THE ROLE OF LOCAL GOVERNMENTS IN DISASTER RISK MANAGEMENT IN THE UNITED STATES

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Guide: Bloom's Taxonomy of lower-order thinking to higher-order critical thinking

INTRODUCTION

Disasters do not respect jurisdictional boundaries, and climate change does not wait for policy consensus. Yet in the United States, the responsibility for protecting communities from floods, storms, and other hazards falls most immediately and most heavily on local governments: the level of government closest to the people, but often the least resourced to act. This four-lecture module examines how local governments are taking on the interconnected challenges of hazard mitigation, disaster risk management, and climate change adaptation. It interrogates how governance actually works in practice, that is, who decides, who acts, who is left out, and who bears the consequences when things go wrong.

The series begins with the big picture: The United States operates under a federal system in which power and responsibility are shared across federal, state, and local governments. Understanding how that system is designed and where it falls short is essential context for anyone seeking to understand why disaster outcomes in this country look the way they do. **Module 1** establishes that institutional foundation.

From there, the series moves from the general to the specific. The Little Sugar Creek watershed in Charlotte, North Carolina, serves as the anchor case study in **Module 2**. It is an exploration that extends well beyond flood risk and stormwater management to the hard work of governing complex problems in real places with real constraints. This module examines this case in depth, drawing lessons that extend well beyond Charlotte.

Module 3 widens the lens again. Climate change is not a distant threat; it is already reshaping the risk landscape that local governments must navigate, thus intensifying flood events, disrupting the historical patterns that planners have long relied on, and deepening existing inequities. This week asks how the lessons of Little Sugar Creek hold up in a rapidly changing climate and what that means for the role of local governance going forward.

Finally, **Module 4** introduces systems thinking as an integrative framework. Systems thinking gives us tools to see beyond individual decisions and isolated events, to understand the feedback loops, interdependencies, and root causes that shape why some communities are more resilient than others, as well as where the most meaningful opportunities for change actually lie.

By the end of these modules, students will be equipped to think critically, systemically, and equitably about how local governments can lead and what they need to succeed.

Central focus:

How are local governments taking on hazard mitigation, disaster risk management, and climate change adaptation?

What can the Little Sugar Creek case teach us about what works, what is challenging, and who needs to be involved?

A. MODULE 1:

Federalism as a lens for contextualizing the role of local governments in American disaster policy.

Module question: Within the American federal system, what are local governments responsible for, and what challenges do they face?

Learning Objectives:

At the end of this module, students should be able to:

i. *Define federalism and explain how the division of power across federal, state, and local governments shapes disaster policy in the United States.*
ii. *Describe the cooperative intergovernmental model of disaster management and distinguish it from how that model functions in practice in the United States.*
iii. *Analyze the role and responsibilities of local governments within the federal disaster policy framework, including their authority, resource constraints, and vulnerabilities.*

READ –

- Birkland, Thomas, and Sarah Waterman. 2008. "Is Federalism the Reason for Policy Failure in Hurricane Katrina?" Publius: The Journal of Federalism 38 (4): 692–714. https://doi.org/10.1093/publius/pjn020.
- Birkland, Thomas A., Kristin Taylor, Deserai A. Crow, and Rob DeLeo. 2021. "Governing in a Polarized Era: Federalism and the Response of U.S. State and Federal Governments to the COVID-19 Pandemic." Publius: The Journal of Federalism 51 (4): 650–72. https://doi.org/10.1093/publius/pjab024.

Orienting note:

Federalism is central to hazard mitigation and disaster risk management in the United States. *What is federalism?* Federalism is a system of government in which power is constitutionally divided between the federal government and other subnational levels of government (in the United States, the state and local governments). Ideally, each level of government has its own defined sphere of authority and responsibility. In practice, however, American federalism is not a clean separation but an ongoing negotiation. Scholars and practitioners have described it alternatively as a "layer cake" (distinct, separate levels) or more

accurately a "marble cake" (overlapping responsibilities). Hazard mitigation and disaster risk management are among the clearest examples of the marble cake model in action.

The U.S. disaster policy framework reflects a bottom-up philosophy rooted in federalist principles. Local governments are the true first responders, as they are closest to the affected population and are the first to deploy emergency services, coordinate evacuations, and assess damage. If a disaster overwhelms local capacity, the governor can declare a state of emergency and mobilize state resources (National Guard, state emergency management agencies, etc.)

