URBAN CLIMATE CHANGE ADAPTATION:

CASE STUDIES IN ANN ARBOR AND GRAND RAPIDS, MICHIGAN

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Abstract

This paper presents in-depth case studies of climate adaptation in two Michigan cities, Ann Arbor and Grand Rapids. We identify eight factors that determine cities' ability to respond to climate impacts (determinants of adaptive capacity), and gather data from 46 interviews with officials from local government and non-governmental organizations. We propose a framework for analyzing adaptive capacity (AC) not only in our case cities but also in other Great Lakes cities, highlighting the influence of and relationships between eight determinants of adaptive capacity—institutions, infrastructure, wealth and financial capital, social capital, political capital, human capital, information, and technology. We identify adaptation activities these cities are undertaking, highlight the factors contributing to their success, and consider constraints to future adaptation that both our case cities and other cities may experience.

Executive Summary

Climate change is already affecting cities and projections of increased risk to infrastructure, health, natural environments, and community well-being may represent a game changer to the way cities function and plan for the future. Local governments will play an essential role in shaping community resilience, due to the highly localized nature of both climate impacts and many public services. Local governments provide essential services, such as public safety and disaster response, and manage critical assets, such as drinking water and stormwater infrastructure. Since specific climate change impacts will vary between communities, municipalities will need to customize their approaches to address these impacts.

While overall the news about climate change and adaptation are for the most part discouraging and at times even alarming, as a society, we will not be able to address its effects without better understanding how different actors, communities, and governance systems perceive, prepare for, and respond to climate-driven risk. The challenges are many, resources limited and, often, the threat of climate change has invited at best inaction and, at worst, skepticism from policy-makers. Yet, despite uncertainty, economic hardship, and political challenges, the message of this study is an optimistic one—we find that our case study cities are taking significant action to prepare for the impacts of climate change.

We document specific action that two Michigan cities, Ann Arbor and Grand Rapids, have taken to prepare for and respond to climate change. Drawing on the climate change literature, we identify eight factors that determine cities' ability to respond to climate impacts (determinants of adaptive capacity). We propose a framework for analyzing adaptive capacity (AC) not only in our case cities but also in other Great Lakes cities. To apply this framework to the Ann Arbor and Grand Rapids cases, we interviewed 46 informants from local government and non-governmental organizations (NGOs) in order to examine what enables and constrains adaptation. We asked informants questions to gauge how the factors that scholars have theorized enhance a system's resilience (i.e., determinants of adaptive capacity) work in the case communities. We emphasized the role of governance in shaping AC in our interviews and analysis. The following table summarizes the eight selected determinants of AC, how we applied them to the urban context, and what we found from the Ann Arbor and Grand Rapids cases.

Determinant	How it Matters for Cities	Findings from this Study
Institutions	Internal standards, local ordinances, funding mechanisms, city plans, bureaucratic structures, city commissions, state and federal incentives and regulations, Federalism, and interjurisdictional collaboration	City standards (e.g., infrastructure design standards) and ordinances (e.g., zoning codes) enhance resilience to climate impacts and promote resource conservation. City plans and departments (e.g., energy offices) integrate adaptation as a priority throughout government operations. Federal and state incentives (e.g., grant programs) and regulations (e.g., building codes) can enable or hinder the creation of effective local institutions. The U.S. Federal governance structure empowers local governments to pursue adaptation initiatives, while introducing political constraints to

		regional collaboration that could enhance adaptation.
Infrastructure	Water, green infrastructure, traditional built environment, transportation (roads, bridges, public transportation), sanitation (sanitary sewer system), and the energy supply.	All other determinants influence infrastructure, shaping the cities' ability to build and maintain urban systems. Cities are looking towards green infrastructure as a tool to reduce impacts from climate change. When installing and maintaining infrastructure, cities have to contend with the fact that the outcomes (built infrastructure) are generally inflexible and long-term (have permanence that creates path-dependencies), creating future constraints to adaptation.
Wealth and Financial Capital	The accessibility, availability, and flexibility of financial wealth and wealth management instruments, such as revolving funds, philanthropy, insurance, and credit	Wealth and financial capital contribute essentially to adaptive capacity by enabling cities to purchase infrastructure, human capital, information, and technology. Both cities draw from diverse sources to fund adaptation-related work. In Ann Arbor, institutional mechanisms, such as revolving loan funds and dedicated mills, fund innovative adaptation projects. Grand Rapids interviewees emphasized social capital in the form of community organizations, volunteers, and private donations to fund projects. In both communities, having some baseline level of wealth enables the cities to protect their assets and secure additional funding.
Social Capital	Public-private partnerships, especially those between city governments and civil society collaborators; organized community leadership and social networks; interpersonal connections between city staff and external organizations	Access to and participation in personal and professional social networks can increase access to information, financial capital, human resources, technology, and political capital. Social capital networks can sometimes function as a supplement for financial capital in the context of challenging economic circumstances.
Political Capital	Leadership, motivation and vision, electoral and local politics, reputation and legitimacy, public perceptions of political leadership, political support gained through public participation and engagement efforts	Climate change remains a politically charged, sensitive, and somewhat partisan issue in the region, however, the presence of motivated, visionary leadership can enable adaptation action. Perceived public support for climate initiatives increases the political capital for and likelihood of adopting adaptation action. Public engagement efforts can help to increase political support for such initiatives.
Human Capital	Communities' overall education levels and the skill and knowledge of City staff	Strong institutional knowledge bolsters adaptive capacity, while layoffs and staffing cuts have constrained staff's ability to address adaptation needs. Key staff persons' professional effectiveness was cited as an enabling factor, as was the overall high level of education in Ann Arbor.

Information	Early warning systems that provide information; scientific understanding of climate change impacts (projections and scenarios) and potential adaptation strategies; and having systems in place to share, discuss, and communicate climate change information and adaptation strategies at various levels	Access to credible, legitimate, and timely information about extreme weather events enables a proactive response and mitigates harm. Lack of information and poor understanding of impacts and adaptation strategies means climate change has not been incorporated widely into decision making. Participation in networks for peer-to-peer sharing and collaborating with local universities and research institutes improves information access, as does communication with State and Federal agencies.
Technology	The application of scientific knowledge for practical purposes; GIS, Doppler radar	Technology enables Ann Arbor and Grand Rapids to be more adaptable and bolsters the other determinants of adaptive capacity. Both Ann Arbor and Grand Rapids value and invest in technology. Technology depends heavily on the other determinants of adaptive capacity, particularly information and wealth and financial capital.

Although the cities do not always call what they are doing "climate adaptation," and our informants do not always recognize the adaptation benefits or relevance of their programs, both Ann Arbor and Grand Rapids are pursuing initiatives with direct relevance for adaptation. They either refrain from using the words "climate adaptation" for political and cultural reasons, or adaptation happens as an ancillary benefit from current plans, policies, and programs with other primary objectives. For instance, both communities have active urban forestry programs that emphasize the stormwater, aesthetic, and air quality benefits of urban trees. However, expanding shade cover offers adaptation benefits that both communities are beginning to realize.

The Ann Arbor and Grand Rapids cases demonstrate that all eight determinants contribute to adaptive capacity in important ways. No determinant operates independently of the others. Instead, we find complex relationships and feedback loops between them. Some determinants enable or bolster others. For example, institutions generate wealth and channel it towards adaptation-relevant material resources and infrastructure systems. Some determinants mutually reinforce each other. For example, wealth and human capital can create a positive feedback loop with institutions. Cities need money to create and staff city departments like Ann Arbor's Energy Office and Grand Rapids' Office of Energy and Sustainability. Entrepreneurial staff (human capital) who work in these organizations innovate by pursuing creative funding mechanisms and capturing grant funding, generating more financial capital for the cities. Many of these new resources are also flexible (when compared with city budgets) and allow for investment in areas that otherwise would not get funding, especially in times of economic hardship. Similarly, some determinants are self-enabling. For instance, wealth begets wealth: a certain baseline level of financial capital enables cities to protect their assets, and leveraging and institutional funding mechanisms enables initial wealth to grow. Further, we find that more of a determinant does not always lead to better outcomes. For example, additional information is not helpful if staff do not have time to

analyze and incorporate it into their activities. Similarly, technology is only as good as the information fed into it and the minds using it (human capital).

While we identify many similarities between the communities, each city emphasizes different determinants in achieving its goals. We do not conclude that either city fundamentally lacks any element of adaptive capacity. Still, different stories emerge in the two cities. For example, many informants in Grand Rapids referred to the usefulness of public engagement—political and social capital—for achieving positive outcomes. Meanwhile, we find several examples in Ann Arbor of institutionalized funding sources enabling adaptation. The complex relationships between determinants and different strategies used (both within and between the cities) make it difficult to prioritize between determinants. Instead, the important story lies in the interrelationships between the determinants and the possibility of combining them differently to achieve adaptation goals.

Individual people bolster AC in the cities through human capital, political capital, and social capital. In both cities, political leaders play a critical role in setting priorities, which helps institutionalize and build public support for adaptation. Social networks also help define priorities and implement programs. Talented personnel develop good ideas; many of our informants attributed the cities' successes to specific highly skilled individuals. Likewise, integration – whether in the form of spreading concepts through the many departments of an organization or by bringing together various disciplinary perspectives to solve problems – emerges as a key tool for successful adaptation. Integration can reduce costs by improving efficiencies, and it can increase staff knowledge by facilitating collaboration and discussion across disciplinary boundaries.

Finally, we identify constraints that cities face in adapting to climate change. Our informants repeatedly referenced the difficulty of achieving interagency collaboration, in light of both institutional and political obstacles. Although we find that integration in planning and decision-making helps foster adaptation, our case cities continue to experience imperfect integration. Silos remain within the city bureaucracy, both because staff lack the time to discuss issues with their colleagues in other departments or because certain city systems have not been fully integrated. Individual or community perceptions also constrain adaptation. Some adaptive actions rely heavily on behavior change. For example, successful emergency response depends partially on individuals' actions in response to information they receive. Further, perceived lack of climate information presents both technical and political constraints to adaptation. Finally, economic conditions constrain adaptation as well, especially given the aforementioned political challenges and information limitations.

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Acronyms

AC - Adaptive capacity

AR4 - Intergovernmental Panel on Climate Change Fourth Assessment Report

ADAPT - Adaptation Database and Planning Tool

DEQ - Department of Environmental Quality

DNR - Department of Natural Resources

DTE - Detroit Edison Energy Company

CCAP - Center for Clean Air Policy

CBDP - Community-based disaster preparedness

CERT - Community Emergency Response Teams

CIP - Capital Improvements Plan

CMAQ - Congestion Mitigation and Air Quality Improvement

CSO - combined sewer overflow

CSP - Community Sustainability Partnership

DDA - Downtown Development Authority

EMS - emergency medical service

FAR - floor area ratio

FEMA - Federal Emergency Management Agency

GIS - geographic information system

GLISA - Great Lakes Regional Integrated Sciences & Assessments Center

GLERL– NOAA's Great Lakes Environmental Research Laboratory

HRWC - Huron River Watershed Council

ICLEI - formerly the "International Council of Local Environmental Initiatives," now known as "ICLEI - Local Governments for Sustainability"

IPCC - Intergovernmental Panel on Climate Change

ISC- Institute for Sustainable Communities

LED - light-emitting diode

LEED -Leadership in Energy and Environmental Design

LID - low impact development

MEDC - Michigan Economic Development Corporation

MPSC - Michigan Public Service Commission

OES - Office of Energy and Sustainability

NGO - non-governmental organization

NOAA - National Oceanic and Atmospheric Administration

NPDES - National Pollutant Discharge Elimination System

NWS - National Weather Service

PACE - Property Assessed Clean Energy

PPP - public-private partnership

RACES - Radio Amateur Civil Emergency Service

SRF - State Revolving Fund (popular name for Michigan's Water Pollution Control Revolving Fund)

TAR - Third Assessment Report (the 2001 report from the IPCC)

USDA - United States Department of Agriculture

USDN - Urban Sustainability Directors' Network

USGCRP– U.S. Global Change Research Program

WMEAC - West Michigan Environmental Action Council

Glossary

Adaptation: "Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory, autonomous, and planned adaptation" (IPCC AR4 Glossary, 2007).

Adaptive capacity: "The ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences" (IPCC AR4 Glossary, 2007).

Capital Improvements Plan: Five-to-ten-year rolling plan for cities' capital infrastructure needs. Generally, the first one or two years of the CIP are connected to the city budget, and the city updates the CIP annually or every second year to add additional projects and fund the first years' projects.

Civil society: Individuals and organizations in a society that are independent of the government.

Climate: The statistical "average" long-term weather patterns over a designated period.

Climate change: Any change that alters the composition of the global atmosphere, whether due to natural variability or as a result of human activity.

Co-benefits: (or "ancillary benefits"): The benefits of policies implemented for various reasons at the same time. For example, mitigation activities that also have adaptation advantages.

Density: In land use planning, the number of residents, dwelling units, or commercial units per a given amount of space, such as an acre.

Design Storm: Hypothetical 24-hour precipitation accumulations projected to occur with a certain probability each year. A 10-year, 24-hour storm refers to a 24-hour rain accumulation that has a 10% chance of occurring annually. Cities design their stormwater infrastructure around design storms, which are projected by the Federal Emergency Management Agency.

Floor Area Ratio (FAR): Metric used in municipal zoning codes to control the density of development. Refers to the ratio of the total area of all floor space in a building to the area of the lot on which the building is located.

Green infrastructure: Systems, natural or human-made, that mimic natural processes of landscapes (e.g., stormwater absorption, wastewater purification, or nutrient cycling). Examples include green roofs, rain gardens, wetlands, parks, trees and woodlands, and open green space. Sometimes also defined to include environmentally friendly aspects of built infrastructure (e.g., "Green buildings," porous pavement, stormwater storage tanks, etc.).

Impacts: Climate effects on natural or human systems.

Low-impact development (LID): Land use approach to manage stormwater and increase onsite infiltration. Examples include rain gardens, bio swales, rain barrels, porous pavement, and green roofs.

Maladaptation: Adaptation actions or traits that do more harm than good.

Mitigation: "Implementing policies, technologies, energy source substitution, or behavioral changes to reduce greenhouse gas emissions and/or increase carbon sinks" (IPCC AR4 Glossary, 2007).

Mixed-Use: In land use, describes neighborhoods that include both commercial and residential properties and building uses.

Nimbyism: The practice of objecting to something that will affect one or take place in one's locality. Derived from "Not In My Back Yard" (NIMBY).

Swirl concentrator: A technology commonly used in stormwater management that uses gravitational separation techniques to remove sediment and debris from water.

Triple bottom line: Aspects of business sustainability defined by the three pillars: economic, environmental, and social.

Resilience: "The ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization, and the capacity to adapt to stress and change" (IPCC AR4 Glossary 2007).

Vulnerability: "The degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity" (IPCC AR4 Glossary 2007).

Chapter 1: Introduction

> *You asked me is climate adaptation important in Ann Arbor and I would say yes, but it's—we're trying to figure out how we integrate into the way we do business because we manage risk all the time and that's what climate adaptation is. It's risk management. We just need good data* […]*Give me all the caveats you want but this is the best data we've got for you to make planning decisions in 25 or 50 year—because there is a lot that we do that will last that long: putting pipes in the ground, certainly tree planting, you know, whether we should be removing buildings from the flood plain*. (Public official, Ann Arbor, 2011)

> *We know that we are already experiencing higher rainfalls. To have a stormwater system that can accept them – and not just a harder, a gray infrastructure system, but a green infrastructure system that can receive that stormwater and treat it onsite before it has to go into our hard infrastructure. You know, that's critical. We've got to plan for a horizon that, at this point, we really can't quite get our heads around but we know it's going to be radically different than what we've got today.* […] *We've got to do a better job of identifying vulnerable people, elderly and people with respiratory diseases that, in extreme heat events are at risk. We can't have a widespread death from an extended heat wave and so when the temperatures hit the — we went above 95 degrees here and stayed there for three days. I think it was the hottest extended period we've had in Grand Rapids since 1988, you know, I'm worried because I don't think we have done a good enough job.* (Public official, Grand Rapids, 2011)

The Great Lakes region – home to more than twenty percent of the world's freshwater, the largest surface freshwater sources in the world, and four of the twelve largest North American cities –faces significant climate change challenges (Sousounis and Glick, n.d.). Projections suggest average annual air temperatures will increase by 3.6 to 11.2° F by 2100. Likewise, severe storms, droughts, and floods are expected to increase in frequency and intensity (GLISA, 2012).

In the United States, local governments provide essential services, such as public safety and disaster response, and manage critical assets, such as drinking water and stormwater infrastructure. Climate change will impact municipal service provision and asset management. Furthermore, since specific climate change impacts will vary between communities, municipalities may need to customize their approaches to address local climate change impacts.

Despite shrinking budgets, conservative political and social pressures, and imperfect information about local climate change impacts, Ann Arbor and Grand Rapids, Michigan, are implementing a surprising and exciting array of strategies to adapt to climate change. This case study of Ann Arbor and Grand Rapids draws on in-depth interviews with political leaders, City department heads and other key staff, and executives at leading local non-profit organizations to evaluate what enables and constrains climate change adaptation in these cities.

We seek to understand cities' capacity to respond to a range of climate change impacts and document specific action Ann Arbor[1] and Grand Rapids have taken to prepare for and respond to climate change. Moreover, we identify opportunities and constraints these cities face in responding to future climate stresses. We focus on two aspects of climate impact response: climate adaptation options (what cities are actually doing) and their level of adaptive capacity (AC). The Intergovernmental Panel on Climate Change (IPCC) defines AC as "the ability of a system to adjust to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences" (IPCC AR4 Glossary, 2007).

In order to examine AC in both cities, we build upon the growing literature focusing on climate adaptation and determinants of adaptive capacity (Eakin & Lemos, 2006; Smit & Pilifosova, 2001a; Yohe & Tol, 2001). We begin by defining a list of determinants of adaptive capacity that we argue are critical to the ability of cities to respond to climate impacts – institutions, infrastructure, wealth and financial capital, social capital networks, political capital, human capital, information, and technology (**Table 6.1**). For example, under the broad determinant of "political capital," we assess the mayor's leadership on environmental issues and public support for adaptation-relevant decisions. We use Grand Rapids and Ann Arbor as case studies to identify how these determinants shape their AC. Using our findings in these cities, we develop and propose a framework for analyzing AC in other Great Lakes cities. Since these determinants do not operate independently, we highlight how different determinants enable, constrain, and influence each other.

Although the cities do not always call what they are doing "climate adaptation," and our informants do not always recognize the adaptation benefits or relevance of their programs, both Ann Arbor and Grand Rapids are pursuing initiatives with direct relevance for adaptation. They either refrain from using the words "climate adaptation" for political and cultural reasons, or adaptation happens as an ancillary benefit from current plans, policies, and programs with other primary objectives. For instance, both communities have active urban forestry programs that emphasize the stormwater, aesthetic, and air quality benefits of urban trees. However, expanding shade cover offers adaptation benefits that both communities are beginning to realize. Further, adapting the urban forestry programs to a changed climate – by diversifying species selection and adding new species to planting lists – is only beginning to emerge as a strategy in these communities. Similarly, our case cities have developed robust programs to fund and implement energy efficiency improvements. The cities frame these programs around cost saving and greenhouse gas mitigation goals. However, given projected temperature increases, reducing base load on the energy grid represents an important adaptation strategy.

The Ann Arbor and Grand Rapids cases demonstrate that all eight determinants contribute to adaptive capacity in important ways. Institutions consist of the rules, regulations, and government structures ensuring that adaptation becomes a priority for public and private actors. Infrastructure systems ensure cities' resilience to climate impacts. Still, the long-term, fixed nature of infrastructure creates path dependence, reducing cities' ability to adapt in the short term. Wealth contributes to

[1] During the course of this project, two team members also worked for the City of Ann Arbor (Parrish Bergquist as a Transportation Planning Graduate Intern and Laura Matson as a Sustainability Fellow).

adaptive capacity since cities need money to pay staff, purchase technology and information, and build and maintain infrastructure projects. Social capital and networks boost adaptive capacity since collaboration and resource sharing helps stretch city resources. Political capital, in the form of leadership and public support, allows the cities to pursue adaptation activities. Human capital in the form of knowledgeable, talented individuals plays a critical role in developing and implementing adaptation programs. Timely information about extreme events helps cities respond to climate-related impacts, and scientific projections about future climate impacts would enable cities to plan systems that will accommodate future events. Technology enables the collection and communication of climate data, and it bolsters the effectiveness of the other determinants in enabling adaptation. Indeed, it is difficult to separate technology as an independent determinant of adaptive capacity, since its effective use depends on other determinants (e.g. human capital, financial capital), and its usefulness primarily consists in boosting other determinants' strength (e.g. information, infrastructure).

No determinant operates independently of the others. Instead, we find complex relationships and feedback loops between them. Some determinants enable or bolster others. For example, institutions generate wealth and channel it towards adaptation-relevant material resources and infrastructure systems. Some determinants mutually reinforce each other. For example, wealth and human capital can create a positive feedback loop with institutions. Cities need money to create and staff city departments like Ann Arbor's Energy Office and Grand Rapids' Office of Energy and Sustainability. Entrepreneurial staff (human capital) who work in these organizations innovate by pursuing creative funding mechanisms and capturing grant funding, generating more financial capital for the cities. Many of these new resources are also flexible (when compared with city budgets) and allow for investment in areas that otherwise would not get funding, especially in times of economic hardship. Similarly, some determinants are self-enabling. Wealth begets wealth: a certain baseline level of financial capital enables cities to protect their assets, and leveraging and institutional funding mechanisms enable initial wealth to grow. Further, we find that more of a determinant does not always lead to better outcomes. For example, additional information is not helpful if staff do not have time or energy to analyze and incorporate it into their activities. Similarly, technology is only as good as the information fed into it and the minds using it (human capital).

While we identify many similarities between the communities, each city emphasizes different determinants in achieving its goals. We do not conclude that either city fundamentally lacks any element of adaptive capacity. Still, different stories emerge in the two cities. For example, many informants in Grand Rapids referred to the usefulness of public engagement—political and social capital—for achieving positive outcomes. Meanwhile, we find several examples in Ann Arbor of institutionalized funding sources enabling adaptation. The complex relationships between determinants and different strategies used (both within and between the cities) make it difficult to prioritize each determinant's contribution to overall AC. Instead, the important story lies in the interrelationships between the determinants and the possibility of combining them differently to achieve adaptation goals.

Throughout our analysis, we find that people matter: human capital, political capital, and social capital bolster the effectiveness of every other component of adaptive capacity. In both cities, political

leaders play a critical role in setting priorities, which helps institutionalize and build public support for adaptation. Social networks also help to define priorities and implement programs. Human capital is critical in that talented staff develop good ideas; many of our informants attributed the cities' successes to specific highly skilled individuals.

Integration emerges as a key tool for successful adaptation. In the context of this study, integration refers either to spreading concepts through the many departments of an organization, or to bringing together various disciplinary perspectives to solve problems. Integration can reduce costs by improving efficiencies, and it can increase staff knowledge by facilitating collaboration and discussion across disciplinary boundaries.

Throughout our research, we identified constraints that cities face in adapting to climate change. Our informants repeatedly referenced the difficulty of achieving interagency collaboration, in light of both institutional and political obstacles. Within the local institutional context, the cities continue to encounter constraints. For example, although we find that integration in planning and decision-making helps foster adaptation, our case cities continue to experience imperfect integration. Silos remain within the city bureaucracy, either because staff lacks the time and energy to discuss issues with their colleagues in other disciplines, or because certain city systems have not been fully integrated. Individual or community perceptions constrain adaptation. Some adaptive actions rely heavily on individual behavior change. For example, successful emergency response depends partially on individuals' actions in response to information they receive. Perceived lack of climate information presents both technical and political constraints to adaptation. Economic conditions can constrain adaptation, especially given the aforementioned political challenges and information limitations.

