- Urban heat island mitigation strategies for trees and vegetation, green roofs, cool roofs, and cool pavements. Accessed Sep. 19, 2012. http://epa.gov/heatisland/mitigation/index.htm.

Georgetown Climate Center. *Adapting to Urban Heat: A Tool Kit for Local Governments*. 2012. http://www.georgetownclimate.org/adaptation-tool-kit-urban-heat.

Green Roofs for Healthy Cities. http://www.greenroofs.org. Accessed Sep. 19, 2012.

U.S. Forest Service. "Urban and Community Forestry." http://www.fs.fed.us/ucf. Accessed Sep. 19, 2012.

Approach 4-F: Streamline and fund the relocation process

Association of State Floodplain Managers. *Mitigation Success Stories in the United States*. 2002. http://www.floods.org/PDF/MSS_IV_Final.pdf.

Boulder County (Colorado) Land Use Department. *Boulder County Land Use Code*. Article 6: Planned Development Districts. Adopted Oct. 18, 1994. http://www.bouldercounty.org/doc/landuse/lucodearticle06.pdf. See Section 6-500 (Noncontiguous Nonurban Planned Unit Development).

Delaware River Basin Commission Floodplain Regulation Evaluation Subcommittee. *Recommendations of the Floodplain Regulations Evaluation Subcommittee (FRES) of the DRBC Flood Advisory Committee (FAC)*. 2009. http://www.nj.gov/drbc/library/documents/Flood_Website/FRES/Report_051909rev060209.pdf. Study on creating more effective flood plain regulations, including providing incentives to relocate structures.

FEMA. "Pre-Disaster Mitigation Grant Program." http://www.fema.gov/government/grant/pdm/index.shtm. Accessed Feb. 15, 2012.

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Massachusetts Executive Office of Environmental Affairs and the Massachusetts Climate Change Adaptation Advisory Committee. *Massachusetts Climate Change Adaptation Report*. 2011. http://www.mass.gov/eea/air-water-climate-change/climate-change/climate-change-adaptation-report.html. Examines assessment, planning, adaptation, and mitigation strategies, including some related to land use and building codes.

New York State Energy Research and Development Authority. *Report 11-18 Response to Climate Change in New York State (ClimAID)*. 2011. http://www.nyserda.ny.gov/Publications/Research-and-Development/Environmental/EMEP-Publications/Response-to-Climate-Change-in-New-York.aspx. Discusses adaptation strategies for local governments.

Approach 5-A: Promote compact, mixed-use development

Center for Clean Air Policy. *Growing Wealthier: Smart Growth, Climate Change and Prosperity*. 2011. http://www.growingwealthier.info. Provides information on the economic and quality of life benefits of compact, mixed-use development.

EPA. *Restructuring the Commercial Strip: A Practical Guide for Planning the Revitalization of Deteriorating Strip Corridors*. 2010. http://www.epa.gov/smartgrowth/corridor_guide.htm. Ideas for revitalizing outdated commercial corridors.

Form-Based Codes Institute. "Code Resources." http://www.formbasedcodes.org/code-resources. Accessed Sep. 19, 2012.

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Urban Land Institute. *Ten Principles for Reinventing America's Suburban Strips*. 2001. http://www.uli.org/ResearchAndPublications/Reports/~/media/Documents/ResearchAndPublications/Reports/TenPrinciples/Tp_SuburbanStrips.ashx.

Approach 5-B: Promote infill development in appropriate locations

Center for Community Progress. *Building American Cities Toolkit*™. http://www.communityprogress.net/toolkit-home-page-pages-292.php. Accessed Nov. 1, 2012.

Maryland Department of Planning. *Models and Guidelines for Infill Development*. 2001. http://planning.maryland.gov/pdf/ourproducts/publications/modelsguidelines/infillfinal_1.pdf.

Municipal Research Services Center of Washington. "Infill Development: Completing the Community Fabric." Updated March 2012. http://www.mrsc.org/subjects/planning/infilldev.aspx. Links to a wide variety of resources, including studies, sample ordinances, and tools.

Oregon Transportation and Growth Management Program. *The Infill and Redevelopment Code Handbook*. 1999. http://www.oregon.gov/LCD/docs/publications/infilldevcode.pdf.

Urban Land Institute. *Barriers and Solutions to Land Assembly for Infill Development*. 2004. http://www.uli.org/wp-content/uploads/2012/07/LandAssembly.ashx_.pdf.

Approach 5-C: Remove roadblocks to appropriate development

Smart Growth Leadership Institute. *Smart Growth Implementation Toolkit*. http://www.smartgrowthamerica.org/leadership-institute/implementation-tools. Accessed Nov. 1, 2012. Includes tools that can help communities identify policies that might be preventing them from getting the type of development they want.