Only when a disaster exceeds state capacity does the federal government formally enter the picture, typically through a Presidential Disaster Declaration, which triggers federal assistance via FEMA and other agencies. The model is explicitly cooperative and intergovernmental, meaning that the federal government is not meant to replace or override local and state action, but to supplement it. Federal assistance, whether pre-disaster grants for mitigation planning, real-time coordination during an event, or post-disaster recovery funding, is designed to flow in a timely and supportive way without displacing local decision-making authority.

Why It Matters for Hazard Mitigation: Federalism shapes who plans, who pays, and who decides in disaster risk management. Programs like the Hazard Mitigation Grant Program (HMGP) flow federal dollars through state agencies down to local governments, reflecting this layered structure. Yet the same structure that enables collaboration can also produce fragmentation and delayed response, particularly when political, fiscal, or administrative gaps emerge between levels of government.

Discussion Questions:

i. How does the gap between the theoretical design of American federalism and its practical implementation create vulnerabilities in disaster management and hazard mitigation?
ii. What do you consider the most significant barrier to achieving the cooperative, intergovernmental model of federalism envisioned in U.S. disaster policy, and why?

B. MODULE 2:

The Little Sugar Creek Case Study — Local Government in Action

Module questions: What decisions did Charlotte-Mecklenburg make, and under what constraints? What worked, what failed, and why? How did federal and state frameworks enable or limit what Charlotte could do? How do local governments acquire funding for large and multi-decade projects like the Little Sugar Creek? How do governments plan when projects take decades?

Learning Objectives:

At the end of this module, students should be able to:

i. *Describe the key features of the Little Sugar Creek watershed case, including the nature of the flood risk, the decisions made, and the governance structures involved.*
ii. *Evaluate how the federal and state policy frameworks enabled or constrained Charlotte's local hazard mitigation efforts.*
iii. *Assess the role of stakeholder engagement, community participation, and environmental justice considerations in shaping the outcomes of the case.*
iv. *Draw generalizable lessons from the Little Sugar Creek case about what works, what is challenging, and who needs to be involved in local hazard mitigation efforts.*

READ –

- Coastal Resilience Blog. 2016. "Let There Be Floods: Charlotte-Mecklenburg County Looks to the Future for Floodplain Management." https://coastalresilienceblog.web.unc.edu/2016/10/let-there-be-floods-charlotte-mecklenburg-county-looks-to-the-future-for-floodplain-management/
- Trautman, Tim. n.d. Charlotte-Mecklenburg Floodplain Buyout Program. Urban Land Institute, Developing Urban Resilience. https://developingresilience.uli.org/case/charlotte-mecklenburg-floodplain-buyout-program/
- Trautman, Tim, and Lynn, Bert. 2025. Adapting Little Sugar Creek for Resilience and Little Sugar Creek Greenway. Presentations delivered at the KIETS Climate Leaders Program Symposium, "Think and Do: Climate Challenges and Solutions," NC State University, October 1–2, 2025. *(These presentations, by the former Program Manager for Charlotte-Mecklenburg Stormwater Services and the Capital Planning Division Director for Mecklenburg County Parks and Recreation, offer direct practitioner insight into the programs, decisions, and lessons learned. Students should read these alongside the academic readings to compare how practitioners and researchers frame the same case.)* *https://drive.google.com/file/d/1LQ6NplQiR-rK6IykaV4B9cUGzT6Me0Ec/view?usp=drive_link*
- Sharma, Tanvi. 2021. Future Flood Mitigation in Charlotte-Mecklenburg. Master's Thesis, MIT Department of Urban Studies and Planning. (Chapters 1–3 recommended; provides the most comprehensive academic treatment of Charlotte-Mecklenburg Storm Water Services, CMSWS's approach to local flood risk mapping, buyouts, and the limits of federal frameworks). https://dspace.mit.edu/handle/1721.1/139342.
- Cardwell, Julia. 2023. "Community Perceptions of a Floodplain Buyout Program in Charlotte, North Carolina." Natural Hazards 115 (3): 2141–2160. https://doi.org/10.1007/s11069-022-05631-1

IMPORTANT TO NOTE: *The presentation slides by Trautman Tim and Bert Lynn represent a rare opportunity to hear directly from the people who built this program over decades. As you read them, treat them as primary sources, not simply as summaries of what happened, but as evidence of how practitioners frame problems, define success, and make the case for their work to different audiences. Notice what the presentations emphasize, what they leave out, and*

how they differ in framing from the academic readings. This comparative reading is itself an important analytical skill.