We begin in Chapter 2 by introducing our case study cities – Ann Arbor and Grand Rapids, Michigan – and outlining the research methodology employed for this study. In Chapter 3, we describe projected climate change impacts in the Great Lakes region. Chapter 4 discusses adaptation strategies other cities have already adopted and highlights opportunities for further action. In Chapter 5, we review the literature about adaptive capacity and determinants of adaptive capacity. Drawing from these three literatures, we propose a framework for assessing AC in cities in Chapter 6. We then apply this framework to Ann Arbor and Grand Rapids to explore critically each of the determinants of interest, in Chapters7-14. For each determinant, we highlight how the presence or absence of the determinant is enabling and constraining adaptation in both cities and discuss key relationships with other determinants. Chapter 15 presents conclusions and opportunities for future research.

Chapter 2: Methodology

We selected two cities in the state of Michigan for this study: Ann Arbor (~42° 16' 14" N, 83° 43' 35" W) and Grand Rapids (~42° 57' 47" N, 85° 40' 5" W). **Figure 2.1** depicts the location of each. Focusing on two cases allowed for an in-depth investigation of the selected cities and facilitated long-lasting and iterative interactions with the interviewees.

Figure 2.1. Grand Rapids and Ann Arbor depicted on Michigan Landsat Image. Source: Created using Landsat imagery from the U.S. Department of Interior U.S. Geological Survey Earth Resources Observation and Science Center (EROS). EROS Image Gallery "Landsat State Mosaics." Accessed from: http://eros.usgs.gov/imagegallery/collection.php?type=landsat_states#0.

Grand Rapids (population 193,707) and Ann Arbor (population 112,917) are the second and sixth largest cities in Michigan, respectively (U.S. Census Bureau, 2009). **Table 2.1** summarizes the demographics of both communities.

Table 2.1. 2009 Population Characteristics of Ann Arbor, Grand Rapids, and Michigan Overall

	Ann Arbor	Grand Rapids	Michigan Overall
Total Population	112,917	193,707	9,969,727
Poverty Level[2]	20.6 %	24.1%	16.2%
Per-capita Income	$27,159	$18,913	$23,728
Food stamp recipient[3]	6.2 %	19.4 %	14.5%
Race			
White alone	74.8%	70.7%	79.9%
Black or African American alone	7.0%	19.4%	13.9%
American Indian and Alaska Native alone	0.0%	0.5%	0.5%
Asian alone	13.1%	1.6%	2.4%
Native Hawaiian and Other Pacific Islander alone	0.0%	0.0%	0.0%
Some other race alone	0.9%	4.6%	1.2%
Two or more races:	4.0%	3.2%	2.0%
Two races including Some other race	0.2%	0.5%	0.2%
Two races excluding Some other race, and three or more races	3.9%	2.7%	1.7%

Source: U.S. Census Bureau, 2009 American Community Survey, B01003. Total Population; B17001. Poverty Status in the Past 12 Months by Sex by Age; B19301. Per Capita Income in the Past 12 Months; B22003. Receipt of Food Stamps/SNAP in the past 12 Months by Poverty Status in the Past 12 Months for Households; B02001. Race.

Within the Great Lakes region, Ann Arbor and Grand Rapids stand out for their reputation of environmental leadership and both were selected for being positive exemplary cases. Both cities are signatories of the U.S. Conference of Mayors Climate Protection Agreement, through which participating cities commit to reducing their greenhouse gas emissions and promote state and federal policies to address climate change (U.S. Conference of Mayors, 2008). Likewise, both cities have been active members of ICLEI-Local governments for Sustainability, "the leading nonprofit membership association devoted to local governments engaged in sustainability, climate protection, and clean energy initiatives" (ICLEI USA, 2012). In 2008, *Fast Company* magazine deemed Grand Rapids "America's Greenest City" and in 2010, the U.S. Chamber of Commerce and Siemens Corporation named Grand Rapids the most sustainable midsize city in the U.S. (West, 2008; Beeke, 2010). Because of their high level of environmental concern and action, we expected the level of engagement and concern with climate change impacts would be high for both cities. Looking to the experiences of leading cities allowed insight into the factors that enabled these cities to take initiative as compared to other communities in the region.

[2] The U.S. Census Bureau defines poverty status as "income in last 12 months below federal poverty level."
[3] The U.S. Census Bureau calculates food stamp recipient as the "percent of households receiving food stamps/SNAP in past 12 months."

Overall, we interviewed 46 key informants starting in August 2011 and lasting until December 2011. We interviewed individuals from local governments and various non-governmental organizations (NGOs). In most instances, two researchers interviewed one informant in-person for one hour.[4] Interviews typically took place in a conference room, coffee shop, park, or office of the interviewee.

Interview questions aimed to assess the enablers of and constraints to adaptation each city faces. Scholars have theorized that certain factors enhance a system's resilience and we asked questions to gauge how these factors operate in the two communities. Interviews generally covered the following topics:

- Background information about relevant policies and programs
- Use of climate change information in decision making
- Leadership and political climate
- Enablers and constraints to climate action
- Perceived climate change impacts and vulnerabilities

Within these broad topics, we customized the interview questionnaire for each informant based on background research, the informant's specialty, and information gathered from previous interviews. Appendix 2 includes a template interview questionnaire.

To begin, we approached the mayor of each city with a formal request to participate in the research process.[5] After receiving confirmation from both mayors, we began by interviewing the mayors and the key informants they identified in each city. We followed a snowball methodology in which additional follow-up interviewees were identified by our first and second round informants. In addition, we reviewed news articles and City reports, plans, and websites to gather background information about both cities and inform our interview process and confirm our findings.

Most interviews were recorded.[6] Before recording, all respondents provided consent.[7] We later transcribed the interviews. To expedite data analysis, we developed a coding system to organize, classify, and identify transcribed interview data consistently. We used the NVivo 9 software package (QSR International Pty Ltd, 2011 http://www.qsrinternational.com/products_nvivo.aspx) for coding, sorting, comparing, and discovering linkages between data. Coding the interview transcripts entailed developing a preliminary list of codes, which were associated with determinants of adaptive capacity (described further in Chapter 5 and Chapter 6), city sectors, and climate events. We then conducted trial coding sessions to assure all members of the five-person group were coding consistently. During these trial coding sessions, all members of the group coded one interview for calibration purposes. Each group

[4] Two interviews were conducted by telephone. Two interviews included two interviewers and two respondents. Three interviews were conducted with one interviewer and one respondent.
[5] Appendix 3 contains a copy of the request letter.
[6] Two interviews were not recorded due to technical difficulties with the audio recorder.
[7] Appendix 4 contains a copy of the consent form.

member then coded for specific determinants, city sectors, and climate events. Throughout the coding process, regular group discussion helped clarify definitions and resolve potential inconsistencies.[8]

After completing coding, we had a searchable database of determinants of adaptive capacity, city sectors, and climate events. In addition, we used NVivo 9 to perform queries, which produced reports specific to the determinant, city sector, or climate event of interest. Moreover, the reports from the queries assisted in identifying and interpreting trends, patterns, strengths, weaknesses, similarities, and differences within and between Ann Arbor and Grand Rapids.

[8] Appendix 5 outlines our coding structure.

Chapter 3: Climate Change in the Great Lakes[9]

The scientific consensus is that climate change is already and will continue affecting social, economic, and environmental systems across the globe (Adger et al., 2007). Climatic variation directly and indirectly affects diverse sectors, including the economy, tourism, human health, agriculture, and natural ecosystems and their respective ecosystem services (EPA, 2010). Observed global impacts from climate changes include: melting glaciers, thawing of permafrost (resulting in additional greenhouse gas emissions from decomposition of once frozen organic matter), later freezing and earlier break-up of ice on various bodies of water, lengthening of growing seasons, increasing frequency and intensity of storms, shifting flora and fauna ranges, and earlier flowering of trees (Adger et al., 2007).

Regions across the United States – including the Northeast, Southeast, Midwest, Great Plains, Northwest, Southwest, Alaska and US islands, and Coastal Regions – have experienced unprecedented warming over the past few centuries (USGCRP, 2012). Increasing temperatures effect heating and cooling requirements in the built environment (EPA, 2010). This warming has created myriad environmental and socioeconomic stresses throughout the country (USGCRP, 2012). However, climate change influences each region differently. For instance, some regions, such as Alaska are warming more quickly than others (USGCRP, 2012).

Projections of climate changes impacts for Ann Arbor and Grand Rapids, Michigan, specifically are not yet available. Therefore, to understand how climate change will affect our case study cities, this chapter provides an overview of climate change impacts in the Great Lakes region and, when available, Michigan specifically in order to better understand what challenges and opportunities climate change will present for these cities.

Climate Change Impacts in the Great Lakes Region

The Great Lakes region includes eight U.S. states, two Canadian provinces, and five Great Lakes (**Figure 3.1**). Projections suggest this region will face an array of complex climate change impacts. Climate change will most likely significantly affect the Great Lakes themselves, which play a pivotal role in shaping the

Figure 3.1. The eight U.S. states, two Canadian provinces, and the five lakes within the Great Lakes region. Great Lakes Information Network 2012. Source: http://www.great-lakes.net/lakes/#overview

[9] Unlike the IPCC reports, the use of terminology such as "likely" and "may" do not have specific confidence intervals associated with them because scientists generally have less confidence about localized climate change impacts.

climate, economies, and social well-being in the region (Karl et al., 2009). In addition, climate change in the region will likely affect human health, agriculture, natural ecosystems, and economies significantly (Kling et al., 2003).

Since the 1970s, the Great Lakes region has been warming at a rate of 0.4°F per decade. Moreover, the average winter temperatures are rising at a more rapid pace of 0.9°F per decade (Union of Concerned Scientists, 2009a). Projections suggest that by 2100, average temperatures will be 3.6 to 11.2° F higher (GLISA, 2012). The winter of 2012 was one of the mildest on record in the region, with the month of March 2012 setting records across several Midwestern states, as depicted in **Figure 3.2**. (National Weather Service, 2012a; Dolce, 2012). Grand Rapids saw the warmest March ever recorded in the city in 2012 (National Weather Service, 2012b).

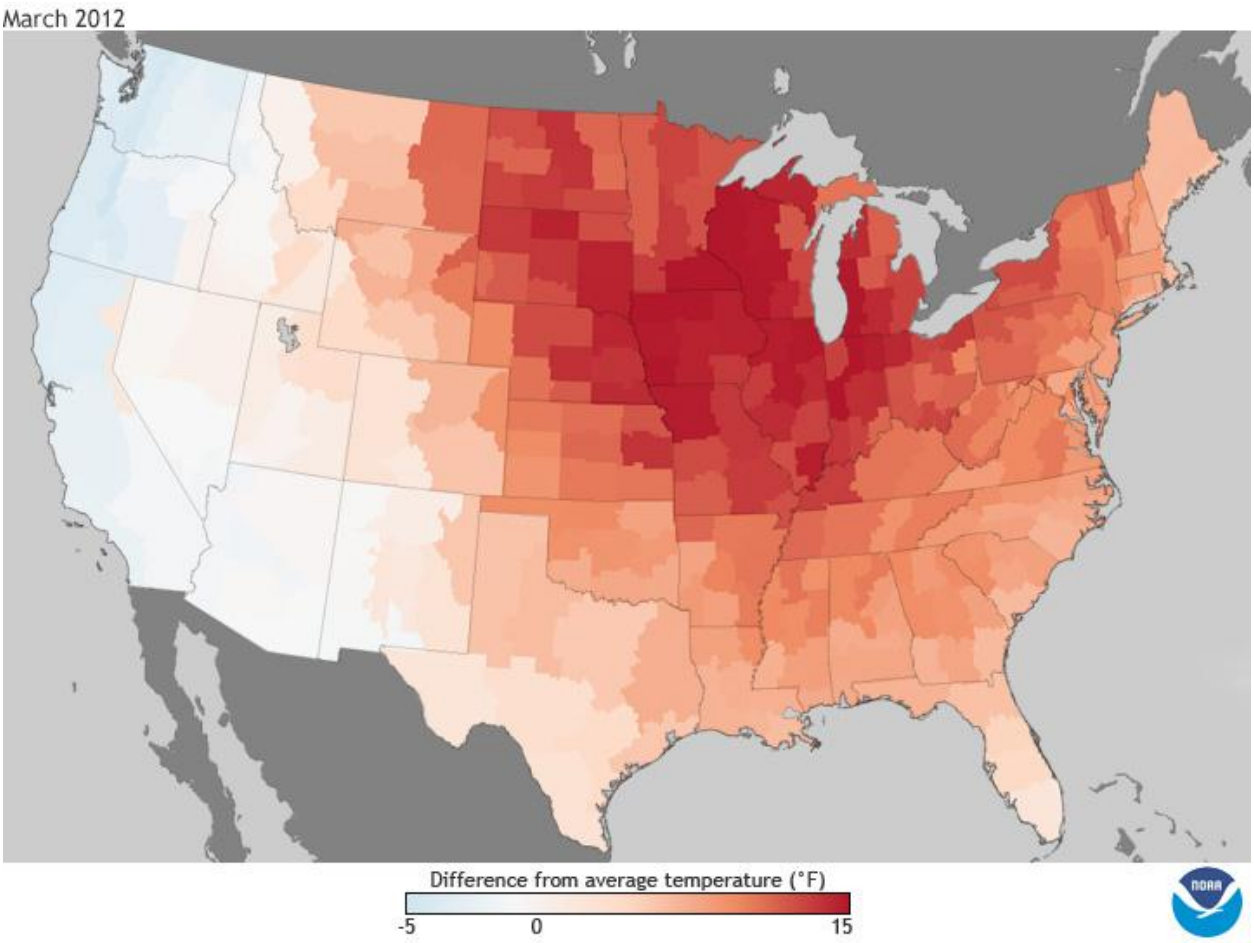


Figure 3.2. March 2012 Temperatures - Departure from Average.

Source: NOAA Satellite and Information Service. "State of the Climate National Overview March 2012." Accessed from http://www.ncdc.noaa.gov/sotc/national/.

Climate models project that the region may experience temperatures more like the states and cities in the south and west during summer months in the coming decades (Karl et al., 2009).[10] As illustrated in **Figure 3.3**, The Union of Concerned Scientists projects that by the end of the century, summers in Michigan will resemble those of current day Arkansas (Union of Concerned Scientists, 2009b). This has sizeable implications for Michigan's agricultural sector, winter recreation economy, and tourism activities.

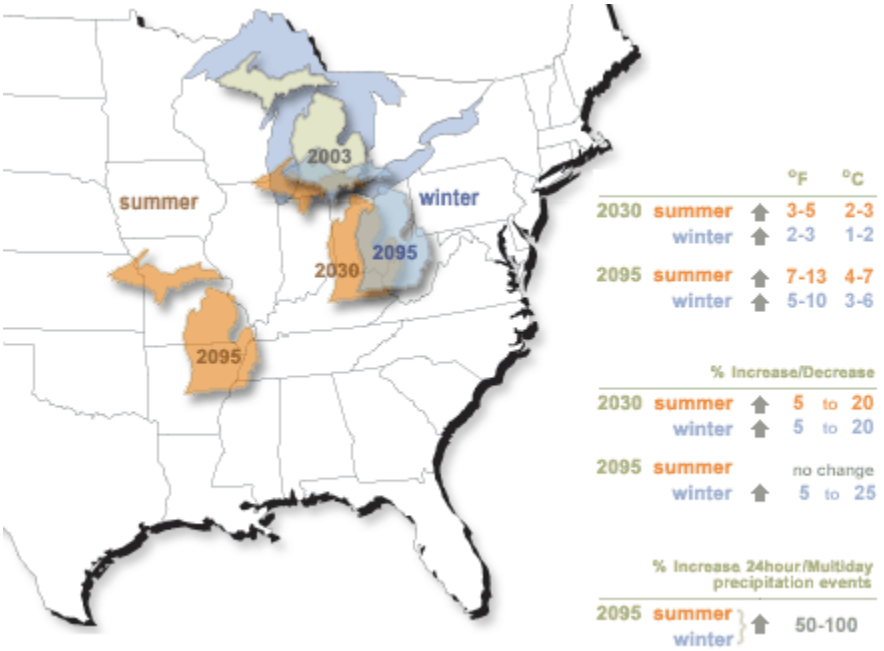


Figure 3.3. Projected Climate Impacts in Michigan

Source: Union of Concerned Scientists, 2009b

Impacts on the lakes

Since the Great Lakes contain 20 percent of the planet's fresh surface water and exert a strong influence on the economies and identities of surrounding communities, the impacts of climate change on the lakes themselves are of particular interest. Higher temperatures and less ice on the lakes during winter months may lead to more evaporation and, therefore, lower lake levels (Kling et al., 2003; Hall & Stuntz, 2007). Indeed, projections suggest that lake water levels of both the Great Lakes and inland lakes of the region will likely decline (NOAA GLERL, 2012; Hall & Stuntz, 2007). One study concluded that Lake Michigan and Lake Huron might drop as much as 4.5 feet (Hall & Stuntz, 2007). **Figure 3.4** shows the trends in lake levels from the mid-nineteenth century to the present, with predictions for continued decline in lake levels into the future (NOAA GLERL, 2012). Lower lake water levels can accelerate the accumulation of contaminants, which may more readily accumulate in the food chain (Kling et al., 2003). Further, increased temperatures will likely lead to longer periods of lake stratification, which will prevent water in the lakes from mixing and cause deepwater anoxic zones that, in turn, kill fish and

[10] The specifics of the projections depend on the emissions scenarios used.

sessile organisms (Kling et al., 2003). In addition, water shortages in other U.S. regions may increase the threat of diverting freshwater from the Great Lakes (Hall & Stuntz, 2007).

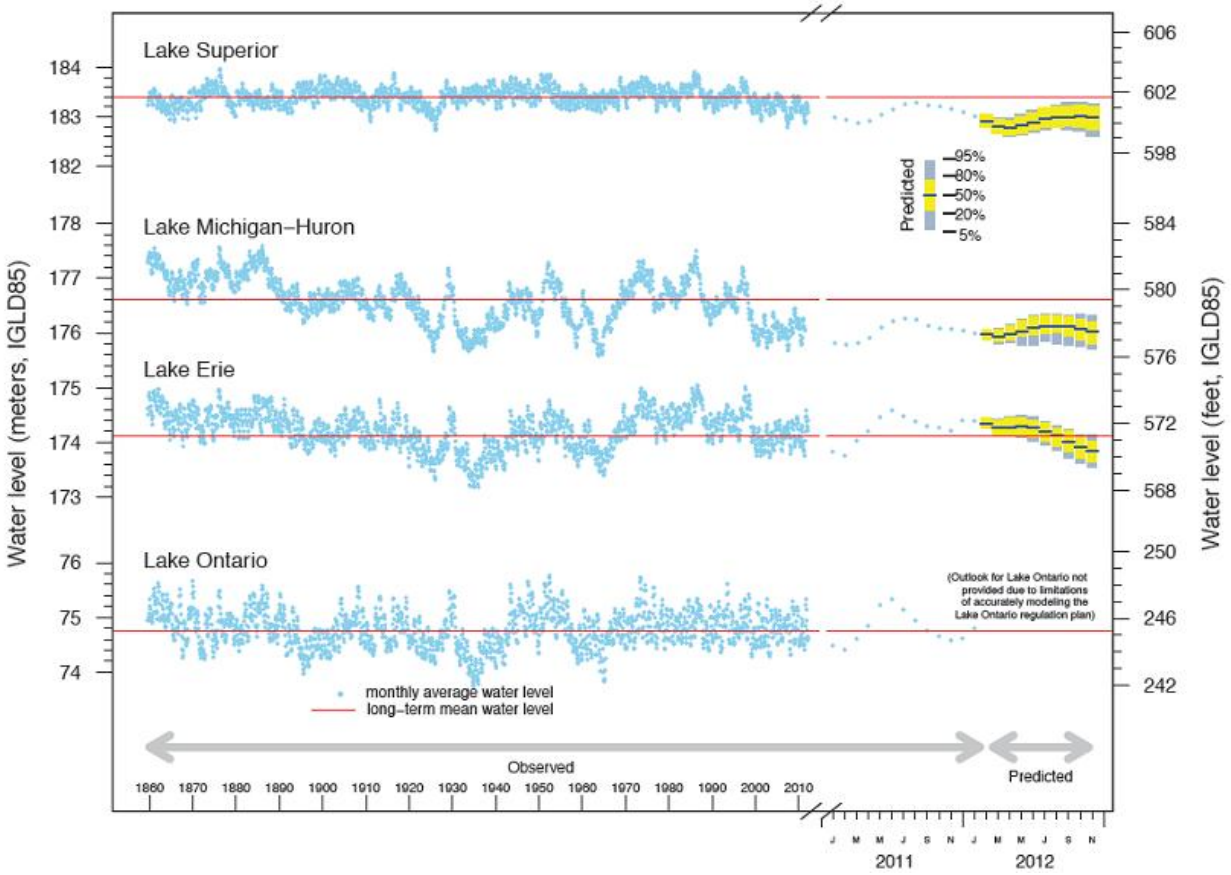


Figure 3.4. "Water Levels of the Great Lakes." February 2012. Source: National Oceanic and Atmospheric Administration (NOAA) Great Lakes Advanced Hydrologic Prediction System (AHPS), Great Lakes Environmental Research Laboratory (GLERL). Accessed from: http://www.glerl.noaa.gov/pubs/brochures/lakelevels/lakelevels.pdf

A recent study from the National Oceanic and Atmospheric Administration (NOAA) Great Lakes Environmental Research Laboratory found a 71 percent decline in Great Lakes ice cover since 1973. This study revealed that Lake Michigan saw a decline of 77 percent of its ice cover in that span (Wang et al., 2012). Less winter ice will likely alter distributions of fish and other marine life, although the specific impacts on different species will vary. Higher temperatures will likely facilitate invasions of species native to areas south of the Great Lakes region that are looking for new suitable habitat as well as invasions of native species; in both cases, these invasions will impact native flora and fauna. Higher temperatures and lower lake levels may also increase bioaccumulation rates of mercury and other contaminants in the aquatic food chain (Kling et al., 2003).

Snow drought (i.e., having less snow cover on the ground throughout the winter) may affect bodies of water in the Great Lakes region as well. As temperatures continue to increase, less snow will cover the ground exposing more soil throughout the winter months. Groffman et al. (2001) found that in a warmer world with less snow cover, soils would be significantly colder because snow acts as an

insulator. In the absence of snow, the soil freezes to a deeper depth and kills more roots (Groffman et al., 2001). When spring precipitation and melting occurs, dead roots will no longer absorb nutrients, including nitrogen and phosphorous. These nutrients then runoff or seep into groundwater flow, both of which ultimately end up in nearby bodies of water and contribute to anoxic zones, or the depletion of oxygen levels in water, which harms aquatic species. Nutrient runoff in the Great Lakes watershed eventually ends up in the Great Lakes, leading to algal blooms, and climatic changes may exacerbate this problem. Moreover, nutrient uptake and runoff can have implications for agricultural yields into the future.