Approach 5-D: Adopt green, complete streets design standards

Complete streets policies and design standards in the MWCOG region include:

- City of Alexandria, Virginia. "Resolution 2444." Adopted Apr. 12, 2011. http://alexandriava.gov/uploadedFiles/localmotion/info/gettingaround/Street%20Resolution.pdf.
- Arlington County, Virginia. *Arlington Master Transportation Plan Streets Element*. Adopted Feb. 12, 2011. http://www.arlingtonva.us/departments/EnvironmentalServices/dot/planning/mplan/mtp/images/file77496.pdf.
- Washington, D.C., Department of Transportation. "Departmental Order No. 06-2010 (DDOT Complete Streets Policy)." Oct. 18, 2010. http://ddot.dc.gov/DC/DDOT/Publication%20Files/About%20DDOT/Policies/ddot_completestreetpolicy.pdf.
- Maryland State Highway Administration. "Context Sensitive Solutions and Complete Streets." http://sha.md.gov/Index.aspx?PageId=332&d=93. Accessed Nov. 1, 2012.
- Montgomery County, Maryland, Department of Transportation. "Design Standards." http://www2.montgomerycountymd.gov/DOT-DTE/Common/Standards.aspx. Accessed Nov. 1, 2012.

- Maryland-National Capital Park and Planning Commission. *Approved Countywide Master Plan of Transportation*. Prince George's County. 2009. http://www.pgplanning.org/Resources/Publications/Mpot.htm.

City of Seattle. *Seattle Right-of-Way Improvements Manual*. Chapter 6: Streetscape Design Guidelines. Revised Aug. 1, 2012. http://www.seattle.gov/transportation/rowmanual/manual/6_2.asp.

National Complete Streets Coalition. http://www.smartgrowthamerica.org/complete-streets. Accessed Nov. 1, 2012. Resources and sample complete streets design standards and policies.

Portland, Oregon, Bureau of Environmental Services. "Green Streets." http://www.portlandonline.com/bes/index.cfm?c=44407. Accessed Nov. 1, 2012.

Approach 5-E: Update building code requirements

EPA. *Sustainable Design and Green Building Toolkit for Local Governments*. Revised 2013. http://www.epa.gov/region4/recycle/green-building-toolkit.pdf.

Bowker, Pam, et al. *Improving the Flood Performance of New Buildings: Flood Resilient Construction*. Department for Communities and Local Government Buildings Regulations (Sanitation) Research Framework and the joint Defra/Environment Agency Flood Risk Management Research and Development Programme. 2007. http://www.planningportal.gov.uk/uploads/br/flood_performance.pdf. Although developed for the United Kingdom, this publication has useful guidance on designing buildings for flood resilience.

The Building Codes Assistance Project Online Code Environment & Advocacy Network has state and local information and guidance about building energy codes, green building, and climate adaptation.

- Washington, D.C.: http://bcap-ocean.org/state-country/district-columbia.
- Virginia: http://www.bcap-ocean.org/state-country/virginia.
- Maryland: http://www.bcap-ocean.org/state-country/maryland.

Rocky Mountain Land Use Institute. *Sustainable Community Development Code Framework*. http://www.law.du.edu/index.php/rmlui/rmlui-practice/code-framework. Accessed Sep. 19, 2012.

U.S. Green Building Council and the University of Michigan. *Green Building and Climate Resilience: Understanding Impacts and Preparing for Changing Conditions*. 2012. http://www.usgbc.org/ShowFile.aspx?DocumentID=18538. Discusses green building techniques for climate resilience. For each option, the report describes the impacts it addresses and how it addresses them, its expected useful life, and which LEED credits are associated with it.

Wilson, Alex. "Checklist: Resilient Design: A Checklist of Actions." *Environmental Building News,* Building Green. Volume 21, No. 3, Mar. 2012. http://www.buildinggreen.com/auth/article.cfm/2012/2/28/Resilient-Design-Smarter-Building-for-a-Turbulent-Future/?checklist=1. Lists specific design approaches to help ensure that buildings are resilient to storms, flooding, temperature extremes, power loss, water shortages, and fire.

Approach 5-F: Incorporate passive survivability into new and existing projects

U.S. Green Building Council. *The New Orleans Principles*. 2005. http://www.usgbc.org/ShowFile.aspx?DocumentID=4395. Planning and design guidance for rebuilding New Orleans after Hurricane Katrina based on principles that include passive survivability.

Wilson, Alex. "Passive Survivability: A New Design Criterion for Buildings." *Environmental Building News*, Building Green. Volume 15, No. 5, May 2006. http://www.buildinggreen.com/auth/article.cfm/2006/5/3/Passive-Survivability-A-New-Design-Criterion-for-Buildings.

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Smart Growth
PROGRAM