Orienting note:

The Little Sugar Creek watershed runs 19 miles through the heart of Charlotte, draining a 49-square-mile largely urbanized landscape before crossing into South Carolina and entering the Catawba River. By the time Charlotte-Mecklenburg formed its Stormwater Services utility in 1993, the watershed had a long history of flash flooding driven by rapid urban development, impervious surface expansion, and development that had been allowed directly within floodplains.

The floods of 1995 and 1997 crystallized the problem. Notably, neither flood received a Presidential Disaster Declaration, which meant the full burden of response and recovery fell on local resources. Rather than wait for federal relief that never came, Charlotte-Mecklenburg chose to act, and what it built over the following three decades became one of the most studied local hazard mitigation programs in the United States.

Tim Trautman, who led much of this work through Charlotte-Mecklenburg Stormwater Services, describes the program's approach through three foundational pillars: **Building for the Future** (future flood mapping, resilient regulations, updated land use planning, and building codes that go beyond minimum federal standards); **Adapting from the Past** (property buyouts, flood proofing, infrastructure improvements, and creative financing); and **Events Response and Management** (real-time flood notification systems, dense monitoring networks, and emergency operations). A central conceptual distinction in Charlotte-Mecklenburg's approach is the difference between the FEMA floodplain — based on the 100-year flood under current conditions and used primarily to rate flood insurance — and the Community Floodplain, which models the 100-year flood under full watershed build-out conditions. This locally developed, forward-looking standard allowed Charlotte-Mecklenburg to regulate development more stringently than federal minimums and to plan for a risk landscape that was still emerging.

As Charlotte-Mecklenburg acquired flood-prone properties through its buyout program, Mecklenburg County Parks and Recreation saw an opportunity: convert those properties into public open space and connect them through a greenway trail system running the length of the watershed. What began in 1988 as a 0.6-mile segment near Morehead Street became, over 35 years and more than $92 million in investment, a 16-mile continuous greenway corridor that today accounts for 42 percent of all greenway visits in the county system. The greenway is now the number one amenity requested by Mecklenburg County residents. It is simultaneously a flood mitigation strategy, an ecological restoration project, a public health and recreation asset, and a story about what long-term local government commitment to a shared vision can produce.

Discussion Questions:

i. Charlotte-Mecklenburg developed its own Community Floodplain standard that goes beyond FEMA's minimum requirements. What does this tell us about the relationship between local innovation and federal frameworks in hazard mitigation?

What enabled Charlotte-Mecklenburg to take this step, and what barriers might prevent other localities from doing the same?

ii. The 1995 and 1997 floods did not receive Presidential Disaster Declarations, leaving Charlotte-Mecklenburg without federal recovery funding. How did this constraint shape the local response? What does it reveal about the limits and unintended consequences of the cooperative federalist model?

iii. Tim Trautman frames the tension between near-term "sunny day" priorities and long-term "rainy day" planning as a central challenge for local governments. How did Charlotte-Mecklenburg navigate this tension over time, and what governance conditions made sustained commitment possible?

iv. The Little Sugar Creek Greenway transformed flood-prone and bought-out land into a beloved public asset. Drawing on the Siders and Cardwell readings alongside the practitioner presentations, evaluate the equity dimensions of this transformation: who benefited, who may have been displaced or left behind, and how should we assess a program that is simultaneously a mitigation success and a potential source of inequity?

v. Bert Lynn identifies the key lesson as: partner with those who share common goals, build resilient places you can maintain, and make it easy — and fun — for people to use. How does this practitioner wisdom connect to or complicate the academic frameworks you have read? What does it suggest about the role of political will, interagency collaboration, and community buy-in in local hazard mitigation?

C. MODULE 3:

Climate Change Adaptation — Reframing the Problem

Module question: How does climate change reframe the lessons of Little Sugar Creek, and what does it demand of local governments going forward?

Learning Objectives:

At the end of this module, students should be able to:

i. Distinguish between hazard mitigation, disaster risk management, and climate change adaptation, and explain why that distinction matters for local government planning and policy.

ii. Explain how climate change is intensifying flood risk and rendering traditional planning assumptions and historical data increasingly unreliable.

iii. Analyze the equity and environmental justice dimensions of climate risk, with particular attention to how vulnerability is unevenly distributed across communities.

iv. Apply the lessons of Little Sugar Creek to the broader challenge of climate adaptation, evaluating what that case reveals about local government capacity and leadership in the absence of consistent federal direction.