Impacts on natural systems

Streams and wetlands of the region are innately connected with the lakes and may face many of the same climate change issues. More intense rain events will likely cause more severe and frequent flooding, leading to more erosion and sediment pollution. Moreover, extreme precipitation events may cause sewer systems to overflow and runoff into nearby bodies of water, which can cause an array of human health and sanitation issues (Union of Concerned Scientists, 2011). The timing of peak runoff from ice melt will change and, therefore, alter the timing of peak stream flows to which ecosystems have adapted (Kling et al., 2003). Drought and lower summer water levels will cause small rivers to dry up, decrease groundwater recharge, and reduce the size of wetlands in the region (Karl et al., 2009; Hall & Stuntz, 2007). This will result in water quality degradation and habitat loss (Kling et al., 2003). These impacts may compound the effects of habitat fragmentation and land use change, which are decreasing the amount of refugia for species (Kling et al., 2003).

Climate change will likely have varied impacts on forests in the region. Increased concentrations of carbon dioxide (CO_2) and nitrogen as well as higher temperatures will foster forest growth, but these positive effects may be negated by a decrease in air quality, more pests, increased ground-level ozone concentrations, and dissipating ecological niches (Karl et al., 2009; Hannah, 2011). Increased temperatures could cause boreal tree species to go extinct in the Great Lakes region and force trees adapted to particular climate niches to migrate farther north (Kling et al., 2003). Summer droughts could lead to increased forest fire frequency, and tree pests typically controlled by cold winters may thrive with shorter and warmer winters (Karl et al., 2009; Kling et al., 2003). These impacts will likely have considerable implications for urban forestry, parks and recreation, and forest management.

Warmer temperatures will most likely cause the habitats of forests and terrestrial wildlife to shift northward (Karetnikov et al., 2008). Similarly, warmer stream water temperatures will hinder coldwater fish species and allow fish species adapted to warmer temperatures to migrate to previously uninhabitable environments in the region (Kling et al., 2003; Cherkauer & Sinha, 2010). Moreover, intensified storm events may lead to more runoff and thus greater stream flow, which can also adversely impact fish species adapted to particular stream flow habitats (Cherkauer & Sinha, 2010).

Ecosystem dynamics will likely undergo climate-induced changes. For example, migratory species that time their migration on day length instead of climate indicators will miss flowering plant species and peak populations in the insects on which they feed (Kling et al., 2003). If new protected areas are not properly planned to accommodate new species range shifts, then there could be extinctions and

desynchronization of life-cycle events (Hannah, 2011; Union of Concerned Scientists, 2011). Warmer winters could make flowers bloom earlier and therefore leave them more susceptible to late season frost (Union of Concerned Scientists, 2011). Michigan experienced this issue earlier this spring when an unusually warm spell in March 2012 was followed by frost, an event that is likely to have dire implications for the state's renowned tart cherry crop (The Lansing Journal, 2012).

Impacts on human systems

Climate change may pose a host of public health challenges in the region. Higher temperatures and higher relative humidity will likely negatively impact human health by increasing heat stress, especially if nighttime temperatures do not drop. These effects are exacerbated in cities due the greater amounts of infrastructure and impervious surfaces that "trap" heat and result in the notably warmer temperatures often evidenced in cities. This phenomenon, the urban heat island effect, is depicted in **Figure 3.5.**

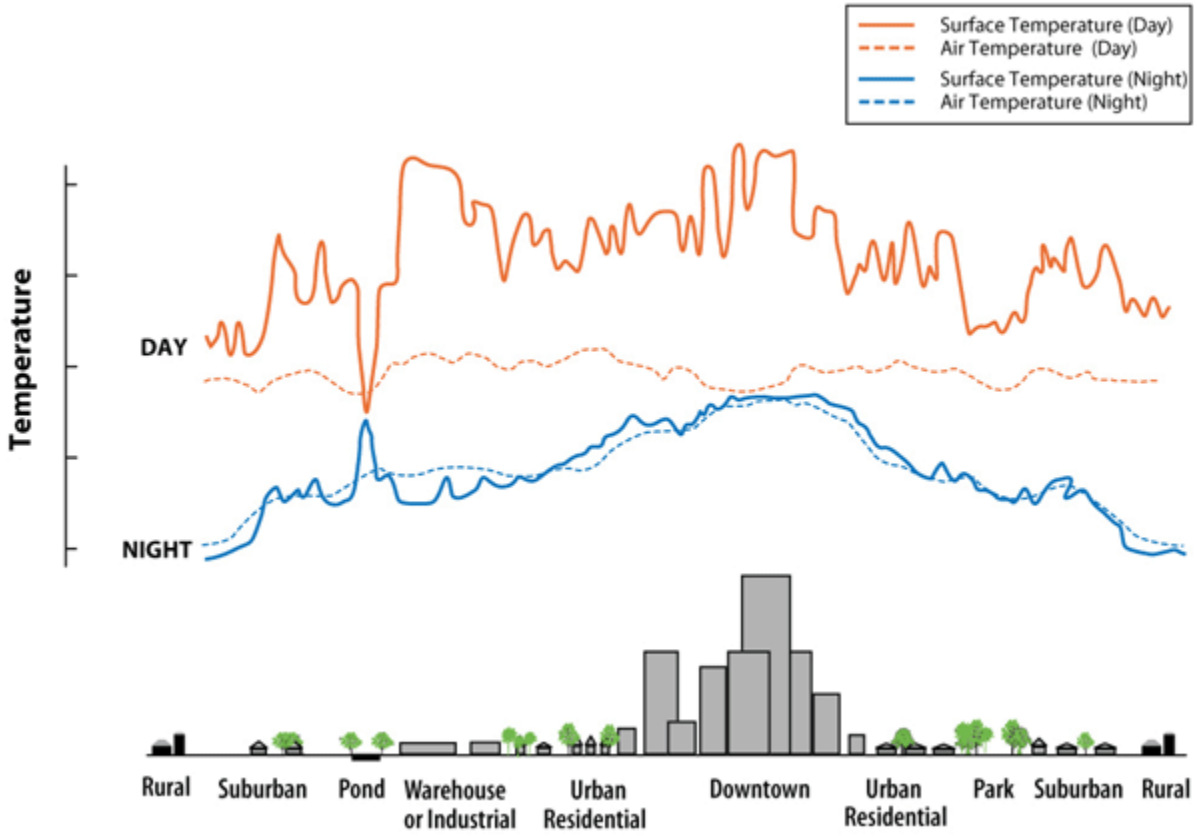


Figure 3.5. The urban heat island effect. Source: The Environmental Protection Agency. "Heat Island Effect." Accessed from http://www.epa.gov/heatisld/about/index.htm.

Vulnerable populations, such as the elderly, are at an even greater risk of succumbing to heat stress (Ebi et al., 2008). Higher temperatures will likely lead to increased cooling demand. This will most likely result in increased electricity generation and the resultant formation of ground level ozone, and thus reduced air quality and accompanying health concerns (Kling et al., 2003; Union of Concerned Scientists, 2011). Furthermore, a warmer climate will exacerbate the spread of disease and increase the prevalence

of allergens and other nuisances. Higher air temperatures allow disease-carrying insects to move to higher altitudes and latitudes (Union of Concerned Scientists, 2011). Similarly, higher temperatures and higher CO_2 may foster quicker growth rates in plants, earlier maturation in the season, and the potential to produce more pollen and thereby increase allergens. The increase in CO_2 levels will create more favorable growing conditions for irritating plants like poison ivy, a native to the Great Lakes region (Union of Concerned Scientists, 2011). Higher temperatures can also impact human health from extreme weather events; decreased air quality; and vector-, water-, and food-borne diseases (Ebi et al., 2008).

Climate change may also impact the economy of the Great Lakes region. Although the shipping industry will have a longer ice-free season to ship goods, it will bear the costs of dredging harbors and channels as well as adjusting docks (Kling et al., 2003). Furthermore, with lower lake levels, ships will not be able to carry as much freight and, therefore, may have to make more frequent trips to transport the same amount of goods (Karl et al., 2009). Additionally, areas that were once navigable by ship may no longer be accessible due to decreased lake levels. Further, decreased water levels could result in a loss of hydropower generation and mean less water for industry use (Kling et al., 2003; Karl et al., 2009).

Shorter winters will most likely result in a loss of winter recreational sports such as skiing, ice fishing, snowmobiling, and cross-country skiing, but it may be compensated by longer warm weather recreation seasons (Karetnikov et al., 2008). The loss of wetlands and lakes coupled with loss of habitable land for migratory species mean the ecotourism, angling, and hunting industries could face declines (Moore, 2011). In Michigan, fishing, hunting, and bird-watching generate $3.3 billion dollars annually; habitat loss, dwindling food sources, and changing migratory patterns will negatively impact this sector (Karetnikov et al., 2008). If climate change causes Michigan to lose its trout population, the state could lose $75 million in trip-related spending (Karetnikov et al., 2008).

The effects of climate change on the agricultural sector in the Great Lakes region are difficult to predict. Higher temperatures and CO_2 levels will most likely lead to greater yields, but these benefits may be hampered by flooding from more frequent and intense storms, higher ozone concentrations, and the impacts of pathogens, insect pests, weeds, and invasive species migrating into new climate induced niches (Karl et al., 2009). Moreover, livestock will likely be detrimentally affected because of heat stress. For instance, livestock reproduction and milk production both decline when temperatures exceed 72°F (Chase, 2006). Therefore, the livestock owners will either lose productivity or invest in cooling equipment and bear the cost of increased energy use. Additionally, pasture grasses may suffer from longer periods of drought (Kling et al., 2003). In Michigan, these impacts may have significant economic repercussions because agriculture currently contributes approximately $63 billion to the state's economy (Karetnikov et al., 2008).

Climate change will likely lead to property damage or necessitate costly adaptation investments as well (Kling et al., 2003). More frequent and severe precipitation events may increase the likelihood of private and public property damage (Kling et al., 2003). Precipitation events may also damage city infrastructure, including buildings, bridges, roads, and sanitation systems (Wilbanks et al., 2008). Estimates suggest direct damage to Michigan's infrastructure will cost $700 million annually and indirect costs may be as high as $506 million (Karetnikov et al., 2008). Similarly, costs for treating and providing

water are unknown, but climate change is expected to increase Michigan's current cost of $367 million annually (Karetnikov et al., 2008).

In addition to bearing the overall effects of climate change, cities will also face additional, urban-specific challenges, such as combating the urban heat island effect, updating aging stormwater management systems and infrastructure, confronting invasive species and pests, and responding to more human health emergencies.

The Great Lakes Regional Integrated Sciences & Assessments Center (GLISA) recently summarized climate change impacts in the Great Lakes region. **Table 3.1** highlights their findings; see Appendix 6 for the full GLISA fact sheet.

Table 3.1. Climate Change Impacts in the Great Lakes Region by Sector

Sector	Impacts
Temperature	• Average temperatures increased 2.3° F between 1968 and 2002 • Higher future temperatures forecasted
Precipitation	• Precipitation will remain same or increase slightly • Less snow and more as rain due to increased temperatures
Extreme Weather Events	• Increased severe storm frequency and intensity • Potential resultant economic losses
Snow and Ice Cover	• Snow cover days and snow depth have decreased • Snow and ice on Great Lakes and land forecasted to decrease • Less ice on lakes could lead to more lake-effect precipitation
Lake Levels	• Decreased lake levels
Lake Temperature and Stratification	• Lakes will likely experience longer warm season • Greater stratification due to warmer surface temperatures, which could cause more hypoxia
Water Availability	• Drier conditions due to warmer temperatures • Droughts affect soil moisture and surface/groundwater supply
Forests	• Increased CO_2 could increase productivity, but drought, forest fire, and invasive species will have adverse effects • Changing temperatures will change species distributions
Fish and Wildlife	• Decline in coldwater fish likely • Biomass productivity could decrease • Changing species distribution
Stormwater Management	• Increased flooding and flood damage
Agriculture	• Longer growing season could positively impact some crops • More severe storms, pests, and pathogens can decrease crop yields • Challenges due to lower water availability and quality
Energy and Industry	• Dry summers could lead to less hydroelectric power • Water availability can interfere with industry • Strain from increased electricity demand

Transportation	• Damage to paved surfaces • Flood damage to roads • Shipping lanes will operate longer • Decrease navigation for ships due to lower lake levels
Public Health	• Increased heat-related stresses • Diseases such as West Nile Virus and Lyme disease may become more prevalent
Tourism and Recreation	• Winter tourism will likely suffer • Fish important to recreation may decline • Changed shorelines • Longer summer recreation season

Adapted from GLISA (2012)

Chapter 4: Urban Adaptation in Action

Over half of the world's population currently lives in urban areas. Therefore, understanding how climate change will influence cities and how urban systems can adapt to climate change impacts deserves special attention. Further, since climate change impacts will be highly localized, selecting adaptation strategies at the city-level allows communities to adopt customized and locally appropriate approaches. Indeed, it is important for municipalities to understand variations in suggested best practices to determine what adaptation strategies will be most successful given local circumstances.

Researchers are beginning to conduct adaptation research on urban areas, as opposed to rural areas (Birkmann et al., 2010). However, the anticipated threat of rising sea level and the concentration of large populations in urban coastal areas mean that most urban climate change adaptation work conducted to date has occurred in cities located along an ocean coast (Hunt & Watkiss, 2011). Conversely, limited applied and academic work has been conducted for inland urban areas. This study aims at significantly adding inland urban areas to the body of research on climate adaptation. To understand the adaptation options available to our case cities, this section reviews adaptation strategies employed in other North American cities.

Adaptation Strategies for Urban Systems

Climate change will influence diverse city sectors. For instance, increased intense rain storms will strain the stormwater system while higher temperatures will create public health challenges. These diverse city sectors and the impacts they are likely to face represent many types of adaptation opportunities. This section outlines the climate change threats and some adaptation options cities have adopted in six sectors: built environment and infrastructure, stormwater management, urban forestry, energy, urban agriculture, and human health and emergency response.

Built environment and infrastructure

Increasing the resilience of infrastructure and the built environment is one major type of adaptation strategy cities can adopt. Jollands et al. (2005) assert that the "main potential vulnerability of the built environment to climate change is from extreme events; including floods and storms, and to a lesser extent heat waves and drought." Examples of adaptation strategies used in the built environment sector include green roofs, permeable and reflective pavement, urban trees, constructed wetlands, and regulating land use through zoning. Green infrastructure offers great potential as an adaptation strategy (Gill et al., 2007). Many cities have adopted municipal regulations, standards, and new construction guidelines to foster green infrastructure development.

Perhaps the best examples of early promoters of adaptation action in this sector, Toronto and San Francisco have implemented policies and standards to facilitate green infrastructure development and enhance the resilience of the built environment. The City of Toronto implemented the Green Development Standard that created a set of performance targets for new construction, including low-rise non-residential, low-rise residential, and any use mid-high rise (City of Toronto, 2008). These design and construction standards create more energy efficient buildings, reduce greenhouse gas emissions, reduce the urban heat island effect, conserve water, reduce stormwater runoff, and improve neighborhood green spaces (City of Toronto, 2008). Additionally, in 2010, Toronto became the first city

in North America to regulate and require the construction of green roofs on new development (City of Toronto, 2009). In 2004, the City of San Francisco passed legislation mandating that all municipal new construction and renovations projects over 5,000 square feet, must achieve at least a Silver rating in the Leadership in Energy and Environmental Design (LEED) green building rating system (City of San Francisco, 2004). The City of San Francisco has more LEED certified buildings than any other city in the U.S. (Cohen, 2011).

Stormwater management

Many local adaptation strategies focus on stormwater management. Example projects include changing a combined sewer system (CS0) into a separated sewer system, more rigorous onsite management of precipitation, integrating green infrastructure, and implementing Low Impact Development (LID) techniques. Local municipalities can use tools such as LID to manage and adapt to more intense and frequent precipitation events, which would otherwise lead to more destructive stormwater flows. LID strategies – including bioretention ponds, green roofs, permeable pavers, rain barrels, and tree box filters – can help decrease residual impacts in a watershed by increasing infiltration, reducing runoff volumes, and delaying the runoff peak (Roseen et al., 2011). A study by the Forging the Link Stormwater Research group found that LID approaches can reduce the total marginal cost increase across a local watershed significantly, compared to replacing undersized culverts (Roseen et al., 2011). For instance, the City of Portland, Oregon, focused on LID strategies that include investing in green streets, rain barrels, and tree planting to significantly reduce maintenance and management costs. This $8 million investment in green infrastructure saved the City $250 million in hard infrastructure costs (Foster et al., 2011a).

Since 2008, the City of Chicago has implemented a Stormwater Management Ordinance that requires certain new construction projects to capture and retain on site the first one-half inch of rain during any storm (City of Chicago, 2008). Projects that "disturb more than 15,000 square feet, create an impervious surface of 7,500 square feet or more, or directly discharge stormwater into any water body or separate sewer system" must comply with the ordinance (City of Chicago, 2012). Since the ordinance has been implemented, 265 development projects have been required to comply, resulting in a 20 percent increase in permeable area per site and a total of 55 new acres of permeable surface area (City of Chicago, 2010). Additionally, the City is looking to collaborate with the Metropolitan Water Reclamation District on a Chicago Watershed Plan that uses vacant land to manage stormwater (City of Chicago, 2008).

Urban forestry

Urban forests can positively contribute to managing increased stormwater runoff, and expanding canopy cover provides shade and counteracts problems associated with the urban heat island effect. In many urban areas, lower income and vulnerable populations tend to live in areas with lower tree canopy cover (Gill et al., 2007). Therefore, planting additional street trees in urban areas offers a relatively low cost option to dealing with heat-related public health challenges. Adaptation strategies in this sector include increasing tree quantity, planting tree species adapted to new climate conditions, and diversifying species type.

Many cities have proposed "million tree" campaigns. The City of Los Angeles, for example, began a cooperative project with local community groups, businesses, and individuals to plant one million new trees. The majority of trees will be planted on public property by City departments. As of January 2012, the project offers seven free street trees to plant on each residential property (Million Trees LA, 2012). The City of Chicago also set the goal of planting one million new trees by 2020, and has published a more expansive plant-growing list that includes vegetation that survives in a warmer climate. Given the inherent uncertainty surrounding climate change, the City will minimize long-term unpredictability and reduce future financial constraints by planting trees that presently survive in more southern climates (City of Chicago, 2008).

Energy

Although improving energy efficiency is typically viewed as a climate change mitigation strategy, energy efficiency programs offer adaptation benefits. Further, developing renewable energy sources is essential for creating a system that does not exacerbate climate change events in the future.

The City of Seattle has implemented several energy efficiency measures. In both the commercial and residential sectors, Seattle provides incentives and has enacted policies to enhance energy conservation. Over 5,000 residents have received home energy audits, in partnership with Seattle City Light and Puget Sound Energy (City of Seattle, 2009). The City also passed legislation that requires commercial buildings larger than 50,000 square feet and multifamily buildings with more than 20 units to disclose the amount of energy used to the City and any potential future owner or resident (City of Seattle, 2009). This program was established to help the City reach an existing goal of improving existing buildings' energy performance by 20 percent by 2020, when compared to 2005 levels.

Several cities have pursued renewable energy programs as well. In 2009, the City of Chicago partnered with Exelon and SunPower to develop a 41-acre solar power plant on a brownfield site that will produce 14,000 megawatts of electricity annually, making it the nation's largest urban solar energy generator. It will generate enough electricity to power 1,200-1,500 homes annually (City of Chicago, 2010). The City of Boston's Solar Boston program promotes solar sources for city residents. The two-year, $550,000 initiative aims to increase solar capacity in Boston to 25 megawatts by 2015 (City of Boston, 2012). The City has reduced barriers for local solar installations by making permits more accessible, conducting feasibility mapping to determine prime locations, and leading the initiative through municipal participation (City of Boston, 2012). In addition to solar, the City of Boston has researched wind energy. The Boston Redevelopment Authority has developed wind energy zoning regulations to adequately manage and address public opposition, create clear rules and statutes, and facilitate efficient installation processes (City of Boston, 2012). In addition, development prospects have been made on a City-owned property to construct a 1.65 megawatt wind turbine on Moon Island that would power approximately 807 homes in Boston and Quincy (City of Boston, 2012).

Urban agriculture

Higher temperatures, as well as earlier spring conditions may lead to a longer growing season for farmers. However, more frequent and more intense precipitation events may make crop production less reliable. For cities, the agriculture sector includes two different focus areas: urban agriculture

opportunities and conservation of farmlands that surround cities and supply them with food. Increasing local agricultural production offers both climate change mitigation and adaptation benefits.

The City of Portland and Multnomah County Climate Action Plan highlights food and agriculture. The City of Portland has a goal to reduce barriers to urban agriculture production through zoning code revisions (City of Portland, 2010). Additionally, Multnomah County is working to develop a 15-year Food Action Plan, targeted at transforming the local food system by promoting healthy eating, social equity, and local economic vitality (City of Portland, 2010).

Ontario's Greenbelt is a large-scale example of a tool to conserve farmland surrounding urban areas and stabilize agriculture opportunities within the region. Located in the Greater Golden Horseshoe region that surrounds the city of Toronto, the Greenbelt protects over 1.8 million acres in total, including approximately 7,000 farms (Friends of the Greenbelt Foundation, 2012). The Greenbelt provides at least two major adaptation benefits: protecting biodiversity in the face of climate change and providing more green space to mitigate the urban heat island (Tomalty & Komorowski, 2011).

Human health and emergency response

More frequent and intense storms will cause emergency events that will affect cities. 2011 witnessed the most frequent and costly storms on record; the U.S. experienced $200 billion in disaster costs (NCDC, 2011). A study of six major climate events in the U.S. between 2000 and 2009 found that estimates for health costs exceeded $14 billion, reflecting over 760,000 patients interacting with the health care system (Knowlton et al., 2011).

An increase in frequency and intensity of heat days can exacerbate specific local problems, such as electrical outages, loss of air conditioning in dense urban residential areas, and evacuations (Hayhoe et al., 2010). Additional problems that arise from heat events include an increase in ground-level ozone, as well as an increase in disease-carrying insects and other animals. The City of Chicago is responding to these threats by updating its plan to react to heat-related events, including a new heat-watch warning system, and implementing plans for reducing heat loads for buildings (Hayhoe et al., N D). Additionally, the City's Climate Action Plan includes a focus on the need to reduce emissions of pollutants from power plants, leading to improved overall air quality (Hayhoe et al., ND).

Urban Adaptation Challenges and Lessons Learned

Many cities have created climate action plans to guide both mitigation and adaptation work. New York City and Chicago's plans have earned special attention and each city has tracked its efforts and reflected on its plan's importance. New York City created the Climate Change Adaptation Task Force, a scientist-stakeholder interactive process. Multi-jurisdictional participation coupled with support from the mayor and other leaders, a coordinating body to manage and facilitate forward movement, consistent interactions between scientists and stakeholders, and transparency of scientific uncertainties contributed to the New York plan's success (Rosenzweig et al., 2011). The City of Chicago also incorporated many strategies that led to the success of its Climate Action Plan. These strategies included a multi-stakeholder planning process, prioritization of the initial list of approximately 150 potential adaptation actions, and developing an action plan that incorporated primary actors, timelines, budgets,

and performance measures (Coffee et al., 2010). The success of the Climate Action Plan will be monitored over time through the Continuous Improvement Performance Measurement initiative (Coffee et al., 2010).

Several factors may mediate cities' design and implementation of climate change adaptation plans and actions. Lemos and Rood (2010) and Carmin et al. (2011) have identified the following barriers:

- A lack of financial, technical, or administrative resources;
- Institutional obstacles (e.g., standard operating procedures, agency politics) within either the decision-making body or implementing agencies;
- Political or social constraints;
- A lack of applied knowledge to translate scientific information into actionable steps;
- Perception of costs versus benefits and effects of time lag (i.e., paying now to receive a benefit in the distant future);
- Uncertainty of information or conflicting scientific evidence;
- Conflicting goals and tradeoffs;
- Backward-looking regulatory regimes;
- Coordination failures; and
- Local culture, beliefs and values, and institutional settings.

Though there are many challenges with implementing climate adaptation strategies, reflection and learning from peer cities help communities progress and overcome these challenges. To this end, the Center for Clean Air Policy (CCAP) convened local government leaders from ten large counties and cities to create a partnership to share information and resources related to climate adaptation strategies. When these leaders reflected on adaptation strategies, four major lessons learned emerged. Foster et al. (2011b) summarize these lessons learned as follows:

- Scientific uncertainty should not necessarily constrain adaptation efforts. Local government officials make daily decisions with a high degree of uncertainty and climate change adaptation is no different. Universities and consultants may be available to advise in the climate adaptation planning process.
- Local governments have started to implement adaptation strategies without labeling it as such. These adaptation strategies are often driven by other city goals, such as improving and protecting health, property, or quality of life for all residents.
- Many local governments have started to integrate adaptation practices into other city policies to help avoid the financial strain experienced when climate adaptation is pursued as a separate goal or task.
- Measurement and evaluation is vital to the overall success of implementing adaptation practices. This is helpful to the larger field of urban adaptation and will prove as a benchmark to compare past, current, and future climate impacts locally.

Likewise, the CCAP's group identified the following strategies that have improved and enabled adaptation activities in cities:

- Early stakeholder and community engagement;
- Presence of a champion;
- Accessible information;
- Down-scaled data;
- Peer-learning with other local governments;
- Leveraging funding through non-governmental sources; and
- Regional adaptation planning (Foster et al., 2011b).

Chapter 5: Understanding Adaptive Capacity and its Determinants

Concepts and Definitions of Adaptive Capacity

The Intergovernmental Panel on Climate Change (IPCC) defines adaptive capacity as "the ability of a system to adjust to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences" (IPCC AR4 Glossary, 2007). Adaptation in turn is ''the adjustment of natural or human systems in response to present and future climatic stimuli or to their effects, in order to mitigate the damage or to exploit beneficial opportunities" (Smit & Pilifosova, 2001a, p. 879). Effectively, adaptive capacity is a system's overall capability to respond, cope and recover by implementing adaptation options (Smit & Pilifosova, 2001b; Smit et al., 2000). The literature on adaptive capacity has proliferated in recent years, yet considerable debate on its definition, drivers, and distinguishing features remains.

Vulnerability assessment to climate change impacts provides an important lens for understanding adaptive capacity. 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" (Smit & Pilifosova, 2001b; Kelly & Adger, 2000). The IPCC posits that vulnerability depends on three factors: Exposure (physical hazard or climate threat), Sensitivity (the "degree to which a system is affected by or responsive to climate stimuli"), and Adaptive Capacity according to the following relationship:

Vulnerability = Exposure + Sensitivity – Adaptive Capacity

(Moss & Schneider, 2001; Smit & Pilifosova, 2001b; Kelly & Adger, 2000; Smit & Wandel, 2006). This definition suggests that high adaptive capacity can offset some degree of exposure and sensitivity, and that higher levels of adaptive capacity reduce vulnerability (Magnan, 2010). Smit et al. write, "It is broadly conceived that increasing adaptive capacity in turn decreases vulnerability to potential climate threats, as well as increases resilience should those threats arise" (Smit et al., 2001). Likewise, adaptive capacity is closely linked with the concept of resilience, or the potential for a "system to recover from a stress" (Gallopin, 2006). Adaptable systems are more flexible and resilient to climate stressors (Magnan, 2010; Engle, 2011). Adaptive capacity is the set of resources, assets, and abilities by which adaptation strategies may be enacted to reduce the vulnerabilities and improve the overall resilience of a system (Smit & Pilifosova, 2001; Adger & Vincent, 2005; Adger, Arnell & Tompkins, 2005; Schipper, 2009).

The literature has identified two types of adaptive capacity: generic and specific. Specific adaptive capacity is defined as the capability "to cope and recover from a particular event, in this case climate-related impact such as drought, flooding, or extreme weather (hurricane, tornado, etc.)" (Lemos et al., 2012, in press). It refers to capacity well suited or intended for a particular climate threat or impact such as tornado warning sirens, emergency response protocols, levees, or having highly educated and skilled engineers design flooding-resistant infrastructure. Generic capacity, by contrast, is defined as "those assets and entitlements that build the ability of different systems to cope and respond to a range of stressors" (Lemos et al., 2012, in press). It encompasses a broader set of societal capacities, which may enable or constrain adaptation measures (Adger, 2004; Sharma, 2007). Generic capacity is a more inclusive or generalized capacity of response; it includes the overall assets or "structural deficits" which

influence adaptation outcomes (Lemos et al., 2012, in press). For example, having a well-educated populace or relative wealth each contribute to generic capacity (Adger et al., 2004; Sharma & Patwardhan, 2008; Lemos et al., in press). In examining determinants of vulnerability, Brooks et al. speak to the implicit differences between generic and specific factors (Brooks, Adger, & Kelly, 2005). Generic factors may serve as structural underpinnings, making more specific and targeted actions possible (Brooks, Adger, & Kelly, 2005). In this study, we focus primarily on the generic adaptive capacity of cities by examining the core determinants believed to comprise AC and by employing Urwin and Jordan's approach of looking at related municipal activities to infer about overall climate adaptive capacity (Urwin & Jordan, 2008). Still, some elements of adaptive capacity included in our study (e.g. technology, information, and infrastructure, as referenced by Lemos et al., in press) refer to the management of specific risk (e.g. extreme events, average temperature, and precipitation rises) and can be categorized as climate-specific adaptive capacity.

Adaptive capacity is contextual based on spatial, temporal, socio-political, and cultural settings (Adger, Arnell, & Tompkins, 2005; Vincent, 2007; Engle, 2011). It is time and scale dependent and deeply influenced by geography, cultural and community characteristics, and institutional structures. Scholars have sought to assess adaptive capacity at a variety of scales, including the household, community, state or provincial, and national levels (Smit & Wandel, 2006; Yohe & Tol, 2002; Adger, 2003b; Smith, Klein, & Huq, 2003; Adger & Vincent, 2005; Adger et al., 2007). Still difficulty persists in reconciling metrics across scales and understanding how AC at one scale may influence it at another. Moreover, drivers at larger scales may considerably influence local level adaptive capacity and vice versa, yet few empirical studies have focused on reconciling such scalar issues (Smit & Wandel, 2006). Some scholars have proposed that, due to its scale-dependence, adaptation strategies are foremost "local" phenomena, leading to the growing adage that "all adaptation is local." Scholars have also argued that the local character of adaptation can potentially lead to more bottom-up participatory processes rather than top-down mandates (Tol, 2003). Accordingly, we focus at the municipal scale of our case cities, yet also endeavor to look at the ways in which factors at state, regional, and federal scales may have bearing on cities' adaptive capacity.

Considerable uncertainty surrounds how to appropriately operationalize and measure the variables believed to contribute to adaptive capacity, particularly given their properties are relatively unobservable, or latent, until an external stressor draws them to action (Smit & Pilifosova, 2001a; Adger & Vincent, 2005; Lemos et al., 2007; Engle & Lemos, 2010). The presence of climate stressors may be prerequisite to "test" a system's adaptive capacity. In the absence of a climatic event, it is challenging to assess the degree to which a system is prepared to handle a climatic change (Amundsen, 2010). Moreover, adaptive capacity is highly dynamic, variable, and flexible by definition, therefore difficult to measure (Lemos et al., 2007; Magnan, 2010; Engle, 2011). Some have developed quantification tools and indices to examine adaptive capacity while others have utilized qualitative case study approaches (Kelly & Adger, 2000; Schroter et al., 2003; Adger et al., 2004; Brooks, Adger & Kelly, 2005). This study employs the latter approach: in-depth case studies to attempt to ascertain cities' response capacities.

Determinants of Adaptive Capacity

While many scholars agree on which factors are essential in shaping adaptive capacity, uncertainty persists around which are the most critical drivers of capacity (Wilbanks & Kates, 1999; Kasperson & Kasperson, 2001; Walker et al., 2002; Adger, 2003a; Adger & Vincent, 2005). Similarly, debate continues over the ways in which these determinants interact and influence each other both positively and negatively. While there are substantial gaps in understanding of determinants of adaptive capacity in action, a number of factors have consistently emerged in different scholars' attempts to theorize about what facilitates and what constrains adaptation. They include wealth and economic resources, knowledge and information, infrastructure, social and human capital, institutional factors, and technology (Smit & Pilifosova, 2001a; Yohe & Tol, 2002; Adger, 2005; Pelling & High, 2005; Magnan, 2010). **Table 5.1** summarizes the classes of determinants frequently referenced in the literature on adaptive capacity.

Table 5.1 Determinants of Adaptive Capacity and Their Frequency in the Literature

Determinant	Authors Citing this Determinant
Wealth and financial resources, economic power, wealth distribution	Smit and Pilifosova (2001a); Kasperson and Kasperson (2001); Yohe and Tol (2002); Tol (2003); Schroter (2003); Eakin and Lemos (2005); Armitage (2006); Smit and Wandel (2006); Adger (2007); Keskitalo et al. (2010)
Technology	Smit and Pilifosova (2001a); Yohe and Tol (2002); Kasperson and Kasperson (2001); Tol (2003); Schroter (2003); Eakin and Lemos (2005); Smit and Wandel (2006); Adger (2007); Keskitalo et al. (2010)
Infrastructure and material resources	Smit and Pilifosova (2001a); Kasperson and Kasperson (2001); Schroter (2003); Eakin and Lemos (2005); Smit and Wandel (2006);Keskitalo et al. (2010)
Knowledge, information, skills, information management	Smit and Pilifosova (2001a); Yohe and Tol (2002); Kasperson and Kasperson (2001); Schroter (2003); Eakin and Lemos (2005); Armitage (2006); Smit and Wandel (2006); Keskitalo et al. (2010); Overseas Development Institute (2011)
Institutions and governance	Smit and Pilifosova (2001a); Yohe and Tol (2002); Tol (2003); Eakin and Lemos (2005); Smit and Wandel (2006); Armitage (2006); Adger (2007); Keskitalo et al. (2010); Overseas Development Institute (2011)
Human capital	Yohe and Tol (2002); Tol (2003); Eakin and Lemos (2005); Adger (2007)
Social capital, organizations and networks	Yohe and Tol (2002); Tol (2003); Eakin and Lemos (2005); Armitage (2006); Adger (2007)
Political capital and	Yohe and Tol (2002); Eakin and Lemos (2005); Smit and Wandel

influence, public perception	(2006); Armitage (2006)
Asset base	Overseas Development Institute (2011)
Natural resources	Adger (2007)
Flexibility	Schroter (2003); Overseas Development Institute (2011)
Innovation	Overseas Development Institute (2011)
Equality	Schroter (2003)
Equity	Smit and Pilifosova (2001a); Keskitalo et al. (2010)
Managerial ability	Smit and Wandel (2006)
Risk-spreading processes	Yohe and Tol (2002)
Community and culture	Armitage (2006)
Kinship	Smit and Wandel (2006)
Resource access and distribution	Yohe and Tol (2002)

Scholars have routinely emphasized different determinants in terms of their criticality to adaptive capacity. Several scholars have pointed out the critical role of institutional and governance mechanisms in enabling or constraining adaptive actions (Brooks et al., 2005; Eakin & Lemos, 2006; Engle, 2007; Adger et al., 2009; Engle & Lemos, 2010). Others have highlighted the role of social capital and social networks in shaping adaptive capacity, of collaboration, or even of public perception of climate risk and exposure (Adger, 2003b; Tol & Yohe, 2007). Finally, research has shown that innovation and flexibility in the characterization of adaptive capacity are important and that information and the range of available technology significantly increase adaptive capabilities (Schroter, 2003; Tol, 2003; Adger et al., 2007; Tol & Yohe, 2007; Magnan, 2007; Jones et al., 2010).

Still, many scholars have suggested that resources alone do not define capacity to adapt. Perhaps more important than an asset or a set of resources and capabilities, adaptive capacity is the ability to effectively make use of, mobilize, and employ such resources (Nelson, Adger & Brown, 2007). Consequently, scholars sometimes highlight different aspects of determinants including access to a resource, its relative distribution across a population, or its integration in the system (Tol, 2003; Tol & Yohe, 2007; Keskitalo et al., 2010). For example, some scholars emphasize access to economic resources; others emphasize the distribution of economic resources, while still others may emphasize access to markets or regional integration (Schroter, 2003; Tol & Yohe, 2007; Magnan, 2010). Indeed, it may be the relative distribution of those resources, the distribution among certain groups of the

population (e.g., notable community leaders), and the mutually beneficial relationships between particular determinants, which allow effective dissemination of knowledge or resources, or simply the flexibility of a diverse array of options, which may prove critical in a given context.

As Chapters 6-14 will explain, this study assesses the determinants of adaptive capacity most relevant to urban systems. We adapted our definitions of each determinant from the literature reviewed above and in subsequent chapters.

Chapter 6: Analytical Framework

This study seeks to identify the reasons for Ann Arbor and Grand Rapids' successes and challenges in responding to and preparing for the impacts of climate change. We specifically focus on two aspects of climate impact response—what cities are actually doing (climate adaption options) and the factors that enable or constrain them to enact those options (their level of adaptive capacity—AC). Building upon adaptive capacity assessment frameworks proposed in the climate adaptation literature, we build an analytical framework that considers not only opportunities and constraints for adaptation but also the types of assets and resources cities may apply to achieve their adaptation goals.

We selected eight determinants of adaptive capacity that were cited most frequently in the literature and that we believed would be significant when applied to U.S. cities: institutions, infrastructure, wealth and financial capital, social capital networks, political capital, human capital, information, and technology. We further refined these determinants and applied them to an urban context by identifying how each may be working within an urban context. **Table 6.1** summarizes how we defined each of the eight determinants for this study. One of this study's goals is to inform the Great Lakes Adaptation Assessment for Cities (GLAA-C) by exploring city government's role in adaptation. To that end, we emphasize the role of governance in contributing to adaptive capacity.

Table 6.1 Determinants of Adaptive Capacity and their Application in this Study

Determinant	Definition from Adaptive Capacity Literature	Application for this Study
Institutions	Norms and rules-formal and informal: governance mechanisms at city, state, regional, and federal and international levels, rules and regulations, institutional and policy frameworks	Internal standards, local ordinances, funding mechanisms, city plans, bureaucratic structures, city commissions, state and federal incentives and regulations, Federalism, and inter-jurisdictional collaboration
Infrastructure	Sector infrastructure: transportation, water, energy, sanitation, green infrastructure, buildings	Water, green infrastructure, traditional built environment, transportation (roads, bridges, public transportation), sanitation (sanitary sewer system), and the energy supply.
Wealth and Financial Capital	Accessibility and availability of financial wealth, or wealth management instruments (revolving funds, philanthropy, insurance, credit), fiscal incentives for risk management	The accessibility, availability, and flexibility of financial wealth and wealth management instruments, such as revolving funds, philanthropy, insurance, and credit
Social Capital	Access to and engagement with networks, businesses, and organizations	Public-private partnerships, especially those between city governments and civil society collaborators; organized community leadership and social networks; interpersonal connections between city staff and external organizations

Political Capital	Political leadership, legitimacy, political climate, decision and management capacity, public opinion, public engagement	Leadership, motivation and vision, electoral and local politics, reputation and legitimacy, public perceptions of political leadership, political support gained through public participation and engagement efforts
Human Capital	Education levels, community risk perception, human labor and capacity	Communities' overall education levels and the skill and knowledge of City staff
Information	Information sources, early warning systems	Early warning systems that provide information; scientific understanding of climate change impacts (projections and scenarios) and potential adaptation strategies; and having systems in place to share, discuss, and communicate climate change information and adaptation strategies at various levels
Technology	Technology sources, access and transmission, technological innovations	The application of scientific knowledge for practical purposes; GIS, Doppler radar

Adapted from Eakin and Lemos (2006), Smit and Pilifosova (2001a), and Yohe and Tol (2001)

We use Grand Rapids and Ann Arbor as case studies to identify examples of these drivers, explore how they shape adaptation outcomes, and propose a framework for analyzing adaptive capacity in other cities in the Great Lakes region. We propose that since, empirically, the determinants we identified do not vary independently of each other, we need to highlight how different determinants enable or constrain others. We expected the determinants would interact with and influence each other, but did not hypothesize specific relationships that would emerge. We considered that the presence of one determinant may help build, complement, or substitute for the other determinants.

While this work holds the promise of critically informing urban systems on how to best adapt to climate change impacts, assessing adaptive capacity is complex and far from straightforward. First, adaptive capacity is to some degree a latent quality that is difficult to test. Researchers may approximately test adaptive capacity by analyzing responses to historic emergencies. Still, it is difficult to extrapolate factors that increase responsive capacity to past emergencies, and understand the degree of their impact for future adaptation.

Further, many U.S. cities are undertaking adaptation work, but not describing it as adaptation. Instead, cities are pursuing strategies to improve environmental and human health and enhance quality of life that have the ancillary benefit of preparing the cities for climate change impacts (Foster et al., 2011b). This approach is true in our case study cities as well. During the time of our interviews, both cities were only beginning to explicitly consider climate change adaptation, yet both had a long history of adaptation-relevant environmental and sustainability initiatives. Since adaptation-driven policies, programs, and initiatives are limited in our case study cities, focusing on explicitly adaptation work would offer only a limited sense of what adaptation-relevant work the cities are undertaking.

Therefore, to examine AC, we draw on the work of governance scholars who have studied the importance of policy and institutions in shaping environmental decision-making and governance. Urwin and Jordan (2008) propose a framework for analyzing both explicitly climate-directed policies and non-climate policies that may have an impact on adaptation. This framework allows examination of policies beyond those that explicitly address adaptation and instead consider "*non*climate" policies that may enable or constrain adaptation.

We expand this framework beyond Urwin and Jordan's policy focus and consider adaptation-*relevant* (not just adaptation-*specific*) institutions, leadership, organizations, infrastructure, information sources, funding mechanisms, technologies, and other variables of interest. In this vein, because many of the cities' activities to date might not be explicitly construed as climate response, we encouraged interviewees to consider the climate-relevant impacts of their work. For instance, we consider emergency management and flood response programs generally, which are relevant for climate change adaptation, even if they were not developed with climate change in mind.

Chapter 7: Institutions

Institutions Background and Definition

In describing the determinants of adaptive capacity, many authors have addressed institutions' role in shaping a system's response (Eakin & Lemos, 2006; Tompkins & Adger, 2005; Engle & Lemos, 2010; Smit and Pilifosova, 2001a). The IPCC reports that "It is generally held that established institutions in developed countries not only facilitate management of contemporary climate-related risks but also provide an institutional capacity to help deal with the risks associated with future climate change" (Smit & Pilifosova, 2001a, p. 897). Although most scholarship in this area agrees on the importance of institutions to adaptation, defining and assessing their role in practice can be challenging. Eakin and Lemos (2006) define "institutions and entitlements" as "informal and formal rules for resource conservation, risk management, regional planning, participation, information dissemination, technological innovation, property rights and risk sharing mechanisms" (p. 10). Tompkins and Adger (2005) argue that institutions are closely related with policy and regulations, yet they do not automatically achieve the goals for which they are designed: "Studies indicate that laws or regulations imposed without enabling a behavioural change will have little or no effect in changing institutions or human behaviour"(p. 567). They argue further that institutions' adaptive capacity depends on their structure: "dynamic institutional structures" may be able to adapt effectively, and "integration among sectors, among government departments, and across different scales of management" enables successful uptake of climate relevant information (pp. 567 - 568).

Amundsen et al. (2010) suggest that higher-level government policies and institutions can enable local governments to take anticipatory adaptation action and recommend governments should establish a policy framework that prioritizes climate change adaptation. Urwin and Jordan (2008) agree and pose that within an

INSTITUTIONS

"Informal and formal rules for resource conservation, risk management, regional planning, participation, information dissemination, technological innovation, property rights and risk sharing mechanisms" (Eakin and Lemos, 2006)

INCLUDES:

Internal standards, local ordinances, funding mechanisms, city plans, bureaucratic structures, city commissions, state and federal incentives and regulations, Federalism, and interjurisdictional collaboration.

KEY FINDINGS

- City standards (e.g. infrastructure design standards) and ordinances (e.g. zoning codes) enhance resilience to climate impacts and promote resource conservation.
- City plans and departments (e.g. energy offices) integrate adaptation as a priority throughout government operations.
- Federal and state incentives (e.g. Federal grant programs) and regulations (e.g. State building codes) can enable or hinder the creation of effective local institutions, and elements of Federalism restricts local autonomy.
- Social, political, and human capital bolster institutional effectiveness, while institutions ensure that infrastructure withstands climate impacts.
- There is a strong synergy between information, financial capital and institutions in shaping cities AC.

established policy framework, municipalities may pursue adaptation actions appropriate to their local circumstances. Conversely, a lack of policy direction from the national government could lead municipalities to neglect adaptation issues, or a national policy's implementation could have unintended effects at the local level (Amundsen et al., 2010; Urwin & Jordan, 2008; Adger et al., 2005). For example, overly prescriptive national policies could hamstring cities and restrict their response capability. According to Amundsen et al. (2010), national governments may use goals, "regulations," and financial mechanisms to prioritize adaptation (p. 278). A dual "top-down" and "bottom-up" analytical framework for integrated policy analysis is desirable since both approaches may shed light on the ability of policies to enable or constrain adaptation. To conduct a top-down study, analysts review policy content and assess goals and techniques. A complementary, bottom-up analysis would judge higher-level policies' actual impact on a system's "ability to respond to climate change," from the perspective of local actors (Urwin & Jordan, 2008, p. 184).

In this study, we examine how standards, laws, plans, and standard operating procedures impact our case cities' adaptive capacity. Building on Tompkins and Adger's framework, we look at bureaucratic structures in our analysis of institutions. We also discuss civic organizations that governments establish to manage resources, including city commissions and other quasi-governmental groups. We focus our analysis both on local institutions and on higher levels of government that impact local responses to climate change, adopting a bottom-up approach to analyze state and federal institutions. Accordingly, we ask our informants from the local government, non-profit, and business sectors for their perspectives on higher-level policies' and institutions' influence on local governments' ability to adapt. This approach highlights "cross-scale interplays" between policies and institutions (Urwin & Jordan, 2008, p. 187). Conversely, we discuss local institutions using a top-down approach, since our informants' perspective reflects how they expect institutions and policies to operate.

Throughout the analysis, we use a cross-sectoral and cross-scale framework, examining local, state, and federal policies and institutions that both explicitly include climate-focused institutions and those that may influence adaptation less unambiguously. Hence, following Urwin and Jordan's framework (2008) introduced in Chapter 6, we analyze existing policies that may not be explicitly labeled "adaptation" and the extent to which the case cities have integrated adaptation policy into their institutions and policies. Anticipated regional climate impacts inform our understanding of "horizontal interplay" between policy areas—we understand policy to be relevant if it may influence a system's response to these impacts (Urwin & Jordan, 2008, p. 182). For example, we consider land use policies in our study, even though public officials do not necessarily consider them adaptation measures. Urban growth into natural landscapes affects ecosystems, and increased impervious surface area exacerbates flood impact. In this sense, land use policy represents an important adaptation mechanism. Our variables of interest include standards for facilities design; local ordinances; city plans; bureaucratic structures; fiscal policies; interjurisdictional and regional collaboration; and elements of federalism including state and federal provision of authority to local governments, requirements, and incentives.