READ –

- Cutter, Susan L. 2021. "The Changing Nature of Hazard and Disaster Risk in the Anthropocene." Annals of the American Association of Geographers 111 (3): 819–27. https://doi.org/10.1080/24694452.2020.1744423.
- Koerth, Maggie. 2017. It's Time to Ditch the Concept of '100-Year Floods.' https://fivethirtyeight.com/features/its-time-to-ditch-the-concept-of-100-year-floods/
- Ingraham, Christopher. 2017. Houston is experiencing its third '500-year' flood in 3 years. How is that possible? https://www.washingtonpost.com/news/wonk/wp/2017/08/29/houston-is-experiencing-its-third-500-year-flood-in-3-years-how-is-that-possible/
- Hooke, Roger LeB. and Martín-Duque, José F. 2012. Land transformation by humans: A review. https://rock.geosociety.org/net/gsatoday/archive/22/12/article/i1052-5173-22-12-4.htm
- Town of Shirley, Massachusetts (2021). Greenways: What are Greenways & Why Do They Matter? https://www.shirley-ma.gov/351/Greenways-What-are-Greenways-Why-Do-They
- Rails to Trails Conservancy (2024). Trails and Climate Resilience. https://www.railstotrails.org/trail-building-toolbox/trails-and-climate-resilience/

Orienting note:

Module 2 introduced Little Sugar Creek as a story about local government leadership, a city in a county that, faced with chronic flood risk and inadequate federal support, built its own technical standards, financing mechanisms, mitigation programs, and ultimately a greenway that transformed a liability into a community asset. That story is compelling precisely because it worked, at least by most conventional measures. Module 3, however, asks a harder question: does it still work, and will it continue to work, in a changing climate? This question requires us to first clarify what we mean by several related but distinct concepts that are often used interchangeably but carry importantly different implications for local governance.

- Hazard mitigation refers to actions taken before a disaster to reduce or eliminate long-term risk to people and property. It is fundamentally about reducing exposure and sensitivity through buyouts, regulations, infrastructure, and land use planning. The Charlotte-Mecklenburg program examined in Module 2 is a strong example of hazard mitigation in action.
- Disaster risk management is a broader concept that encompasses the full cycle of disaster-related activity: preparedness, response, and recovery. It treats disaster risk as something to be actively managed across time, not simply reduced in a single intervention. Charlotte-Mecklenburg's Flood Information and Notification System (FINS), its emergency operations planning, and its post-event recovery protocols are all elements of disaster risk management.
- Climate change adaptation represents a further conceptual shift. Where hazard mitigation and disaster risk management generally take the risk landscape as given, or

> at most, changing gradually, adaptation explicitly grapples with a future that is fundamentally different from the past. It asks not just "how do we reduce risk from known hazards?" but "how do we govern effectively in the face of deepening uncertainty, shifting baselines and risks we may not yet fully understand, and wicked problems with no clear-cut solutions?"

This conceptual distinction matters enormously for local governments. Hazard mitigation tools — buyouts, floodplain regulations, stormwater infrastructure — were largely designed around historical data: historical climate patterns and statistical models that assume a stable climate. As the Koerth and Ingraham readings make clear, that assumption is no longer defensible. The "100-year flood," that is, a flood that has a one percent probability of occurring in any given year, is a statistical construct built on historical data that climate change is rapidly rendering obsolete. The underlying probability distributions that form the very foundations of flood risk planning are increasingly shifting beneath our feet.

Hooke and Martín-Duque situate this challenge in a still broader frame. Human land transformation (urbanization, deforestation, agricultural expansion, and large-scale landscape alteration) has itself been a primary driver of hydrological change long before climate change became the dominant frame. As land is converted to impervious surfaces, natural infiltration is reduced, runoff is accelerated, and flood peaks are amplified. Charlotte-Mecklenburg's decision to map flood risk under full watershed build-out conditions rather than current conditions was an early and sophisticated recognition of this reality: land use change is a flood risk driver that can and should be anticipated in local planning.

Cutter argues that we are living in the Anthropocene — an era in which human activity has so thoroughly transformed Earth's physical systems that the boundary between natural hazard and human-made disaster has effectively collapsed. In the Anthropocene, floods are not simply natural events that happen to strike human settlements. They are the product of interacting physical and social processes in which human decisions about land use, infrastructure, greenhouse gas emissions, and governance are themselves causal factors.

What all these portend is that we need to revisit how we think about local governments and their responsibilities. If hazards are partly of our own making, then hazard mitigation is not just about managing exposure to an external threat. Rather, it is about reshaping the conditions, physical, social, and institutional, that produce risk in the first place. It also raises the stakes considerably for equity.