Due to the variety of topic areas that our interview subjects specialize in, we tried to match the institutional questions to each informant's specific program area. Through these questions, we gathered information about which local institutions are most relevant for adaptation and why, how state and

federal institutions enable or constrain adaptation, and the interrelationships between institutions and other determinants of adaptive capacity. Example questions include:

- Has anything about the city government structure enabled or constrained it in making climate-relevant decisions?
- Have any programs or policies helped or hindered your department in handling sustainability or adaptation issues?
- Are there ways in which the state and federal governments have constrained or enabled [the city's] ability to adapt to climate change?
- Has preparing for climate change influenced your department's work? In what ways?
- Has preparing for climate change influenced decision-making that influences your department's work? In what ways?
- What factors have enabled or constrained the city in prioritizing sustainability work?
- How does the __ program work? (e.g., stormwater utility, Property Assessed Clean Energy, Greenbelt, etc.)

Institutions in Ann Arbor and Grand Rapids

Local institutions can influence climate adaptation by bolstering resilience to physical impacts, influencing natural resource conservation, and making adaptation a priority across government units. To bolster resilience, institutions in the form of regulations and standards can ensure that cities' infrastructure withstands climate impacts. Standard operating procedures such as emergency response protocols can guide a community's response to climate impacts. To promote resource conservation, cities use local ordinances such as zoning codes. By setting formal goals and articulating visions, city plans can integrate adaptation as a priority across the organization and in the community. Higher-level institutions—state, federal, and regional agencies and policies—shape response to climate change by provide funding, information, or regulations that either enable or hinder communities' adaptation. This chapter will highlight ways in which institutions—local, state, regional, and federal—influence adaptation outcomes. **Table 7.1** presents the type of institutions we investigate, our key findings concerning these institutions' relevance for adaptation, and examples.

Table 7.1. Institutions and their Relevance for Climate Adaptation

Type of Institution	Key Findings	Examples
Standards	Facilities design standards can ensure that infrastructure withstands climate impacts.	Stormwater system design standards
Ordinances and regulations	Requirements on private companies and residents promote resource conservation and improve resilience to climate impacts.	Stormwater detention requirements; green space percentage requirements on private property; floodplain regulations; zoning codes
Local funding	Dedicated funding sources ensure that financial	Greenbelt millage,

mechanisms	resources are available for adaptation activities.	stormwater utility fee, Property Assessed Clean Energy (PACE) program
City plans	Cities integrate adaptation-relevant goals, policies, and metrics into plans that impact many departments. This helps to integrate adaptation as a priority across the organization and set a framework for local laws.	Sustainability Plan's metrics that departments must meet such as rain barrel installations
City departments	City departments manage programs and obtain funding for adaptation-relevant projects.	Office of Energy and Sustainability; Systems Planning Unit
City commissions	Advisory commissions advocate for and manage programs and recommend policy actions.	Greenbelt Commission; Urban Forestry Committee; Energy Commission
State/Federal incentives	Funding sources, data, and policy incentives promote adaptation work.	Increased revenue sharing to encourage regional governance; State grants funding tree inventory; FEMA floodplain maps
State and Federal requirements	The State and Federal Governments regulate public facilities and promote natural resource conservation.	Mandate to separate sanitary and stormwater sewers; requirements to reduce pollutant loads in lakes and rivers
Federal structures and regulation	State law grants authority to local governments (simultaneously enabling and constraining adaptation activities). Constitutional and common law precedent concerning property rights restrict governmental regulatory authority.	Michigan Zoning Enabling Act grants zoning authority to cities, villages, townships, and counties; State law prohibits cities from writing local building codes
Interjurisdictional collaboration	Regional collaboration can improve efficiencies in achieving adaptation goals, or promote resource conservation across jurisdictions.	Metro area transit agencies with oversight from multiple municipalities; shared emergency management services; County-level watershed management

Standards: Designing stormwater infrastructure to withstand climate impacts

Standards and regulations are critical institutions shaping climate adaptation. Cities use ordinances and internal standards to regulate both public and private development, and the stringency of certain

rules could determine whether infrastructure withstands climate impacts. In discussing public infrastructure, our informants were most concerned with severe storms and flooding, and they identified local standards to ensure that the stormwater sewer system withstands these impacts.

Both cities cited stormwater management standards as a variable of interest, since climate scientists project that the Great Lakes region will experience flashier, more intense rain events in the future. Public officials in Ann Arbor explained that cities design their stormwater infrastructure around design storms—probability projections for precipitation events that the Federal Emergency Management Agency (FEMA) generates. While FEMA produces the storm probability projections (design storms) that underlie these standards, cities choose which storm to design their system to accommodate. The City of Ann Arbor builds stormwater pipes to accommodate a 10-year, 24-hour design storm.[11] This regulation ensures that the stormwater sewer system can prevent flooding during most storms. However, if climate change causes stronger storms—implying that more rain would fall during a 24-hour period—public officials asked whether they should change their design standards. One public official asked, "Do we start changing that and putting bigger pipes in because we know that bigger rains are coming?" (Public official, Ann Arbor, 2011).

The City of Grand Rapids designs its stormwater sewers to a 25-year, 24-hour design storm, which is a less stringent standard than the 10-year storm used in Ann Arbor. (According to an Ann Arbor official, communities choose their design standard based on tolerance for risk relative to infrastructure expense). Grand Rapids' public officials recognized a need to better manage stormwater in the city, citing a need for quantifiable targets and regulations. Still, they expressed uncertainty regarding how the city would structure new standards. Grand Rapids' City Council did pass an ordinance allowing the city to identify neighborhoods with "significant influence on the sanitary sewer system with the footing drains connected" and requiring them to participate in the City's footing drain disconnection program (Public official, Grand Rapids, 2011). This program responds to the City's combined sewer overflow problem, and helps prevent the sanitary sewers from dumping raw sewage into the Grand River during severe rain events.

[11] The Federal Emergency Management Agency generates design storms, which are hypothetical rain volumes projected to occur with a certain probability each year. A 10-year, 24-hour storm refers to a 24-hour rain accumulation that has a 10% chance of occurring annually (Stormwater Management within the City of Ann Arbor).

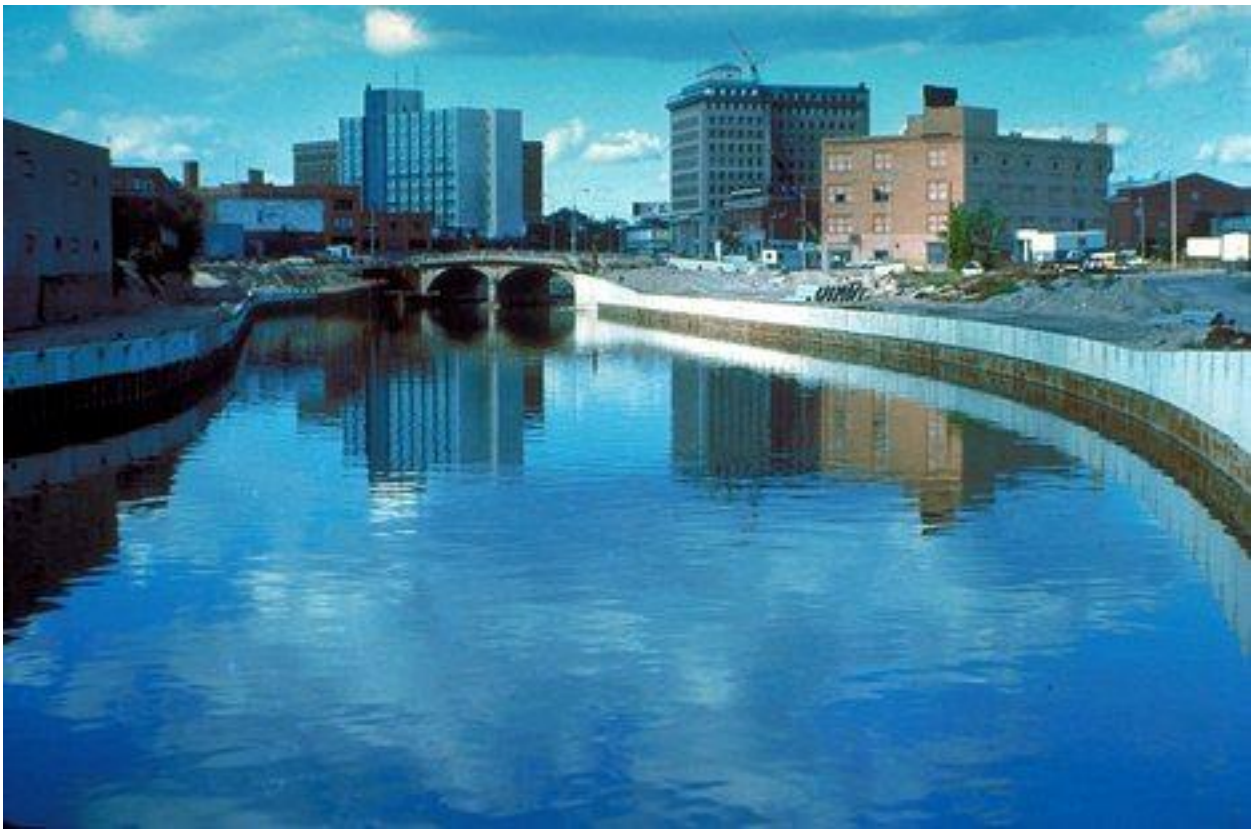


Figure 7.1. The Grand River flowing through downtown Grand Rapids. Photo credit: http://wn.com/Flint. Accessed from the WMEAC blog at http://thewmeacblog.org/2011/12/13/a-watershed-moment-stormwater-management-in-grand-rapids/.

Ordinances and regulations: Promoting adaptive behavior and resource conservation

Both cities have instituted ordinances to promote adaptive behavior and resource conservation by city residents and the community as a whole. During our interviews, public officials from both cities referenced ways in which local policies promote resource conservation. These include wetlands protection ordinances, stormwater infiltration requirements for private property owners, zoning codes, and incentives to encourage sustainable growth in neighboring communities.

Environmental goals such as protecting ecosystems, maintaining high water quality, and limiting urban growth pre-date the cities' concern for climate adaptation. Still, conservation activities are relevant for adaptation. Wetlands, for example, serve important nutrient filtration and flood mitigation functions, which could become even more critical in the face of stronger storms and increased precipitation. An official in Ann Arbor commented that the City's wetlands ordinance is even stronger than state law (Public official, Ann Arbor, 2011). Storms will also increase runoff into rivers and streams, making pollutant reduction ever more important. By increasing impervious surface, urban growth could expose the cities to flood risk. Conversely, promoting dense development and incorporating on-site stormwater management help to mediate this risk. Both Ann Arbor and Grand Rapids are using regulations and incentives to achieve conservation goals relevant for climate adaptation.

Both cities have instituted regulations addressing stormwater management on private development, to capture some rainwater before it enters the storm sewers. A public official in Grand Rapids referred to the Sustainability Plan's goals to "reduce stormwater discharge by at least 50,000 gallons per rain event by June 30, 2013" and "at least 5% of new roads to be constructed of pervious pavement by June 30, 2015" (City of Grand Rapids, 2011, p. 26). These targets set a framework within which Grand Rapids can increase the use of source controls that capture stormwater on-site. Complementing these targets, Grand Rapids' revised zoning code includes a green space percentage requirement that varies according to neighborhood type. Residents can meet this requirement by installing a green roof, plantings, green walls, or permeable pavements, but the City designed the percentage to be high enough to force residents to install some level of "green intervention" that would detain or infiltrate stormwater (Public official, Grand Rapids, 2011). **Figure 7.2** depicts an example of a green roof in Grand Rapids.

Figure 7.2. Green Roof atop the East Hills Center (of the Universe) building in Grand Rapids. Designed by Guy Bazzani. Source: Cool Cities. "The Uptown Revitalization Project." Accessed from: http://www.coolcities.com/project61.html.

Ann Arbor has also imposed stormwater management requirements on private development, including the requirement that single family and duplex homeowners must retain or infiltrate first flush storm events (the first half-inch of rainfall) when they construct additions onto their home that add more than 200 square feet of impervious surface. The City has also instituted a stormwater utility fee, which both promotes adaptive behavior and helps to channel financial capital towards stormwater

infrastructure. (The stormwater utility fee is discussed in Chapter 8.) Multifamily developers must also retain or infiltrate stormwater on-site, and the amount of water they must retain increases as the size of the development's impervious surface area increases (Ann Arbor, MI, Municipal Code title V chap. 63). For small developments, these stormwater infiltration requirements probably achieve conservation goals rather than reducing flooding. This is because small developments must only infiltrate the "first flush," which is a smaller amount of water but it carries the most pollutants in its runoff (Public official, Ann Arbor, 2011). Larger developments, on the other hand, must infiltrate up to the 100-year storm, which could reduce the load on stormwater infrastructure.

Both cities use floodplain regulations to protect against flooding, and the cities may need to alter these ordinances in light of climate change. City and County officials in Ann Arbor said that Ann Arbor's zoning code regulates buildings in the 100-year floodplain, to prevent "net loss of flood storage capacity" (Ann Arbor, MI, Municipal code title V chap. 57). However, the likely expansion of the 100-year floodplain area under climate change scenarios may further challenge the ability of the cities to respond successfully. Several public officials pondered whether the City should pass an ordinance regulating the 500-year floodplain, or simply leave the ordinance as-is and adapt the floodplain sizes based on projected rainfall under climate change scenarios. Notably, the cities do not designate the floodplains themselves; as is the case with design storms, the Federal Emergency Management Agency (FEMA) produces maps that reflect the 100-year and 500-year floodplains in cities around the country. Climate information would play a critical role in changing stormwater design standards and floodplain regulations, both by informing the new regulations and supporting a city's decision in the face of political opposition from developers and the public. Chapter 11 addresses the importance of information for supporting potentially controversial decisions.

Zoning codes and land use regulations can help promote sustainable urban development. Ann Arbor's officials provided more detailed explanations of the City's zoning code; therefore, this analysis will focus on specific regulations contained in Ann Arbor's code. An official in Ann Arbor stated that the City's land use Master Plan goals and objectives promote "more compact development patterns, more vertical capture of square footage, a greater emphasis on pedestrian orientation or pedestrian and transit oriented design, more efficient use of land and infrastructure through higher densities" (Public official, Ann Arbor, 2011). Officials in Ann Arbor emphasized recent changes to the zoning code, intended to direct development along transit corridors and thereby promote the use of transit. One official said that, through recent zoning code changes, the City has imposed "minimum density standards" of seven units per acre on the outskirts of Ann Arbor, to promote development in areas served by transit and water infrastructure rather than in undeveloped interstices (Public official, Ann Arbor, 2011). The official also cited increases to the permitted floor-area ratio (FAR) on transit corridors, from 50 percent to 200 percent, adding that the City will allow additional FAR if developments include residential units within these primarily commercial corridors. He said:

> *Ann Arbor is one of the very few places where you can get the density associated with transit.... So to answer your question, I think we've been pushing sustainable land-use but not calling it climate adaptation. We're calling it sustainable land-use, but I think it corresponds directly with climate adaptation.* (Public official, Ann Arbor, 2011)

Notably, the official remarked that developers have not taken advantage of the FAR bonus for building mixed-use developments in transit corridors, likely because they do not perceive demand for housing along the primarily commercial transit corridors (Public official, Ann Arbor, 2011). Another official clarified that, "The commercial districts have always allowed residential in them, have always allowed office. It [the zoning code change] just increased the amount of that and it didn't really incentivize the mix though" (Public official, Ann Arbor, 2011). The official added that the City had reduced its parking requirements previously, which is another measure to promote dense development and transit use. Officials hope that these changes will direct development to the corridors, but success depends on the market. If Ann Arbor residents prefer to live along primarily commercial transit corridors, the city has instituted changes that will allow them to make this choice.

The market does seem to support infill development in Ann Arbor's downtown. Officials, NGO representatives, and a city commission member emphasized the importance of promoting density "where the infrastructure exists," including downtown, to prevent sprawling urban development (NGO representative, Ann Arbor, 2011). According to public officials, the zoning code has allowed density and mixed-use development downtown for years, and several high-density residential developments have gone up in the past ten years (Public official, Ann Arbor, 2011). An official explained, "within the downtown where we want residential, we incentivize that by allowing for premium floor area. So if you provide residential, you get bonus floor area in order to build these buildings that are going up to 13, 14 stories" (Public official, Ann Arbor, 2011). The official also referenced the Discovering Downtown Initiative, a 2006 study that updated the zoning code to promote "density in appropriate locations."

Even with these policies in place, two external stakeholders did not express confidence that all the pieces fit to promote dense development. As one informant phrased it, "There is a pretty big reluctance to improve density. When it comes down to actually approving the site plan, they've had some problems with that. That's no secret. Lots of…There's a big element in the community that doesn't want the city to change much" (Public official, Ann Arbor, 2011). Public officials' desire to preserve political capital may explain the lackluster support for some site plans. In the case of land use regulations, market forces and politics seem to shape institutional impact.

We face somewhat conflicting messages, then: some officials believe their zoning code promotes "sustainable land use," while others note that implementation of density-promoting policies lacks rigor. The truth may lie in between, that is, Ann Arbor has imposed minimum density standards in corridors where the market does not demand residential housing. But what does the zoning code allow in the areas immediately surrounding the downtown? According to a national survey gauging real estate developers' interest in building high-density products, the "inner suburbs" immediately bordering downtown areas represent tremendous growth potential from the perspective of real estate developers (Levine, 2006). In Ann Arbor, the downtown periphery is also full of historic single-family homes, and likely represents a significant source of conflict between promoting density and preserving local character.

Both Ann Arbor and Grand Rapids also influence land development through water sales to neighboring communities. According to a public official in Ann Arbor, "We certainly don't have a growth

boundary; we have a way to—we limit the amount of water we sell to other communities and that, by definition, limits growth" (Public official, Ann Arbor, 2011). This official contrasted Ann Arbor's approach to that of the City of Detroit, which effectively enabled suburban sprawl by supplying its neighbors with a plentiful supply of water. Grand Rapids also sells water to its neighbors, but in the 1990s, the City incorporated "economic incentives" into its water sales contracts to "encourage more compact growth" in its suburbs (Public official, Grand Rapids, 2011). These incentives are structured around the fact that it is cheaper to provide water service to a more compact area, due to high infrastructure costs.

In addition to land use planning, Grand Rapids officials highlighted new rules intended to protect and grow the urban forest. To elaborate a vision that will enable the city to "catch up" after "a couple of decades" of "scant" urban forestry management work, the Urban Forestry Committee produced an urban forest management plan including the new urban forester staff position (Public official, Grand Rapids, 2011). Green Grand Rapids, the City's 2011 Master Plan update, also set the goal of achieving a 40% tree canopy by planting 185,000 trees in the city (Public official, Grand Rapids, 2011). Still, questions remain concerning how to protect trees on private property, and the ordinance review may help to answer these questions. An informant explained the tension between respecting private property rights and recognizing trees as a public resource "connecting the air and the water" (which the Federal Clean Air Act and Clean Water Act regulate) (Public official, Grand Rapids, 2011). Informants also noted that, at the time of the interviews, the City had not instituted a mechanism for selecting tree species based on "future climate zones" (Public official, Grand Rapids, 2011).

Fiscal policy: Institutionalizing adaptation through dedicated funding sources

Particularly in Ann Arbor, officials referred to fiscal mechanisms for prioritizing environmental sustainability, and some of these programs are relevant to climate adaptation. Specifically, Ann Arbor's dedicated greenbelt millage, Property Assessed Clean Energy (PACE) program, and stormwater utility fee enable the city to prioritize adaptation by ensuring the availability of funding.

In 2003, Ann Arbor voters passed a millage to begin a "greenbelt program," through which the city purchases development rights on farmland and undeveloped land surrounding the city. The city leverages taxpayer funding by obtaining external matches and buys conservation easements to prevent the city from sprawling into the countryside. A public official in Ann Arbor explained that the greenbelt program complements the city's push for increased density in the downtown and on transit corridors, "When you couple the preservation of land around the outside of the city with a push for increased density on the inside we're doing all the right things" (Public official, Ann Arbor, 2011).

Figure 7.3. An Ann Arbor Greenbelt property. Photo by Doug Coombe. "The Ann Arbor Greenbelt, Then and Now." Concentrate Media. Accessed from: http://www.concentratemedia.com/features/annarborgreenbelt0173.aspx.

The City of Ann Arbor has also initiated a Property Assessed Clean Energy (PACE) Program, which sets up a loan fund for the city to help commercial property owners pay for energy retrofits. Initially, the City will issue bonds to fund the program, and it will leverage the bond revenues tenfold. The City will loan money to commercial property owners, who will use the funding to install efficiency retrofits. Owners will repay the City through increased property taxes over time (Public official, Ann Arbor, 2011). If the retrofits achieve their goal of reducing energy costs, owners should still save money over time despite the increase in their property taxes.

Notably, Ann Arbor's PACE program is unique in covering commercial instead of residential properties. This resulted from federal mortgage backers' fear that increasing assessed property values would impair residential property owners' ability to keep up with their mortgage payments. Ann Arbor devised a way around this objection by limiting the program to "commercial industrial" properties. To use public funds to pay for the program, the City also argued that improving efficiency "serves a public purpose" (Public official, Ann Arbor, 2011). Indeed, decreasing overall load on the energy grid, the PACE program may help Ann Arbor adapt to climate change. In so doing, it represents a prime example of a program that combines climate change mitigation—decreasing greenhouse gas emissions through efficiency improvements—with adaptation.

Integration: Institutionalizing climate adaptation as a priority

To provide a framework for changing regulations and ordinances, public officials in both Ann Arbor and Grand Rapids cited the need to change high-level city policies. By setting a vision, producing plans that articulate that vision, and establishing city offices and commissions to implement the vision, cities can prioritize adaptation throughout the City government and community.

Both Ann Arbor and Grand Rapids recognize the importance of mainstreaming climate adaptation — making it part of standard operating procedures — but they use different mechanisms to accomplish this. Ann Arbor emphasizes the importance of a government structure that enables an integrated approach to asset management across city systems, whereas Grand Rapids has created metrics and evaluation procedures that permeate the entire city structure. Many of our informants stressed the theme of integration, as a key way that city institutions can make climate adaptation a priority.

Officials in both cities point to planning documents as key mechanisms for prioritizing climate adaptation, but neither city showed interest in preparing climate adaptation plans as standalone documents. As a public official in Grand Rapids stated,

> *I've just incorporated a lot of our climate change stuff into our existing documents rather than creating something all new. So our Master Plan and Zoning Ordinance, they all have climate change elements in them, but it's not like screaming….Because I think it says something to the community, it's still a little weird. But you can just do it, because it's the right thing to do without naming it that.* (Public official, Grand Rapids, 2011)

This theme arose throughout our interviews: both cities are pursuing climate-relevant policies without calling them "climate adaptation," and they are incorporating these policies into their existing plans rather than writing new plans. In both cases, this integrated approach — wherein climate policies are embedded into the larger planning framework — preserves political capital. Neither city considers the public to be ready for a conversation about climate adaptation, particularly while city budgets are tightening. An Ann Arbor official echoed the above sentiment and added a fiscal justification:

> *That's why we don't need new plans; we've got a lot of plans. We need to integrate the planning we have done and set some priorities because that way, we can start saying there's not really a goal, you know, the gap analysis: where's the climate adaptation goal or climate adaptation goal is really built into a bunch of these goals. Where's the climate change goal? Because if the council and these commissioners say climate change is the number one thing we ought to be working on, great, or if energy efficiency is the number one thing we ought to be working on because it's the thing we can do most for climate change, great. But now we are starting to create a set of priorities in kind of a sustainability lens throughout all these plans that then also can be passed to council where, when they start thinking about the budget, they can start looking at the budget through this sustainability lens.* (Public official, Ann Arbor, 2011)

According to this official, then, planning goals establish the institutional framework through which the local legislature can channel financial resources. Another official echoed this sentiment, arguing that if a grant becomes available to fund adaptation activities, and if the city can point to planning

documents that prioritize adaptation, then the city will be more likely to win the grant. Notably, the City of Ann Arbor is currently developing a Climate Action Plan, but that plan is primarily focused on climate change mitigation (Public official, Ann Arbor, 2011). Through the course of our interviews, several informants mentioned that adaptation could be incorporated into that plan, but it remains to be seen whether the City has done so.

How, then could these two cities integrate adaptation goals into their city plans? What have they done so far? Public officials in Ann Arbor referred to two opportunities: capital planning and the city's forthcoming Sustainability Framework. Because of Ann Arbor's unique capital budgeting process, the Capital Improvements Plan (CIP) could become a mechanism for incorporating adaptation into fiscal decisions. The City of Ann Arbor prepares its CIP by bringing together staff from across the city who deal with the planning, design, installation, and maintenance of city assets. Relevant staff persons participate in focus groups organized around asset categories, and they identify projects based on their own knowledge and public input. The groups prioritize the projects using a set of criteria and a simple one-to-ten scoring system. While the criteria are similar across the various asset categories, they can be adjusted to suit each category. Before the process begins for each asset category, the asset team also weights the criteria so that, later, a scoring system reflects the relative importance of each criterion. Staff then scores projects by each criterion, and a Microsoft Excel-based "prioritization tool" calculates the relative benefits of each identified need (Ann Arbor, MI, 2012a). The tool produces a chart reflecting the disaggregated scores for each need, so that the asset team can make adjustments as needed (Public official, Ann Arbor, 2011). Public officials suggested that, by adding adaptation-relevant priorities to the CIP planning process, the City could institutionalize adaptation as a lens for infrastructure planning and thereby channel financial resources to adaptation objectives (Public official, Ann Arbor, 2011).

The Sustainability Framework does not connect as directly with the city's financial choices as the CIP process, but Ann Arbor officials cited it as an important opportunity for mainstreaming adaptation. The Framework—in its development stages at the time of our interviews—will prioritize and integrate goals and objectives from all of Ann Arbor's planning documents. The Framework will categorize these goals into four "buckets," relating to Land Use and Access, Climate and Energy, Community, and Resource Management. The Framework will then help to guide city departments in future planning efforts. One official highlighted the Framework as an opportunity to "get everybody on the same page," referring to city staff. She expressed her hope that the Sustainability Framework will help "to increase the knowledge base of the professionals that deal with us on a regular basis" and that the goals will bring climate mitigation and adaptation "to the forefront" of master planning efforts. The Sustainability Framework may be "the best avenue to bring in climate change, mitigation, adaptation into the way we do things." Policy visions such as the Sustainability Framework, then, present an opportunity to boost human capital and to incorporate adaptation objectives into all city departments' work. At the same time as the Framework will build human capital, it could also ensure that adaptation goals do not depend on individuals but instead are incorporated into the way the city does business.

In its Sustainability Plan, the City of Grand Rapids has elaborated quantifiable metrics for city departments to achieve within economic, social, and environmental sustainability areas. Many public officials testified that the Sustainability Plan has guided their departments' work. According to an

official, "It has forced every department—you know, whether it's wastewater treatment or treasury—to look at their work in terms of how it conforms to the triple bottom line."[12] The Sustainability Plan sets targets that departments must meet. For example, the Environmental Services Department assumes responsibility for installing a certain number of rain barrels throughout the city. The engineering department can contribute to the city's renewable energy and pervious surface goals by designing projects in collaboration with the Office of Energy and Sustainability. Departments must report to the City Manager on progress towards achieving their goals. Most officials who discussed the Sustainability Plan confirmed that the targets do drive the city's actions, and one public official identified this document as the best opportunity for incorporating adaptation into the city's work.

Officials in both cities expressed their belief that adaptation goals are included in other city plans as well, including land use master plans, water and sewer system plans, energy plans, and urban forest management plans. In addition to planning documents and processes, though, both cities highlighted elements of their bureaucratic structures that help to make adaptation a priority. Ann Arbor officials view their Systems Planning Unit and Energy Office as key to incorporating climate-relevant priorities into the City's work, and Grand Rapids officials identified the Offices of Energy and Sustain ability, Planning, and Urban Forestry.

City offices and commissions

In 2002, according to one official in Ann Arbor, the City's incoming Public Services Area Administrator identified a need for better long-range infrastructure planning and pulled together a group of engineering and utility staff to form the Systems Planning Unit (SPU). While it began as a unit focused on infrastructure, over time the SPU added staff concerned with other city systems including energy, water resources, and urban vegetation. By bringing together managers responsible for an array of city systems, the SPU adopted an integrated systems-based approach to asset management focused on long-term planning. The SPU also manages the CIP process, incorporating its long-range, integrated planning approach into fiscal planning (Public official, Ann Arbor, 2011).

Public officials in Ann Arbor emphasized the importance of the Systems Planning Unit in enabling the city to engage in "long-range asset management" (Public officials, Ann Arbor, 2011). One official stated,

> *I think it's been a big success so far, and has provided benefit, and in really many ways; one is to have a group whose more major role and function is too look more big-picture because the city before, and I think a lot of organizations like us who would typically, if you didn't have a group that you set aside to say, hey, it's okay to go think of these things more program-wide or programmatic or at a higher level. People get into the roles really quickly of, "I'm here to keep this thing working."* (Public official, Ann Arbor, 2011)

[12] "Environmental, economic, and social impact." These principles guide Grand Rapids' Sustainability Framework (Public official, Grand Rapids, 2011).

Similar to the other "organizations" referenced by this official, SPU staff also get absorbed in their daily tasks; one official said that "We're all busy and the actual time to sit down and share across people is not there" (Public official, Ann Arbor, 2011). Nonetheless, public officials expressed their conviction that cross-pollination does occur either as issues arise, through informal relationships between city staff, or during external training opportunities, and that the SPU structure encourages this collaboration. To the extent that systems thinking and long-range asset planning will enable cities to adapt to climate change, the Systems Planning Unit should help the City of Ann Arbor. As one official put it, the SPU has "12 full-time staff paying attention to basically sustainability issues, all that have direct relevance to change and adaptation" (Public official, Ann Arbor, 2011).

Within the SPU, Ann Arbor officials pointed to one office in particular for its effectiveness at achieving climate-relevant objectives: the Ann Arbor Energy Office. The Energy Office assumes responsibility for improving energy efficiency across the city, identifying energy saving opportunities in any department, monitoring energy use, and analyzing causation behind dips and spikes (Public official, Ann Arbor, 2011). One official stated that, "Going back twenty years, Ann Arbor has benefited from having an energy office sooner than most communities" (Public official, Ann Arbor, 2011). Political leaders and public officials echoed the sentiment that Ann Arbor has achieved many energy efficiency improvements because the City had a staff position dedicated to managing the energy program and tracking information. They specifically referred to the City's internal revolving loan fund, which the Energy Office manages to help city departments pay for efficiency improvements. To the extent that improving efficiency will help Ann Arbor adapt to hotter summers and the associated rise in energy demand for cooling needs, the energy office will continue to enable Ann Arbor to adapt. The Office has also helped to integrate energy efficiency as a priority across all departments.

Like Ann Arbor's Energy Office, the Office of Energy and Sustainability (OES) stands out as a key institution for the City of Grand Rapids. The OES helps "advance the principles" of the Sustainability Plan by working with other departments to "identify barriers" and "help them work through those barriers" (Public official, Grand Rapids, 2011). The OES also pulls staff together in committees to discuss progress towards meeting the Sustainability Plan's targets and potential changes to the targets for the future (Public official, Grand Rapids, 2011). Staff testified to the importance of having staff dedicated to these activities, and one official referenced the OES's success in identifying and obtaining funding for projects (2011). Like Ann Arbor's Energy Office, Grand Rapids' OES also tracks and monitors energy data for city departments, and helps them identify energy saving measures. Both these offices, then, contribute to prioritizing energy efficiency across the cities.

Informants in Grand Rapids also highlighted changes made in the City's forestry operations, since these changes could boost the urban forester's effectiveness at engaging in long-range forestry. According to public officials and a commission member, urban forestry responsibilities fell under those of a staff position that also included snow-plowing. In effect, the City delegated urban forestry operations to a part-time staff position, and the City's Urban Forestry Committee viewed this structure as inadequate for achieving robust urban forestry goals (2011). At the urging of the Urban Forestry Committee, the City re-designed the urban forester position to attract a high-talent individual with "the capability to be really involved in planning, involved in the community, and be involved in operations"

(Public official, Grand Rapids,2011). As a full-time position "devoted entirely to the administration and development of [the] forestry program," the new urban forester would launch Grand Rapids' urban forestry program, write grants, and prepare management plans around visions set forth by the Urban Forestry Committee (Public official, Grand Rapids, 2011). The revamped urban forester position demonstrates a way in which institutions overlap with human capital (discussed in Chapter 12), since the office was designed with the explicit goal of boosting human capital within the City government.

The Urban Forestry Committee represents an example of another type of institutional setup that informants in Grand Rapids highlighted: city commissions and formal committees. The City established the Urban Forestry Committee by statute in 2003, and it includes staff, a utility representative, mayoral and city manager appointees, and several community members (Public official, Grand Rapids, 2011). As a formally established city committee, the group champions the urban forest and makes "recommendations to the city on tree planting and maintenance, species, policies" (Public official, Grand Rapids, 2011). It also conducts public education campaigns about forestry issues and thereby helps to promote the benefits of urban forestry throughout the community. Since the City established this committee through a statute, we consider it a formal institution. However, it also represents a prime example of the intersection between social capital, human capital, and institution.

Figure 7.4. Urban forestry in Grand Rapids. Source: MLive Press File photo. 2012. "Grand Rapids to plant trees, rewrite tree laws in effort to increase urban canopy." Accessed from: http://www.mlive.com/news/grand-rapids/index.ssf/2012/02/grand_rapids_to_plant_trees_re.html.

Officials in Ann Arbor referred to city commissions including the Energy Commission, Environmental Commission, and Greenbelt Commission, pointing out the key role that these groups have played in helping the City to implement its policies and programs. The Commission plays an advisory role to the City, recommending parcels where the City should purchase development rights and preserve open space. While City Council actually administers the program and makes final purchasing decisions, Council relies heavily on the Committee's advice and almost always acts on the recommendations the Committee makes (Public official, Ann Arbor, 2011). Human capital may help improve city commissions' effectiveness. A city leader in Ann Arbor relayed, "If you look at the people that I'm able to choose from to appoint to things like the Planning Commission, the Parks Commission, the Energy Commission, we have a really highly qualified and motivated pool of people to work with" (Public official, Ann Arbor, 2011). He continued,

> *And a lot of them are scientists and you know are professionals working in different areas that maybe you have a great knowledge coming from that, so four of our energy people work in the energy field, you know, so everybody's people in the environmental commission, there's a toxicologist, there's some other scientists. People in the Greenbelt commission, there's some land specialists, so when you begin to look around, we have a lot of really good knowledge base.* (Public official, Ann Arbor, 2011)

City commissions, then, play a critical advisory role in the functioning of city institutions, and the caliber of their members boosts their effectiveness. They demonstrate overlap between institutions and human capital.

Higher-level institutions and interjurisdictional collaboration: Enabling or constraining local institutional capacity

We asked our informants for ways in which state and federal policies, laws, or agencies help or hinder their adaptation activities. While officials in both cities expressed the strong conviction that neither the State of Michigan nor the Federal Government are doing much to encourage adaptation, they did not view State or Federal inaction as a binding constraint. Instead, they heralded cities as the innovation centers for developing progressive climate policies. They did identify some State and Federal policy constraints, mostly centering on limits to local government authority and the large number of municipal governments in the State of Michigan. Officials also highlighted funding sources and information as mechanisms through which the State and Federal Governments enable adaptation.

While officials in both cities expressed pessimism that the State of Michigan and Federal Government are using policy to encourage adaptation, neither city seemed deterred by higher governments' inaction. As one official in Grand Rapids remarked, "The Federal Government is not going to be solving any problems in terms of climate change or climate issues" (Public official, Grand Rapids, 2011). Still, instead of lying down complacently, officials in Grand Rapids believe that cities should lead in climate adaptation (and mitigation). Political leaders, NGO representatives, and public officials in Ann Arbor echoed this sentiment. One official added that, instead of looking to higher governments for policy direction and innovation, the City looks to its peers:

> *You know, there is some stuff going on in the state and the federal but that's not where I'm looking for guidance. If they happen to come up with some funding we will try and go after it but I'm mostly looking to peer cities trying to push sustainability and trying to figure out what they are doing. And I think that is, at least in the next five years, barring significant changes, that's where I think we are going to learn the most about the ways cities can be more sustainable and adapt to climate change.* (Public official, Grand Rapids, 2011)

Nevertheless, as this official insinuated, higher governments do supply funding that enables adaptation; they also provide information and impose regulations that facilitate or force the creation of relevant local institutions.

One public official in Ann Arbor did suggest that, without the State mandating the creation of certain institutions, such as energy plans or greenhouse gas mitigation plans, cities' approach will be "hit-or-miss" across the state (Public official, Ann Arbor, 2011). Cities also identified certain constraints to adaptation activities. For example, public officials in Ann Arbor said that, because of the uniform Michigan building code, the City cannot impose energy efficiency requirements on real estate developments. Despite cities' determination to lead from the bottom, informants did perceive that higher level policies—whether by their presence or by their absence—do constrain cities' ability to adapt.

Regulations, funding, and information: Enabling adaptation at a local and regional level

Both cities mentioned state and federal mandates and requirements that influence their climate adaptation decisions. Both the State and Federal Governments impose these rules, and they push the cities to create some of the local institutions previously mentioned. For example, the Department of Environmental Quality has imposed a mandate on the City of Grand Rapids to separate its stormwater and sanitary sewer systems (Public official, Grand Rapids, 2011; discussed in detail in Chapter 8). Compliance likely drives the City's Long-Term Weather Control Plan and its footing drain disconnection program. The State issues permits regulating the types of industrial pollutants that the cities' wastewater treatment plants may accept (Public official, Grand Rapids, 2011). Similarly, federal and state law requires cities to instate emergency management plans and to run trainings every year (Public official, Grand Rapids, 2011). During our interviews with officials in Grand Rapids, they indicated that these trainings and procedures help city and NGO partners to coordinate a smooth response.

City and NGO officials in Ann Arbor testified that the Environmental Protection Agency's Clean Water Act enforcement measures have moved Ann Arbor to undertake water quality improvement measures. For example, the city passed a phosphorous control ordinance after the EPA declared that two local lakes exceed total maximum daily loads of phosphorous (NGO representative, Ann Arbor, 2011). The Clean Water Act also requires the County to manage the Huron River Watershed to reduce pollutants. This mandate falls on the County since it owns storm drains both inside and outside the city, and it has jurisdiction over many of the creeks to which the storm sewers empty. According to a public official:

> *We [Washtenaw County] have jurisdiction of many of the main water bodies in the city but we have no authority over land use. We basically receive their water and they, in turn, deposit their water in our creeks. So we have—if we have an easement at all, it's probably 50 or 60 feet wide on each side and we have no control over what goes on outside of that easement and we have very little control over what goes on inside that easement. We don't have any land use authority. So, if the city owned all those creeks, the partnership wouldn't make much sense if they had jurisdiction and if they don't, we do and we have to work together. Their permanent discharge, discharged to us so—and then we're [under permit] but we can't do anything without collaborating with them on land use issues like, you know, they just passed a fertilizer—no phosphorous fertilizer ordinance a couple of years ago. This year they passed an ordinance that even if you're doing just a 200 square foot addition or more, you have to put in storm water, even if it's a single family detached neighborhood, which is a good chunk of the city. So, we collaborate on those things.* (Public official, Ann Arbor, 2011)

Because of the County's jurisdiction over creeks and the City's jurisdiction over land inside its borders, the watershed management mandate helps to institutionalize a cooperative relationship between the Washtenaw County Water Resources Office and the City of Ann Arbor's stormwater management program. The City follows Washtenaw County's rules for stormwater management, including the stormwater sewer system's 10-year design storm standard and detention requirements for private developments (Public official, Ann Arbor, 2011). Meanwhile, the City passes land use regulations such as the stormwater detention requirement on single-family properties that the County official referenced.

The City of Ann Arbor and Washtenaw County also share the County's Environmental Manager; each jurisdiction pays half of this employee's salary (See Chapter 8). This partnership likely emerged partly because of the watershed management requirements. Still, according to a county official, it also stems from social and political capital between Ann Arbor's Mayor and Washtenaw County's Water Resources Commissioner. Describing the partnership between the two elected officials, he remarked, "They are elected by a constituency that believe in watershed management, protecting the environment, so it kind of flows from the top down" (Public official, Ann Arbor, 2011). Financial capital also plays a role in facilitating the partnership. The official said, "We have fewer partnerships within the county than we used to have just because of there is just no money there. Ypsilanti would be a key partner but they have no money at all" (Public official, Ann Arbor, 2011).

Officials in both cities referred to an array of funding sources stemming from the State and Federal Governments. For example, a state grant provided initial funding for Ann Arbor's Energy Office beginning in 1985. Grand Rapids officials referred to a Michigan Department of Natural Resources grant to conduct a street tree inventory as part of the City's revived urban forestry management efforts. Officials in both cities referred to Governor Snyder's use of revenue-sharing incentives to foster regional collaboration in emergency management and service provision. While officials surmised that other communities may be forming new institutions around Snyder's incentives, they did not indicate that Grand Rapids or Ann Arbor had taken action in response to the new State rules. To the contrary, officials in Ann Arbor said that tying grant funding to adaptation requirements would help to incentivize

communities, in a similar way that tying transportation funding to regional collaboration has encouraged jurisdictions to work together (Public official, Ann Arbor, 2011). An official in Grand Rapids said that the City had contracted some emergency management services to Kent County, but did not indicate that this resulted from State incentives (Public official, Grand Rapids, 2011).

The cities identified a number of state and federal information sources that underlie local institutions. Public officials in Ann Arbor explained that they base stormwater management decisions on precipitation probability information produced by the Federal Emergency Management Agency. The City also uses FEMA's floodplain maps to write zoning ordinances that regulate buildings in the floodplain. As previously discussed, precipitation could change with the climate; the City depends on FEMA's updated maps for designing policies that will enhance flood resilience (Public official, Ann Arbor, 2011).

Federal institutions and local jurisdictions: Local autonomy and adaptation

Officials in both Ann Arbor and Grand Rapids identified the lack of regional planning in Michigan as a constraint to adaptation. One public official in Ann Arbor remarked, "There is no incentive to do it [regional planning] and these problems are regional, you know, global. So us working on climate adaptation in a vacuum is good but…" (Public official, Ann Arbor, 2011). An NGO official further elaborated the benefits of regional planning:

> *In a way, if you were to put it together and you were to do planning at the level of Ann Arbor, Ypsilanti and the surrounding townships, you could say, we're going to send all of the growth and development to Ann Arbor and Ypsilanti and they're going to share some of that revenue with the townships and meanwhile we're going to encourage the agricultural and natural area boundary around it and preserve that. And by sharing that tax base, we all benefit in the end.* (NGO representative, Ann Arbor, 2011)

However, one can imagine that sacrificing local autonomy over development to a regional planning body would not sit well with smaller towns, and the NGO official confirmed that the "loss of control, fear of animosity [from other local governments], parochialism" prevents regional planning from emerging organically in Michigan (NGO representative, Ann Arbor, 2011).

We wanted to know: institutionally, what prevents regional planning from taking place in the State of Michigan? A public official in Grand Rapids attributes it to the large number of municipal governments in Michigan (Public official, Grand Rapids, 2011). More precisely, the Michigan Zoning Enabling Act grants broad zoning authority to city, village, township, and county governments of which there are 1,858 (Michigan Zoning Enabling Act, 2006; Advamed, 2010). Under this law, every local government enjoys relatively broad autonomy to control land use within its borders, and, without incentives, "parochialism" prevents them from working together to achieve regional benefits. While the Zoning Enabling Act does not prohibit regional planning, inter-jurisdictional politics may discourage collaborative planning agreements. As an NGO official in Ann Arbor put it:

> *Each township sort of says, "Well, I have to have a little bit of an urban area or a city center and then I have each community has to have a designated mobile home park or high intensity, each*

community has to have an agricultural zone," and in some townships it doesn't make sense for each of them to have that. (NGO representative, Ann Arbor, 2011)

Institutionally, then, nothing prevents townships and cities from engaging in regional planning efforts. Instead, as one informant remarked on the subject of regional collaboration, "They [local governments] can probably do a lot more in law, especially in terms of regulating land-use, than any local official is willing to do politically" (Key informant, Ann Arbor, 2011).

Regional planning does occur more often in the transportation sector, facilitated by institutional structures but also by human capital. Public officials in Ann Arbor referred to a Washtenaw Avenue corridor planning effort between the Cities of Ypsilanti and Ann Arbor, and Pittsfield and Ypsilanti Townships (Public officials, Ann Arbor, 2011). A transit official in Grand Rapids suggested that "cross-border urban planning" began after two cities appointed their planning directors to the regional transit agency's board (Public official, Grand Rapids, 2011). The Rapid—the regional transit agency serving Grand Rapids—contains six cities within its jurisdiction, and each appoints members to The Rapid's board. This board structure, combined with good relationships between board members from different cities, may help spur regional planning within the Grand Rapids metro area.

Figure 7.5. The Rapid, the LEED certified transit center in Grand Rapids. Personal photograph. 2011.

Similarly, in the emergency management realm, officials were better able to transcend jurisdictional boundaries and work across 'political' institutional lines. In Kent County, cities naturally banded together in response initiatives. The City of Grand Rapids and several of its suburbs and local townships have an informal "good neighbor" agreement to assist one another in times of crisis (Public officials, Grand Rapids, 2011). Response staff and resources are routinely deployed to regions outside a political

jurisdiction's boundaries. A respondent spoke to the need for this type of collaboration from an emergency response standpoint, as well as a job security and political one, stating,

> *[for] the most part, Emergency Management and Homeland Security professionals are extremely collaborative and I think the writing is on the wall. You have to be that way in order to be successful. You know? And I think they know that. For the most part. But when your mayor comes in and says, "You're going to do this, that, or the other thing," you have to follow what the mayor says, and that's where the problems start, is where you try and advance your political agenda using Homeland Security or EPA grant-funding resources, or you know, when you try to take that money and customize it and make it a politically beneficial activity instead of truly common vision.* (Public official, Ann Arbor, 2011)

Despite public officials' complaints about the State of Michigan's providing too much autonomy to too many governments, public officials in Ann Arbor repeatedly referenced their lack of authority over building regulations as a constraint to adaptation. As an elected official commented, "One of the big frustrations for us was state building code. We cannot enforce a building code any stronger than the state's" (Public official, Ann Arbor, 2011). Officials in Ann Arbor claimed that the state's building code restricted their efforts in two areas: energy efficiency and floodplain regulation. The official quoted above continued, "People will at some point start building houses again, and for an extra $1500 you could have a much better insulation package, and when you begin to look at what that would do to the bottom line for all the energy use in the state, it would be incredible if all the new buildings required that" (Public official, Ann Arbor, 2011). Since the city cannot impose energy efficiency requirements, it incentivizes efficient building through its zoning code. According to officials, the City grants bonus floor-area ratio for building a LEED-certified building. Officials also note that consumers seem to be demanding more energy-efficient buildings. The market may drive green building more than institutions.