Greenways as Adaptation Infrastructure

Returning to Little Sugar Creek through this climate adaptation lens reveals something that was perhaps not fully articulated at the time the greenway was being built: the transformation of flood-prone and bought-out land into connected green infrastructure goes beyond just the recreational co-benefits of hazard mitigation. It is an equally significant investment in adaptive capacity.

The Shirley, Massachusetts greenways document and the Rails to Trails Conservancy report on trails and climate resilience (all in required readings) both make this case explicitly. Greenways and trail networks preserve and restore natural floodplain functions, reduce impervious surface coverage, provide permeable corridors for stormwater absorption, support ecological connectivity as species ranges shift under changing conditions, and offer communities pathways to physical and psychological resilience that are difficult to achieve through engineered infrastructure alone. They also create the kind of civic attachment to natural systems — the experience of a creek as a community asset rather than a drainage problem — that can sustain long-term political support for adaptation investments.

Viewed in this light, the Little Sugar Creek Greenway looks less like a happy byproduct of a buyout program and more like a prototype of the kind of multi-functional, nature-based adaptation infrastructure that climate change demands. The question this module asks students to engage is whether it is sufficient, and what a genuinely climate-adaptive version of the Charlotte-Mecklenburg model would look like if designed from scratch today, with full knowledge of what climate change is bringing.

The Local Government Challenge

This module closes by returning to the federalism framework introduced in Module 1. Climate adaptation, like hazard mitigation before it, is increasingly falling to local governments, not because it should be, given the planetary scale of the drivers involved, but because federal policy has not kept pace with the scale and urgency of the challenge. The populations and places most at risk from intensifying climate hazards are often those with the least institutional capacity to respond. ***The gap between what local governments are being asked to do and the resources and authority they have to do it is one of the defining governance challenges of the Anthropocene.***

Charlotte-Mecklenburg's experience across Modules 2 and 3 is instructive precisely because it represents a best-case scenario: a large, well-resourced county with strong technical capacity, long institutional memory, sustained political commitment, and a willingness to exceed federal minimums. Most local governments in the United States do not have these advantages. Understanding what made Charlotte-Mecklenburg's approach possible, and what structural conditions would need to change to make it replicable elsewhere, is among the most important practical questions this module asks students to consider.

IMPORTANT TO NOTE: *As you engage with this module's readings, return to the Trautman presentations from Module 2 with fresh analytical eyes. Trautman's observation that hazards are non-stationary anticipates much of what Cutter, Hooke, Koerth, and Ingraham argue from academic and journalistic perspectives. The convergence between practitioner insight and scholarly analysis is itself significant: it suggests that the people who have been doing this work longest have understood, sometimes intuitively, what the research is now confirming. Module 4 will explore the systems thinking dynamics in all of this, to see the feedback loops,*

interdependencies, and structural conditions that explain both the achievements of the Charlotte-Mecklenburg model and its limits in the face of accelerating climate change.

Discussion Questions

i. Koerth and Ingraham both argue that the "100-year flood" concept is misleading and potentially dangerous as a planning tool. Returning to the Charlotte-Mecklenburg case, Tim Trautman explicitly acknowledged that hazards are non-stationary and that future flood maps must account for rainfall changes, watershed runoff changes, and other shifting conditions. What would it mean for a local government to fully internalize the implications of non-stationarity in its planning? What tools, institutional arrangements, and political conditions would that require?

ii. Cutter argues that in the Anthropocene, the distinction between natural and human-made disasters has become untenable. How does this reframing change what we expect of local governments in their disaster planning and climate adaptation efforts? If local governments are not just managing exposure to external hazards but are partly responsible for the conditions that generate risk, through land use decisions, infrastructure investments, and regulatory choices, what does that demand of them politically, technically, and ethically?

iii. Hooke and Martín-Duque document the planetary scale of human land transformation and its cumulative hydrological consequences. Charlotte-Mecklenburg addressed land-use-driven flood risk through its Community Floodplain standard and proactive watershed planning. What are the limits of this local approach when the drivers of risk are regional, national, and global? What would an adequate multi-level governance response look like?

iv. Both the Rails to Trails Conservancy and the Town of Shirley frame greenways as climate resilience infrastructure. Returning to the Little Sugar Creek case, evaluate this claim specifically: in what ways does the Little Sugar Creek Greenway function as climate adaptation, where does this framing have limits, and what would need to be added or changed to make it a more complete adaptation strategy?

v. Charlotte-Mecklenburg represents a best-case scenario for local government leadership in hazard mitigation and climate adaptation. What structural conditions (fiscal, technical, political, and institutional) made this possible? And what does it suggest about the challenges facing localities that do not share these advantages, particularly those serving lower-income or smaller communities?

D. MODULE 4:

Systems Thinking — Seeing the Whole Picture

Module question: If we view hazard mitigation, disaster risk management, and climate adaptation as a system, what leverage points exist, and what does that mean for how local governments should plan and act?

Learning Objectives:

At the end of this module, students should be able to:

i. *Define systems thinking and explain its core concepts, including feedback loops, interdependencies, unintended consequences, and leverage points, as they apply to disaster risk and climate adaptation.*
ii. *Apply a systems thinking framework to analyze the interactions among governance structures, physical infrastructure, social vulnerability, and environmental change in the context of hazard mitigation.*
iii. *Distinguish between interventions that address symptoms and those that target root causes within complex socio-environmental systems.*
iv. *Synthesize the learning from all four modules to develop an integrated perspective on how local governments can most effectively engage with the issues of hazard mitigation, disaster risk management, and climate change adaptation within a federal system.*

READ –

- Meadows, Donella H. 2008. Thinking in Systems: A Primer. Chelsea Green Publishing. (Chapters 1–3 recommended — introduces stocks, flows, feedback loops, and leverage points).
- Meadows, Donella H. 1999. "Leverage Points: Places to Intervene in a System." Sustainability Institute. https://donellameadows.org/archives/leverage-points-places-to-intervene-in-a-system/
- Berkes, Fikret. 2007. "Understanding Uncertainty and Reducing Vulnerability: Lessons from Resilience Thinking." Natural Hazards 41 (2): 283–295. https://doi.org/10.1007/s11069-006-9036-7
- Folke, Carl, et al. 2010. "Resilience Thinking: Integrating Resilience, Adaptability, and Transformability." Ecology and Society 15 (4): 20. https://www.ecologyandsociety.org/vol15/iss4/art20/
- Meerow, Sara, and Joshua P. Newell. 2019. “Urban Resilience for Whom, What, When, Where, and Why?” Urban Geography 40 (3): 309–29. https://doi.org/10.1080/02723638.2016.1206395.

Orienting note:

The first three modules of this series have moved progressively from the general to the specific and back again. Module 1 established the institutional architecture of American federalism and the cooperative intergovernmental model that shapes how disaster policy is designed and delivered. Module 2 descended into the particulars of a single watershed, a single county, and the decisions made by real people working under real constraints over more than three decades. Module 3 widened the lens again, asking how climate change, understood through Cutter's Anthropocene framework, reframes everything that Charlotte-Mecklenburg built and raises the stakes for what local governments must now attempt.

Module 4 offers something different: not more content, but a different way of seeing. Systems thinking is an analytical framework — a set of concepts and habits of mind — that helps us understand why complex problems persist despite good intentions and capable people, why interventions so often produce unintended consequences, and where the most meaningful opportunities for change actually lie. It is, in a sense, the integrative lens through which the entire module series can be re-read and understood at a deeper level.

What Systems Thinking Is — and Why It Matters Here

Meadows defines a system as a set of elements interconnected in such a way that they produce their own pattern of behavior over time. Systems are complex, meaning that their behavior emerges from the interactions among their parts in ways that cannot be predicted simply by understanding each part in isolation. This distinction between complicated and complex is vital for understanding why hazard mitigation, disaster risk management, and climate adaptation are so difficult to get right.

The core vocabulary of systems thinking includes several concepts that will organize this module's analytical work.

- *Stocks* are the elements of a system that accumulate or deplete over time — things that can be measured at any given moment. In the context of disaster risk, stocks include physical infrastructure, housing, ecosystem health, community wealth, institutional knowledge, and social trust. The Little Sugar Creek watershed, viewed through this lens, contains multiple interacting stocks: the physical condition of the creek and its floodplain, the stock of properties in the flood zone, the accumulated technical capacity of Charlotte-Mecklenburg Stormwater Services, the greenway miles built and maintained, and the reservoir of community support that sustained political commitment across three and a half decades.
- *Flows* are the rates at which stocks change — the inflows that increase them and the outflows that deplete them. New development increases impervious surface; buyouts reduce the stock of flood-exposed properties; budget decisions increase or decrease the flow of resources into mitigation programs; extreme events can rapidly deplete stocks of infrastructure, housing, and community resilience that took years to build.
- *Feedback loops* are the mechanisms by which a system's outputs become inputs that influence future behavior. A reinforcing loop amplifies change in one direction; for example, as flood damage increases, property abandonment and tax base erode, reducing local government capacity to invest in mitigation, which in turn increases future flood damage. A balancing loop works to stabilize a system around a goal or threshold; for example, as flood risk increases, political pressure for mitigation investment rises, which eventually produces more investment, which reduces risk. Understanding which loops are dominant in a given system, and under what conditions they can be shifted, is at the heart of systems-based problem solving.
- Unintended consequences arise when an intervention changes one part of a system in ways that produce unexpected and often unwanted effects elsewhere. In the disaster context, one of the most well-documented unintended consequences is the levee effect: flood control infrastructure reduces the apparent risk of living in a floodplain, which