Also concerning the state building code, an Ann Arbor official expressed a conundrum over how to regulate development in the floodplain, since the floodplain area may expand due to climate change. The state building code imposes very few restrictions on buildings that would lie between the current 100-year and 500-year floodplain boundaries. Due to climate change, the 100-year floodplain may shift out. To mitigate risk to buildings, the City would like to impose additional building requirements for this zone, but the State of Michigan prohibits cities from imposing structural regulations more strict than the state's building code. To get around this problem, an official suggested that the City could regulate land use more strictly in the expanded floodplain. As the official explained, "If we say you simply can't do certain things, and even though the building code shows you how to do it, it's like no, that our zoning says you can't do that at all (Public official, Ann Arbor, 2011). Still, the City must tread carefully to avoid infringing on private property owners' right to use their land as they see fit. The City feels squeezed by an inability to regulate building structures because of the State's rule. Still, it hopes that adapting its land use regulations in a wider floodplain will help to mitigate flood risk to buildings.

Energy regulation presents jurisdictional limits similar to the state building code. While both cities have pursued progressive energy programs, they do not hold jurisdiction over the power infrastructure, nor do they control energy generation. Instead, the Michigan Public Service Commission (MPSC)

establishes rules about renewable energy, energy efficiency, and responding to power outages. The utility companies control the grid, they source electricity in compliance with state law, and they repair damage to the grid (Public official, Ann Arbor, 2011). An elected official in Grand Rapids expressed concern over the Federal Government's lack of climate preparedness in the energy sector:

> *I worry about the power infrastructure and the damage to the power grid in repeated extreme storms, straight line winds and, you know, even tornados although we have been fortunate enough to avoid those in this area of late. But we need to be prepared for those kinds of events and yet, you know, protecting the power grid is not something that falls into the portfolio of local government. It's a federal mandate and I don't know they are doing the kind of job that needs to be done yet. I mean, we don't even have a national energy policy, right, much less plans for dealing with massive power outages across the country and in extreme storms or high heat events where the system is overwhelmed.* (Public official, Grand Rapids, 2011)

Thorough analysis of state and federal energy policies is beyond the scope of this study. Still, our data do reveal that Michigan cities do not hold authority over the power grid, and their response to climate events depends greatly on state agencies.

Key Relationships

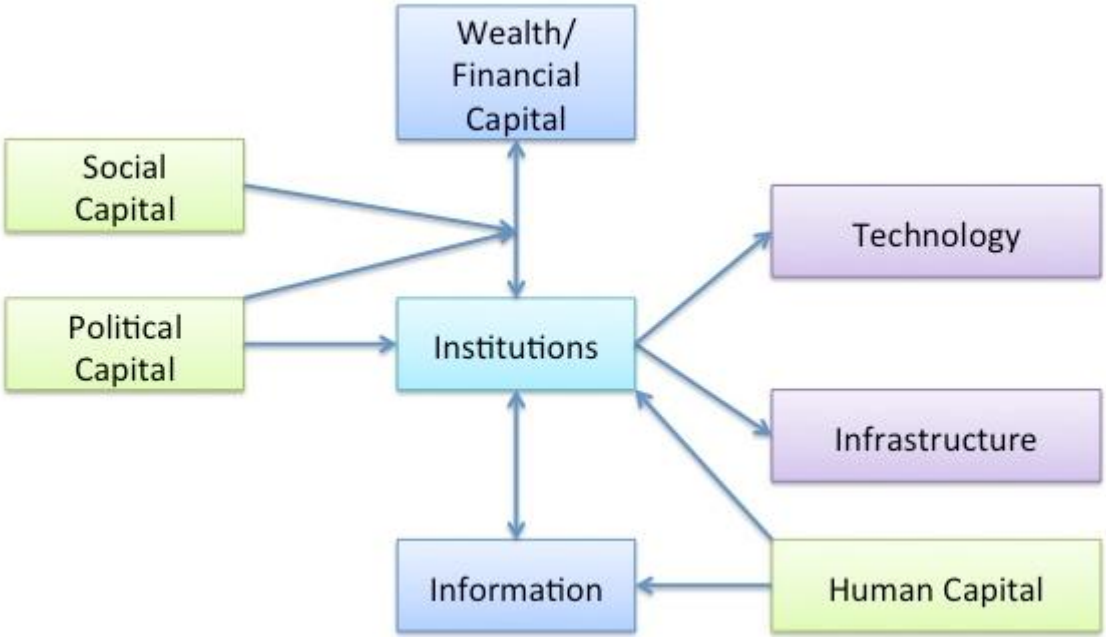
While identifying institutional enablers and constraints of climate adaptation is an interesting project in its own right, an even more compelling story emerges when we analyze how other determinants of adaptive capacity interact with institutions. In both cities, we find that institutions' effectiveness depends on the individuals who inhabit certain city offices (human capital), relationships between city staff and other organizations' staff (social capital), public involvement in decision-making (political capital combined with social capital), and funding to implement rules and support programs (financial capital).

Institutions such as standards and regulations can help to ensure that the cities' infrastructure withstands climate impacts, and they can promote natural resource conservation. Social capital influences institutions in both cities, as exhibited by grassroots advocacy work to shape institutions (Ann Arbor) and implement programs (Grand Rapids), partnerships with community organizations, and personal relationships that foster collaboration. Closely related to social capital, human capital bolsters institutional effectiveness in two ways: organizations and individuals provide technical knowledge, and city staff persons possess knowledge that improves their ability to achieve adaptation goals. We find that the relationship between institutions and financial capital is bidirectional: institutions help channel wealth to adaptation activities, and funding allows institutions to function. Just as we find that people matter to the effectiveness of city offices (human capital), we find that political leaders matter to our case cities' visions and actions. On the other side of political capital, we find that public engagement and support enable the city to institutionalize climate adaptation (usually under a different name) and public opposition can forestall adaptation activities. Both cities cited the importance of information for designing the rules, standards, plans, and programs that make up their adaptation activities and institutions enable the adoption of technologies. These determinants—and their influence on institutions—are discussed in detail in their respective chapters of this report.

Table 7.2 Relationships between Institutions and Other Determinants in our Case Cities

Determinant	Relationship with Institutions
Institutions	• State and federal regulations require adaptation activities. • State and federal regulations restrict adaptation activities.
Infrastructure	• Standards ensure that infrastructure withstands impacts. • Decision-making processes and criteria prioritize adaptation-relevant infrastructure improvements. • City structure and plans allow for an integrated approach to infrastructure/systems management.
Wealth and Financial Capital	• Budget cuts restrict ability to implement policies and plans. • Energy offices improve efficiency and save the cities money. • Institutionalized funding sources ensure funding for adaptation-relevant programs. • Shrinking budgets increase regional collaboration between institutions, and departmental consolidating within cities. • Cities turn to social capital to implement programs in the face of budget shortfalls.
Social Capital	• Grassroots groups and NGOs advocate for policy changes. • Civic organizations supplement the City's work to implement initiatives.
Political Capital	• Mayor plays the role of visionary and spokesperson for policy initiatives. • Political leaders forge partnerships between institutions. • Public support is critical for policy enactment.
Human Capital	• Universities and science-based NGOs provide data and technical assistance. • Cross-trained staff improves administrative efficiency. • Individuals are key to institutional success (policy implementation, integration between departments, and public engagement). • Lack of staff knowledge/brain drain constrains functionality. • Leadership of key individuals shapes city structure and success. • Plans educate city staff. • City commissions are effective due to strong knowledge base.
Information	• Data helps support policy decisions in case of public opposition. • Information helps to create effective infrastructure management standards. • State and Federal institutions provide information. • Cities seek guidance from peer cities to inform policies. • Educational and scientific organizations collect data to help cities design policies.
Technology	• Institutions enable technologies to be adopted.

Figure 7.6 Institutions in Context with Other Determinants in our Case Cities



Institutions help promote resource conservation and ensure infrastructure's resilience to climate impacts. Human capital in the form of staff and expert knowledge bolsters institutional effectiveness, and organizations generate data that inform standards and policies. Political capital in the form of public support is key to enacting new policies. Financial capital enables policy implementation while budget cuts can impact municipal structures and effectiveness. The existence of some institutions actually generates financial capital for the cities. Relationships with civic groups and the public—if they provide appropriate support—can achieve counter-effects to resource limitations. Institutions enable the adoption of technologies.

Chapter 8: Infrastructure

Infrastructure Background and Definition

Infrastructure is an important and valuable resource to assess and protect when considering pending threats from climate change. Climate change will impact natural systems, as well as human systems and the built environment. The quality of infrastructure and the ability to maintain and upgrade are often, but not always, considered when evaluating adaptive capacity in a local municipality. The main threats from climate change on a local scale include potential magnified damage from extreme events, potential changes to the Great Lakes water levels, changes in precipitation patterns and water availability, and increased maintenance costs due to higher temperatures (Neumann, 2009; Kling et al., 2003). Regarding cost, the estimated total U. S. public spending on infrastructure annually exceeds $300 billion and is expected to rise with growing climate change impacts (Neumann, 2009).

Infrastructure is often used to evaluate the comprehensive adaptive capacity of developing nations (Adger et al., 2004; Smit & Pilifosova, 2001a; Keskitalo et al., 2011). Adger et al. (2004) calls this determinant physical infrastructure, which encompasses the quality and situation of settlements, commercial infrastructure, quality, and density of roads and other transport routes, quality of sanitation infrastructure, and availability of clean water. Proxies used to measure physical infrastructure incorporate number of road kilometers, percent population without access to sanitation, and rural population without access to safe water, all metrics determined for developing countries (Adger et al., 2004). Smit and Pilifosova (2001a) specifically identify infrastructure to be one of the six determinants of adaptive capacity. The availability and access to social infrastructure and resources by decision makers and vulnerable populations influences the overall adaptive capacity of a place (Smit & Pilifosova, 2001a). Keskitalo et al. (2011) uses the similar framework as developed by Smit and Pilifosova, incorporating infrastructure as a

INFRASTRUCTURE

City systems and assets that support vital activities and "for which the diminishing functioning or destruction of such systems and assets would have a debilitating impact on public safety and/or economic security" (Rosenzweig et al., 2011)

INCLUDES

Water systems (stormwater, drinking water, pipes and water infrastructure, low impact development strategies), green infrastructure (urban forestry, greenbelt), traditional built environment (buildings), transportation (roads, bridges, public transportation), sanitation (sanitary sewer system), and the energy supply.

KEY FINDINGS

- All other determinants influence infrastructure, converging to allow the construction and maintenance of urban systems.
- Cities are looking towards green infrastructure as a tool to reduce impacts from climate change.
- When installing and maintaining infrastructure, the results are generally inflexible long-term ("path dependency") creating constraints to adaptation in the near future.

separate and individual determinant. Infrastructure is defined to include the physical infrastructure, as well as access to sustain local development of infrastructure. In a study to assess the adaptive capacity in developed countries, Keskitalo et al. (2001) found that the quality and extent of physical infrastructure is very location dependent. The study focused on the level of infrastructure development, as well as the potential vulnerabilities to climate change. Urban areas with well-developed infrastructure are not necessarily less susceptible to surrounding locations, but are vulnerable in different ways including risk to infrastructure. Additionally, infrastructure maintenance is closely linked to institutional capacity – reducing maintenance will reduce institution capacity and increase climate change vulnerability (Keskitalo et al., 2011).

The City of New York focuses on issues that incorporate the effects of climate change on critical infrastructure, using New York City's sustainability plan PlaNYC as a tool to create viable adaptation strategies (Rosenzweig et al., 2011). Critical infrastructure is defined as "systems and assets (excluding residential and commercial buildings, which are addressed by other efforts) that support activities that are vital to the city and for which the diminishing functioning or destruction of such systems and assets would have a debilitating impact on public safety and/or economic security" (Rosenzweig et al., 2011).

Often, in the context of institutions and adaptive capacity, the use of green infrastructure is a common adaptation strategy. Gill et al. (2007) suggest, for example, that green infrastructure with potential options such as green roofs, enhancing greenspace, and using drought-resistant plantings can potentially enhance adaptive capacity. Gill et al. use utilities and infrastructure as an assessment metric that includes "energy production and distribution, water storage and treatment, refuse disposal, cemeteries and crematoria (Gill et al., 2007, p.117). Eakin and Lemos (2006) further break down infrastructure to include subcomponents such as transport, water infrastructure, buildings, sanitation, energy supply and management, and environmental quality. For the purposes of our study, we have included many sub-determinants that aggregate together to comprise the infrastructure determinant of adaptive capacity developed by Eakin and Lemos (2006).

Hence infrastructure includes six key components: (1)water systems (stormwater, drinking water, pipes and water infrastructure, low impact development strategies), (2) green infrastructure (urban forestry, greenbelt), (3) traditional built environment (buildings), (4) transportation (roads, bridges, public transportation), (5) sanitation (sanitary sewer system), and (6) the energy supply. In interviews, city engineers and city officials in leadership roles spoke to the importance of infrastructure in many of their current and future projects through answering some of the following questions:

- How effective is the process the City follows for updating infrastructure, such as pipes and roads?
- Where does the majority of infrastructure funding come from, and what is the process for obtaining it? What are the barriers to obtaining funding?
- How are projects prioritized?
- Has preparing for or adapting to climate change influenced this process of updating infrastructure?

Infrastructure in Ann Arbor and Grand Rapids, MI

Many cities across the country and around the world are experiencing costly infrastructure maintenance and construction due to continuing development. To make matters worse, scientists predict that threats from climate change will negatively affect infrastructure systems through higher demands and more intense use of the built environment. Both Ann Arbor and Grand Rapids face the issue of an increasingly costly, aging infrastructure system that requires constant maintenance and updates. For example, in Ann Arbor, one informant stated,

> *We have aging infrastructure that we're trying to deal with, yet you have to mitigate the rate increases that you can pass on to your customers, so that's the big struggle. For instance, right now we're in the midst of rebuilding a portion of the wastewater treatment plant which is a very old building from the 1940s and we have to replace it.* (Public official, Ann Arbor, 2011)

Threats from climate change are real and could exacerbate current issues that municipalities face regarding aging infrastructure assets. Pipes and roads are experiencing more strain from increased precipitation, temperatures, and storm events. For example, "you're seeing places that flood that didn't flood. You're seeing infrastructure in the streets that might have taxed in the past to pass these storms; it just can't do it anymore" (Public official, Ann Arbor, 2011). **Figure 8.1.** depicts flooding on Geddes Road in Ann Arbor in the spring of 2011.

Figure 8.1 Flooding on Geddes Road in Ann Arbor, May 2011. Source: Angela J. Cesere, AnnArbor.com. Accessed from: http://www.annarbor.com/cgi-bin/mt/mt-search.cgi?search=flooding&__mode=tag&IncludeBlogs=1&limit=20&page=2

Both municipalities are focusing on integrating green infrastructure into the built environment to reduce impact from climate change. As defined by Benedict and McMahon (2002), green infrastructure is "an interconnected network of green space that conserves natural ecosystem values and functions and provides associated benefits to human populations." Examples of green infrastructure include green roofs, urban forests, rain gardens, and rain barrels. They are used to help reduce the impact to a system, such as stormwater, and create a low-cost indirect mitigation strategy to deal with impending climate change threats. In Grand Rapids, there is a shift to incorporate green infrastructure into sustainability work, as well as adaptation planning. An informant stated,

> *Well, here we are now, what, 15 years later still trying to figure out how we are going to generate the revenue to pay for the kind of gray infrastructure we need, much less incentivize green infrastructure for storm water. So that would be my top priority for adaptation planning.* (Public official, Grand Rapids, 2011)

Stories about infrastructure illustrate that sustainability and climate related work has taken place locally. They also demonstrate connections between determinants and the factors that enable or constrain overall adaptive capacity. Two notable stories emerge for both cities and were cited by many informants as influential projects. Grand Rapids informants pointed to the separation of the combined sewer system and green buildings as achieving sustainability objectives. For Ann Arbor, stormwater system improvements and energy efficiency projects have enhanced the City's adaptive capacity.

Combined sewer system

Historically, the sanitary and stormwater sewers in Grand Rapids merged, creating a problem when excessive rains burdened the system. In such cases, contaminated sewage flows into the Grand River and eventually Lake Michigan. Efforts to separate the sewer system began in the late 1980's and over 99% of all systems have been separated to date. The wastewater collection system encapsulates a geographic area that is over 200 square miles (City of Grand Rapids, 2006). The western side of Grand Rapids has been successfully separated, while the infrastructure design and construction on the eastern side of the city is still in progress and slated to be completed before the end of 2019. Below we describe how many factors combine to explain how this process came together, including supporting evidence collected from informant interviews.

The State of Michigan issued a long-term combined sewer overflow control mandate to the City of Grand Rapids to eliminate all combined sewer overflows by December 31, 2019 (City of Grand Rapids, 2006). As a result, this requirement prompted Grand Rapids to separate their sewer system in a timely and efficient manner. Additionally, as referenced in Chapter 7, the Michigan Department of Environmental Quality imposes regulations on the types of pollutants that the city's sewage treatment plans may accept.

Financial capital is tightly linked to infrastructure, since cities need money to build infrastructure. The total cost for separating all combined sewer overflows in the City of Grand Rapids is estimated at $260 million, with the west side subsystem combined sewer project totaling $160 million (City of Grand

Rapids, 2006). The investment in this project is significant and the majority of costs have been placed on the local community. As an informant stated,

> *In three years we will have completed the sewer separation for a community of 200,000 people. I think it's all but seven percent of it has come from local dollars so people of Grand Rapids have made a huge investment in this river and they are starting to own it and appreciate it*. (Public official, Grand Rapids, 2011)

Many departments within the City of Grand Rapids have sufficient information and technical knowledge to make educated decisions about separating the sewer system. Although there is a high level of uncertainty regarding how to adapt or what information is more accurate, technology is available to help mitigate risks. Maintenance and upkeep of systems is dependent on new technology to streamline and create more efficient infrastructure evaluations. An informant gave an example of technology being used to monitor and update infrastructure systems in Grand Rapids to reduce excessive infrastructure repairs:

> *We send a camera in by remote control. It's almost like a video game. You can get a condition assessment of the inside of your system. We use that and tie it to our GIS system so that the GIS system not only contains the television video but also the report done by the field crew and the specific location. So if there's a manhole that is severely deteriorated, we have a standard rating system for manholes and that gets attached to the attribute in the GIS system with the video that we televised the sewers with. We have been starting to do that more and more as a condition assessment to kind of come up with an asset management plan*. (Public official, Grand Rapids, 2011)

The West Michigan Environmental Action Council (WMEAC) coordinates with the City of Grand Rapids to enhance and influence low impact development (LID) to decrease runoff in the stormwater system. LID strategies are tactics used to manage stormwater and increase direct onsite infiltration opportunities. By increasing LID use through an established rain barrel and rain garden program, individual property owners allow for more direct infiltration of precipitation on site and reduce the overall strain on the stormwater system. An example of a rain garden in Grand Rapids is shown in **Figure 8.2.**

> *We* [the City of Grand Rapids] *provide the funds for the parts and stuff to create the rain barrels, they* [WMEAC] *provide the labor to drive the holes and the workshops and teach people about them. Coca-Cola right here across the river provides the old syrup barrel to us at not cost…So very low cost. And we've put thousands of rain barrels out into the community. And that's one of the targets in the sustainability plan and I've exceeded it more than I ever thought I would*. (Public official, Grand Rapids, 2011)

Figure 8.2. "An example of a rain garden." Photo by Melissa Schrauben. Source: The Rapidian, 2010. Accessed from http://www.emmitsburg.net/gardens/articles/adams/2008/photo/rain%20garden.jpg.

Green buildings

Alongside the separation of Grand Rapids' combined sewer system's influence on the City's adaptive capacity, Leadership in Energy and Environmental Design (LEED) buildings have become increasingly popular. The American Institute of Architects reported that, until recently, Grand Rapids had the greatest number of LEED certified buildings per capita than any other U.S. city (Rainwater, Martin and Kara, 2009). Grand Rapids has many of the first LEED designed building categories, including but not limited to the first LEED municipal building, first LEED public transit station, and the first LEED public art museum (depicted in **Figure 8.3**.)

Figure 8.3. Grand Rapids Art Museum, aerial view. Source: Grand Rapids Art Museum: LEED Gold Certified / wHY Architecture. wHY architecture? Accessed from http://ad009cdnb.archdaily.net/wp-content/uploads/2008/05/gram-aerial.jpg.

Relationships have emerged between green buildings and other determinants, creating an adaptive strategy that will reduce the overall risks from climate change. Exemplifying the influence of human capital, long-standing design culture has been influential in Grand Rapids as a result of the prominent and historical furniture industry. Herman Miller, Steelcase, and Haworth are among the nation's top furniture producers nationwide. One informant stated,

> *The notion of LEED, the whole idea of a standardized set of measures for building environmentally sustainable buildings came out of here. It came out of the Herman Miller plant in neighboring Zeeland. And so at an early stage we had major corporations that were talking about sustainable buildings, green buildings.* (Public official, Grand Rapids, 2011)

The culture of private developers has contributed to the popularity of LEED construction. Many developers feel that without building more sustainably, their product will be less desirable to the

general consumer base in Grand Rapids. A cultural shift has produced high demand for high quality, green buildings. Education and consumer desires are driving the market in Grand Rapids and raising the bar to increase the number of green buildings citywide. An informant explained:

> *A major developer in the area says if we don't build a LEED certified building today, we know it's obsolete the day we open the doors—a brand new building; it will be obsolete the day we open the doors. So it has become part of the culture and I think that's through some leadership, some repetition.* (Public official, Grand Rapids, 2011)

The City of Grand Rapids has enhanced and revamped zoning codes to better enable green building throughout. An informant explained:

> *We have embedded LEED standards into our building code, into our zoning ordinances, LEED ND—neighborhood development—is embedded in our zoning so if you comply with our zoning ordinance you will be . . . I think it's two-thirds of the way to getting LEED ND certification for your project or your development.* (Public official, Grand Rapids, 2011)

The City of Grand Rapids has also mandated that all new municipal construction and major renovation (over 10,000 square feet and $1,000,000) meet LEED certified standards. Comparatively, San Francisco was the first city to mandate a LEED standard for building over eight years ago. However, San Francisco only recently surpassed Grand Rapids' number of LEED certified buildings per capita (Public official, Grand Rapids, 2011).

The Mayor and city officials have been very supportive of the green buildings field and have worked with developers to make green building a norm in Grand Rapids. The Mayor has been a strong proponent of this increase in LEED development, creating policies that help institutionalize this effort.

Many local governments have found a need to incentivize LEED to increase green building and minimize the costs of certification through priority permits tactics, subsidized tax credits, fee reductions, and density bonuses (USGBC, 2012). However, Grand Rapids does not offer any incentives to increase the number of LEED buildings in the City. The costs for building green have been significantly reduced recently but consumer desires and political leadership account for the amount of LEED certified buildings in Grand Rapids (Public official, Grand Rapids, 2011).

Stormwater infrastructure

As introduced in Chapter 7, the City of Ann Arbor has used design standards and regulations on private development to ensure that its stormwater infrastructure withstands climate impacts. A number of stormwater improvements, will enhance the community's resilience to the high-intensity storms projected under climate change scenarios. Without a properly managed system, damage from flooding and erosion may intensify. In total, the City of Ann Arbor is responsible for maintaining over 360 miles of stormwater pipes (City of Ann Arbor, 2012b).