encourages more development there, which increases the consequences when the infrastructure eventually fails or is overwhelmed. Charlotte-Mecklenburg's decision to go beyond FEMA minimum standards, to map the Community Floodplain under full build-out conditions and regulate accordingly, was, in part, a recognition that minimum standards create their own perverse incentives.

- Leverage points are places in a system where a small shift can produce large changes in system behavior. Meadows identified a hierarchy of leverage points, ranging from the least powerful: adjusting numerical parameters like tax rates or budget line items, to the most powerful: changing the goals of the system, the rules that govern it, and ultimately the mindset or paradigm from which the system arises. This hierarchy is directly relevant to the challenge of local government leadership in disaster policy. Many interventions in this space operate at low leverage points — adjusting funding formulas, updating flood maps, and revising building codes. These matter, but they do not change the underlying dynamics that produce risk. Higher leverage interventions like changing the rules of the federal disaster declaration system, shifting the goal of disaster policy from response to prevention, or reconceiving the floodplain as community open space rather than developable land, are harder to achieve but more durable in their effects.

Berkes and Folke et al. extend systems thinking into the specific domain of social-ecological resilience — the capacity of linked human and natural systems to absorb disturbance, reorganize, and continue to develop in the face of change. Berkes argues that resilience thinking, at its deepest level, requires the willingness to recognize when a system has reached a threshold beyond which adaptation is insufficient, when transformation, not just adjustment, is required. The question of whether climate change demands transformative rather than merely adaptive responses to flood risk is one of the most important and unresolved questions in this field.

Meerow and Newell's contribution to this module is to subject the resilience concept itself to critical scrutiny. Their central question: *urban resilience for whom, what, when, where, and why?* is a direct challenge to the tendency in resilience discourse to treat resilience as a self-evidently desirable goal whose benefits are shared equitably across a community. As they argue, resilience is not a neutral concept. When a city builds flood resilience, the question of whose resilience is being built, and at whose expense, is a political question, not merely a technical one. The investments in technical infrastructure and future-oriented flood mapping that made Charlotte-Mecklenburg a national model required sustained fiscal and political capacity that most localities, and particularly those serving the most vulnerable populations, do not possess. Meerow and Newell push us to ask whether a resilience framework that does not explicitly address power, equity, and distribution is genuinely resilient or merely resilient for some.

Applying Systems Thinking to Little Sugar Creek

Consider the feedback loops at work in the watershed before Charlotte-Mecklenburg intervened. Rapid urbanization increased impervious surface, which accelerated runoff and amplified flood peaks — a reinforcing loop that worsened flood risk with each new

development. Flood damage depressed property values in affected neighborhoods, making them attractive to lower-income households who had fewer options, which concentrated vulnerability in flood-prone areas — another reinforcing loop. The federal flood insurance program, by making flood-prone properties insurable at subsidized rates, reduced the apparent financial risk of floodplain development, encouraging more of it — a balancing loop that worked against mitigation.

Charlotte-Mecklenburg interrupted several of these loops simultaneously. The Community Floodplain standard changed the rules that governed new development, breaking the reinforcing loop between permissive regulation and increasing exposure. The buyout program reduced the stock of flood-exposed properties, changing the physical configuration of the system. The stormwater utility provided a dedicated, stable funding stream, which is a critical stock of institutional resources that insulated the program from the annual budget fluctuations that undermine so many local mitigation efforts. And the greenway converted the floodplain from a zone of concentrated liability into a public asset, shifting the system's goal from flood control to floodplain restoration — one of Meadows' higher-order leverage points.

What systems thinking also reveals, however, are the loops that Charlotte-Mecklenburg did not change. The federal disaster declaration system, which creates perverse incentives for reactive rather than proactive investment, remained unchanged. The national flood insurance program, which subsidizes floodplain development, remained unchanged. The structural inequities that concentrated flood risk in lower-income neighborhoods were addressed in part through the buyout program, but the displacement dynamics that followed buyouts, and the question of where bought-out residents relocated, were not fully tracked or addressed. Also, the climate feedback loops that are intensifying precipitation, raising sea levels, and shifting the entire risk landscape were, by definition, beyond the reach of any local intervention.

This is not a criticism of what Charlotte-Mecklenburg accomplished. It is, rather, an honest account of what local government leadership, even with the most desire, can and cannot achieve within a system whose most powerful leverage points lie beyond local jurisdiction.

What This Means for Local Government Planning and Action

Synthesizing the learning from all four modules through a systems lens produces several interconnected conclusions about how local governments can most effectively engage with hazard mitigation, disaster risk management, and climate adaptation.

First, local governments must understand the system they are operating in, not just the immediate problem they are trying to solve. The federalism framework from Module 1 is itself a systems structure, one with its own feedback loops, leverage points, and structural tendencies. Effective local leadership requires understanding where, within that structure, local action can be most consequential and where it is fundamentally constrained.

Second, the most durable interventions are those that change the stocks and rules of the system, not just the flows. Charlotte-Mecklenburg's stormwater utility, a dedicated, stable funding mechanism, changed the stock of institutional resources available for mitigation in ways that no single grant or budget allocation could. Its Community Floodplain standard

changed the rules governing new development in ways that accumulated benefits over decades. These structural interventions are harder to achieve and take longer to show results, but they operate at higher leverage points than project-by-project mitigation.

Third, the distinction between resilience, adaptability, and transformability matters enormously as climate change accelerates. Many current local government programs are building resilience in the narrow sense — the capacity to absorb and recover from known shocks. Fewer are building the adaptability needed to adjust to shifting conditions over time. And almost none are engaging seriously with the question of transformability — whether the physical, social, and governance systems we have inherited are adequate to the magnitude of what climate change is bringing, or whether something more fundamental needs to change.

Finally, and perhaps most importantly, systems thinking is an argument for humility as well as for ambition. Complex systems are full of surprises. Interventions that seem well-designed produce unintended consequences. Problems that seem solved re-emerge in new forms. The appropriate response to this complexity is not paralysis but iterative, learning-oriented action, which is the kind of adaptive management that the Little Sugar Creek story, at its best, embodies.

Discussion Questions

i. Meadows argues that the most powerful leverage points in a system involve changing the goals, rules, and paradigms from which the system arises. Applying this hierarchy to U.S. disaster policy: where are the highest-leverage opportunities for change, and what would it take to act on them? What does the Charlotte-Mecklenburg case suggest about what is achievable at the local level versus what requires action at higher levels of the federal system?

ii. Berkes and Folke et al. distinguish between resilience, adaptability, and transformability. Evaluate the Charlotte-Mecklenburg program against all three. Where did it achieve resilience? Where did it demonstrate adaptability? And where does the evidence suggest that transformation, rather than adaptation, may ultimately be required?

iii. Meerow and Newell ask: resilience for whom? Apply this question to the Little Sugar Creek case. Who benefited from the mitigation investments and greenway development? Who may have been displaced, excluded, or left behind? And what would it mean to redesign the program with equity as a first-order goal rather than a secondary consideration?

iv. Systems thinking draws attention to unintended consequences — the ways in which well-intentioned interventions can produce unexpected and sometimes counterproductive effects elsewhere in the system. Identify at least two unintended consequences (actual or potential) of the Charlotte-Mecklenburg approach. What do these reveal about the limits of local government action within a larger system?

The Little Sugar Creek watershed is, in the end, a microcosm of the larger challenge. It is a place where federal policy, local governance, physical infrastructure, ecological systems,

community history, and climate change all interact; where the decisions of engineers, planners, elected officials, community members, and federal agencies have combined over decades to produce an outcome that is remarkable in many ways and insufficient in others. Seeing it through the lens of federalism, case analysis, climate science, and systems thinking is the analytical task this module series has been designed to support.

The question of how local governments can most effectively lead on hazard mitigation, disaster risk management, and climate adaptation within a federal system has no simple answer. But students who have worked through these four modules should be better equipped to ask the right questions, resist simple solutions, understand the structural forces that shape what is possible, and identify where and at what level of the system meaningful change can be made.

Exercise

This module series began with federalism and ends with systems thinking. Looking across all four modules, construct an argument, drawing on at least three of the modules' readings, for what you consider the single most important change that would improve how the United States governs disaster risk and climate adaptation. Justify your choice in terms of both its leverage and its feasibility.