The National Pollutant Discharge Elimination System (NPDES) Permit covers the Ann Arbor stormwater system. The goal of this program is to regulate and control the discharge of the pollutants

into surface waters to protect the health of the local environment. In addition, the City of Ann Arbor has created partnerships between both the County and local entities to enhance stormwater management in its jurisdiction. For example,

> *Doyle Park was done as a collaboration between the county, the city, and the township and the township discharged their stormwater to that area and they were willing to pay their 17% or whatever, based on their percentage of land in the water shed. So that benefitted the creek and that benefitted the city and the county*. (Public official, Ann Arbor, 2011)

The City of Ann Arbor has adopted a unique financing mechanism to assist in funding the majority of stormwater projects. Since 1984, Ann Arbor property owners pay a fee based on the square footage of impermeable surfaces located on their parcel (City of Ann Arbor, 2012b). The City allows residents to install residential infrastructure, such as rain barrels and rain gardens, as a credit to reduce their overall stormwater utility bill (City of Ann Arbor, 2012b). Nevertheless, grossing millions of dollars annually, the stormwater utility is the primary source for maintenance and new construction projects within the stormwater asset category of the Capital Improvements Plan (City of Ann Arbor, 2012b). This financing mechanism creates a sustainable funding source and enables more innovative stormwater and low impact development projects.

Although the stormwater utility has been a major enabler for Ann Arbor to become one of the best managed cities in Michigan for stormwater infrastructure, financial constraints do exist. For example, major flooding around Allen's Creek, a diverted creek running under the heart of Ann Arbor through a 7x9 foot box culvert has been a critical problem. Notwithstanding, city officials have decided it is too costly to eliminate flooding surrounding Allen's Creek by replacing the current infrastructure with larger pipes (City of Ann Arbor, 2012b).

The City of Ann Arbor shares one official position with Washtenaw County focused on stormwater management, partially funded by both entities. As a shared employee, this person is responsible for finding grants and other opportunities to fund additional projects including stream restoration, wetland construction, underground detention, stormwater road rights-of-way, and additional stormwater projects (Public official, Ann Arbor, 2011). This position is funded through the stormwater utility budget and enables the City to create more coordinated projects with the county, as well as have additional financing for stormwater projects.

Due to the inherent uncertainty surrounding climate change, lack of actionable information is a constraint to decision-making for stormwater infrastructure. An informant explained,

> *Give me all the caveats you want but this is the best data we've got for you to make planning decisions in 25 or 50 year—because this is a lot that we do that will last that long: putting pipes in the ground, certainly tree planting, you know, whether we should be removing buildings from the floodplain, floodway. (Public official, Ann Arbor, 2011)*

Energy efficiency

Ann Arbor has emerged as a leader in energy efficiency and many links can be made to highlight the relationships between factors that build adaptive capacity. One major project that has been used to promote energy efficiency in the city is the installation of light-emitting diode (LED) streetlights to replace more energy intensive light bulbs. Since 2005, the city has converted over 1,000 streetlights to LED.

The Downtown Development Authority (DDA) has partnered with the City of Ann Arbor to reduce energy use and increase energy efficiency through the City. Through a financial backing and educational program, the DDA has helped Ann Arbor become one of the nation's leaders in energy efficiency programs. An interviewee explained, "It's going to cost you more up front. But our LED lights paid for themselves in four years. So if you're going to make that investment, why not ensure energy efficiency and it would make a huge difference if all of the streetlights in Michigan were LEDs" (NGO representative, Ann Arbor, 2011).

In 2007, the DDA approved a $630,000 grant to retrofit 1,400 streetlights located in downtown Ann Arbor (DDA, 2012). The initial investment was significant but the replacements have saved the City an average of $49,000 annually (DDA, 2012). An informant explains, "especially when we had the funding available, it was one of the best energy efficiency programs offered anywhere in the United States was right here for downtown businesses through the Ann Arbor DDA" (NGO representative, Ann Arbor, 2011).

Figure 8.4. "City of Ann Arbor Pilots LED Street Lights and Reduces Costs." 2010. Photo by: Jin-Gwo Lin Source: Green Architecture and Building Report. Accessed from: http://www.gabreport.com/2010/03/city-of-ann-arbor-pilots-led-street-lights-and-reduces-costs.

The majority of Ann Arbor's grid energy comes from coal and there is a general lack of large-scale renewable energy sources available (Public official, Ann Arbor, 2011). A major constraint for energy work in Ann Arbor comes from the local energy utility company. Without full support from this private entity, adaptive capacity will be limited. The City of Ann Arbor has replaced all streetlights within the downtown area. However, they own only about one quarter of the lights outside the downtown area (NGO representative, Ann Arbor, 2011). These streetlights are currently in the process of being retrofitted with LED lights; however, the local utility company owns the remainder. A constraint does exist because the City of Ann Arbor cannot replace the lights but would benefit from reduced energy costs overall if they were replaced. Political pressure and leadership have not been successful in incentivizing the utility company to make changes and continue to help lead the field.

> *But we only own about a quarter of the lights outside of the downtown area. We're replacing all those this year. And what happened is DTE would have to make an investment, because they own the rest of the lights. We can't replace their bulbs for them. And if you think about the way they are incentivized, that means they're going to use less energy at night, and we would owe them less money, and at night is when they have extra capacity in the summertime, for instance.* (Public official, Ann Arbor, 2011)

Ann Arbor's energy office is unique and one-of-a-kind for a mid-sized city. Ann Arbor has the political backing and support of city official leaders. Much success can be attributed to the fact that Ann Arbor has a full-time employee dedicated to improving energy efficiency and creating partnerships both locally and nationally.

Key Relationships

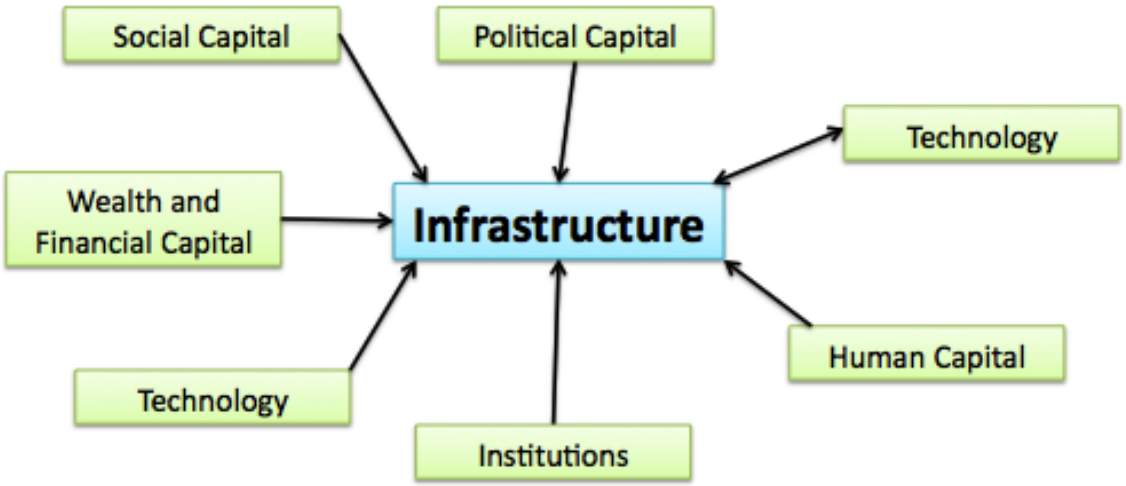
Urban infrastructure is influenced and enabled by various factors and systems that converge to allow the construction and maintenance of urban systems. Infrastructure as a determinant of adaptive capacity manifests itself in different ways when analyzing both Ann Arbor and Grand Rapids. There are key relationships that influence everyday operations and future priorities for the Cities related to infrastructure projects. **Table 8.1** and **Figure 8.5** summarize the most significant relationships between infrastructure and other determinants that emerged during this study.

Table 8.1. Relationships between Infrastructure and Other Determinants in our Case Cities

Determinant	Relationship with Infrastructure
Institutions	• Policies and regulations that control environmental impacts on the surrounding area and require design infrastructure design guidelines • Mandates from state or federal level to improve environmental quality • Zoning ordinance changes to enhance more sustainable development
Wealth and Financial Capital	• Utilities create a more sustainable funding source • Grants and outside funding sources supplement funding for large infrastructure projects • Constrained by the dynamic between level of service offered and willingness to pay by residents
Social Capital	• Partnership between Washtenaw County and local community groups to

Networks	enhance stormwater management • Local community groups helped to encourage Green Building practices
Political Capital	• Shared leadership position between the County and City to enhance funding opportunities for stormwater management • Mayor and city official support and leadership for encouraging LEED construction
Human Capital	• Highly educated and engaged community that participates in creating infrastructure improvement plans • WMEAC's involvement in providing expertise on LID strategies (rain barrels, rain gardens) • Trained and educated designers contributing to the success of LEED development
Information	• Constrained by not having down-scaled data that will help make more accurate and informed decisions for the future • Crucial in the designing making and design process to create appropriate local infrastructure
Technology	• Pilot testing LED streetlights as an energy conservation measure • Stormwater system is designed around the 25 year/24 hour rain event • Remote control camera sent into underground infrastructure to determine poor conditions

Figure 8.5. Key Relationships between Infrastructure and Other Determinants in our Case Cities



Social Capital, Political Capital, Technology, Human Capital, Institutions, Technology, and Wealth and Financial Capital contribute to building Infrastructure (the presence of these determinants builds Infrastructure while the absence of the determinant hinders development of Infrastructure).

Chapter 9: Wealth and Financial Capital

Wealth and Financial Capital Background and Definition

Wealth and financial capital can be viewed as a critical enabler, as well as a constraint, for adequately adapting to climate change. Included here are wealth and financial resources, economic power, and wealth distribution and can be further unpacked into economic resources, including economic assets, capital resources, financial means, wealth, the general economic conditions of nations and groups, or poverty (Smit and Pilifosova, 2001a). In their analysis of AC in Latin America, Eakin and Lemos (2006) break this determinant down to include income and wealth distribution, economic marginalization, accessibility and availability of financial instruments (insurance, credit) and fiscal incentives for risk management. Yohe and Tol (2002) operationalize wealth in a slightly different way by examining the availability of the resources and their distribution across populations. They analyze a locale's economy and determine whether or not the financial resources are distributed equally across the geographic region. While Schroter et al. (2003) classify income inequalities under equity as an adaptive capacity indicator and determinant, economic power is a separate determinant, including world trade share and budget surplus.

Much of the literature focuses on the difference between developing and developed nations with regards to economic factors as they enable or constrain adaptation. Golkany (2007) writes, "developing nations are generally deemed to be most vulnerable to climate change…largely because they lack adaptive capacity. In particular, they lack economic resources and human capital needed to implement technologies to cope with climate change." It is generally accepted that wealthier countries will be more readily able to adapt to climate change versus poorer nations (Smit & Pilifosova, 2001a).

WEALTH & FINANCIAL CAPITAL:

Monetary assets and financial structures available to cities

INCLUDES:

Accessibility, flexibility, and availability of wealth management instruments such as revolving funds, philanthropy insurance and credit

KEY FINDINGS:

- Contributes essentially to AC by enabling Cities to purchase infrastructure, human capital, information, and technology.
- Both Cities drew from diverse sources to fund adaptation-related work.
- In Ann Arbor, institutional mechanisms, such as revolving loan funds and dedicated mills, funded innovative adaptation projects.
- Grand Rapids emphasized social capital in the form of community organizations, volunteers, and private donations to fund projects.
- In both communities, having some baseline level of wealth enabled both cities to protect their assets and secure additional funding.

Overall, worldwide, available economic resources partially or fully define vulnerability.

Keskitalo (2011) uses the IPCC framework and definition to analyze the economic resources in developed nations and determine their adaptive capacity. Local economic resources are often dependent on access to wage employment at the individual level, as well as revenue generated through municipal taxation at the institutional level. Yet, in a case study focusing on Stockholm, Sweden she found that often value systems can greatly limit local adaptive capacity, even if economic resources exist (Keskitalo, 2011). Higher income per capita along is not considered to be a sufficient indicator of the capacity to adapt to climate change, even if it does provide better opportunities through greater access to technology and financial investments in adaptation strategies (Moss et al., 2001).

For the purposes of this study, wealth and financial capital includes the accessibility and availability of financial wealth and or wealth management instruments (revolving funds, philanthropy, insurance, credit). The main questions that we used to gather information on this topic include:

- How much has the City budgeted for climate adaptation work over the past 5 years?
- Is there money set aside in the budget for emergency response and is that money adequate? How effectively can you mobilize it?
- Do you consider funding sources to be a large barrier to the City adapting to Climate Change?
- What is the main funding mechanism for sustainability/climate change work? (e.g., grants, millage, etc.)
- Has the City felt financial constraints as a result of the State of Michigan tightening the budget?

Wealth and Financial Capital in Ann Arbor and Grand Rapids

In both Ann Arbor and Grand Rapids, wealth and financial capital contribute essentially to adaptive capacity by enabling infrastructure, human capital, information, and technology. Likewise, funding limitations constrain such assets. Indeed, many interviewees viewed limited access to funding as the biggest barrier to tackling additional adaptation projects. Both Cities drew from diverse sources to fund adaptation-related work. In Ann Arbor, institutional mechanisms, such as revolving loan funds and dedicated millage, funded innovative adaptation projects and initiatives. In contrast, Grand Rapids emphasized social capital in the form of community organizations, volunteers, and private donations to fund projects. Both communities showed strong evidence of wealth enabling the acquisition of more wealth; having some baseline level of wealth enabled both cities to protect their assets and secure additional funding. Although wealth was significant for protecting and securing other assets, budget cuts did not necessarily reduce AC. In some instances, budget cuts prompted efficiency and streamlining, although there are limits to the amount of efficiencies that could be realized.

Wealth as key constraint

Cities need money to pay staff, purchase technology and information, and build and maintain infrastructure projects. Nearly universally, interviewees identified lack of financial resources as the key limitation to additional adaptation work. For instance, one official said, “Money is absolutely the main constraint. We know what to do. I say that with a fair level of confidence” (Public official, Grand Rapids, 2011). Likewise, another City official said, “What we struggle is in the funding category. You can have the

best asset management plan on paper, but if you don't have the funding to back it, it doesn't mean anything" (Grand Rapids, 2011).

A public official in Ann Arbor provided a concrete example of limited resources' impact on institutional effectiveness. She explained, "Implementation requires resources to babysit. I mean, compliance is people looking over your shoulder, whether it's your boss, whether it's your local government" (Public official, Ann Arbor, 2011). Referring to the city's requirement that residential neighborhoods install stormwater detention ponds, she continued, "There's no mechanism for maintenance so unless someone comes and tells that homeowner's association you're going to have to spend money to pull out the sediment and periodically maintain that, they're not going to do that." The city's stormwater detention requirement may be progressive adaptation policy in theory. Still, sustaining source control treatments requires additional resources, both from residents and in the form of a staffed compliance program.

Officials in both communities spoke of the financial challenges of adopting environmentally preferable technologies and infrastructure specifically due to the cost barrier. For instance, porous asphalt, which offers stormwater management benefits compared to conventional pavement, is more expensive. An Ann Arbor official said the cost difference made it so the City did not adopt this material widely (2011). Similarly, another Ann Arbor official cited the additional expense of LEED certified green buildings as a barrier to widespread green building development (2011).

Despite this limitation, both Ann Arbor and Grand Rapids have found successes by refusing to be limited by budget constraints. In some cases this means prioritizing other considerations, instead of funding, when undertaking projects. For example, one interviewee, in discussing how capital improvement projects are prioritized said, "funding is pretty important as far as ranking and prioritizing, but that's not the driver for why we should be doing a project. It's really a safety situation that's most important" (Public official, Ann Arbor, 2011). Similarly, another City official, in reference to infrastructure investments, said:

> *[The] property acquisition that we're doing for parks, you know, which should make absolutely no sense in a time like this when the city has no money. Why the heck are we acquiring property for more green space when we can't even afford what we've got? But we're doing it. And you know, why should we be painting bike lanes when we can't even, we don't even have the budget? It costs about $275,000 to maintain all of the pavement markings that we have now for crosswalks and stop bars and striping. The budget this year was $200,000. So why are we painting bike lanes when we can't even afford what we've got now, but we're adding bike lanes. […] if you don't do it, well, you're never going to get anywhere and how are you going to be a city with a high quality of life and sustainable if you never take that next step? So despite not having the resources like we'd like, we're continuing to push ahead.* (Public official, Grand Rapids, 2011)

Therefore, although funding is important, it is not the be-all and end-all in determining what the case study cities are able to do.

Figure 9.1. Comstock Riverside Park in Grand Rapids. Personal photograph. 2011.

Diversity of funding sources for adaptation

Both communities draw from diverse sources to fund adaptation-related work. Although the General Fund provides important funds for infrastructure and other projects, much of the innovative work underway in both cities is funded from other sources. **Table 9.1** provides an overview of funding types and examples of projects funded through these sources. (This table is not comprehensive, but instead provides examples raised by our informants to illustrate the diversity of funding streams the case cities are accessing.)

Table 9.1. Funding Types and Example Sources and Projects Funded in Ann Arbor and Grand Rapids

Class/Type of Funding Source	Example Projects Funded*
Federal	
Grants	- *Public Health Emergency Preparedness Grant* - Helping human service and mental health agencies develop so vulnerable populations are prepared for emergencies in Kent County - *Energy Efficiency and Conservation Block Grant* – Establishing a loan launch reserve fund to start commercial PACE (Property

		Assessed Clean Energy) financing program in Ann Arbor - *U.S. Department of Agriculture's Farm and Ranchland Protection Program* – Supplements Greenbelt funding to preserve additional farmland (Ann Arbor)
	Earmarks	- Congressional earmark funded development of The Rapid's transit center, a LEED certified green building in Grand Rapids
	Other Allocations	- Federal declaration of disaster makes community eligible for FEMA (Federal Emergency Management Agency) reimbursement - Participation in National Flood Insurance Program through FEMA
State		
	Sales Tax Revenue Sharing	- Portion of State revenue allocated to local government units, which goes into the general fund towards public health, public safety, infrastructure, and other needs
	Federal Money Distribution	- Congestion Mitigation and Air Quality Improvement (CMAQ) – distributed to states based on population and federal air quality classification. Grand Rapids uses to make transit service free on ozone action days (funneled through Metropolitan Planning Organization) - State funnels Environmental Protection Agency and Centers for Disease Control money to County public health departments based on population share - FEMA's Emergency Preparedness and Homeland Security grants – provide general support for emergency preparedness and management (funneled from State to Regions to local units)
	Grants	- DNR (Department of Natural Resources) Urban Community Forestry Fund provided funding for tree inventory and analysis (neighborhood and city-wide) in Grand Rapids - MEDC (Michigan Economic Development Corporation) provided funding water loss audit program in Grand Rapids
	Disbursements	- Act 51 (Gas tax) revenue distributed to local governments to fund major road improvements and other transportation projects
	Tax Credits	- Brownfield Redevelopment Tax Credit - Public Act 116 – Farmland Preservation Tax Credits
	Fee for Service	- State of Michigan contracts with Grand Rapids to do air quality testing for western Michigan region
	Low-interest Loans	- State Revolving Fund – Provides low-interest loans for water quality projects, including stormwater mitigation
City		
	Dedicated Millage	- Bus Millage to expand The Rapid's services (Grand Rapids) - Solid Waste (Ann Arbor) - Natural Areas Preservation (Ann Arbor) - Greenbelt (Ann Arbor)
	General Fund	- Based on property tax revenue, funds infrastructure, capital improvements, public safety, etc.
	Utility Fees	- Water - Sanitary sewer - Stormwater (Ann Arbor)

Tax Increment Financing	- Special tax stream that can be used for local improvements. For instance, used to develop a park on a brownfield site in Grand Rapids
Special Assessment	- Neighborhood-level improvements to sidewalks - Establishing water service in new communities
Bond	- Ann Arbor's Energy Fund established by City going to bond
Grants from Foundations	- Dyer-Ives and Grand Rapids Community Foundation provide local match for State's Urban Community Forestry grant - Grand Rapids Community Foundation provided support urban forestry ordinance review process study
Partnerships with Non-Profit Organizations	- Friends of Grand Rapids Parks raises money and mobilizes volunteers to support park maintenance and development - CERT (Community Emergency Response Team) and RACES (Radio Amateur Civil Emergency Service) provide volunteer labor during emergencies - Van Andel Institute paid to fix up a nearby park and funds maintenance of the park in exchange for preferential scheduling three days per year (Grand Rapids)
Partnerships with Businesses	- Founder's Brewing Company funded half of an engineering study for a whitewater course along the Grand River

*These examples are not exhaustive; examples were selected based on sources interviewees highlighted and are included here to illustrate the diversity of funding types in use and available

Not all funding sources have the same characteristics. Interviewees highlighted benefits and shortcomings with several funding sources. Grants from the State, Federal agencies, and private foundations, for instance, provided funding for numerous studies and infrastructure projects that the cities would not otherwise have been able to pursue. While interviewees expressed appreciation for those funds and the opportunities they afforded, several informants also criticized the process of applying for and reporting on grants. Several interviewers said that the complicated grant process required specialized expertise and consumed considerable staff time. For instance, one informant said, "the grant distribution process can become very problematic and can actually be a time waster" (Public official, Grand Rapids, 2011).

Utilities provide a relatively stable and secure funding source. In particular, officials lauded Ann Arbor's stormwater utility (in which property owners are charged based on the amount of impervious surface area on their property) for providing a secure funding source that adequately covered stormwater system maintenance and improvements. One official said:

> *I think of storm water-funded stuff because we have this storm water utility and it's a fairly stable funding source, because the less people go out and change their impervious areas, it's still charged. It's a little different than other utilities like water, so if people start feeling the pinch of the economy and say, "I'm going to use less water because I don't want to pay," when you have complete control over it. And you have complete control over impervious area too, but people aren't going out and ripping up their driveways to save money; they're just not showering as*

> *long or not watering the lawn, so those other, and sanitary is based on water use also, so those funds are kind of volatile. But the storm water is not. It's like you put together a pretty solid thing. So in the storm water world, we haven't felt the downturn in the economy.* (Public official, Ann Arbor, 2011)

At the same time, however, informants noted two key drawbacks to such funding sources. First, cities were hesitant to pass expenses on to customers through rate increases. One informant said,

> *particularly utilities, you have to try and levelize* [sic] *the rate increases for the customers. I mean, the economy is in a, a lot of people out of work, the economy is not a good situation. We have aging infrastructure that we're trying to deal with, yet you have to mitigate the rate increases that you can pass on to your customers, so that's the big struggle.* (Public official, Ann Arbor, 2011)

For Water Utilities in particular, officials in both cities spoke about the conflicting goals of selling water to generate revenue and promoting conservation. One official said, "We want to conserve, but we need to sell more to keep rates low. […] Conservation versus selling – they're two competing goals" (Public official, Grand Rapids, 2011). Similarly, another official said:

> *And so from that aspect of sustainability and preserving the resource, we set the* [rate] *structure up to try to conserve water. So that's a growing trend in the utility business. On the flip-side of that, you want people to use less water, well, be careful what you ask for, because* […] *that means we get less revenue. So it's again, it's a balance in trade-off and again, a really key piece of sustainability and asset sustainability, where's that balance of what do you need in terms of funding and resources to maintain and sustain the system but yet sustain the resources yet have things at a funding level that the customers can be comfortable and can provide and keep the system at a level of service* […] *that they're willing to accept. If you want guaranteed no water main breaks on your street ever, or once a year, once a decade, we could maybe provide that, but you're going to be paying a lot of money for that.* (Public official, Ann Arbor, 2011)

The amount of money coming from the State of Michigan to local governments has declined significantly in recent decades. Consequently, several interviewees commented on the unreliability of State revenue sharing and other funding coming from the State of Michigan. One City official said:

> *The state, I think has been placing downward pressure on local governments because it's reducing the amount of money it's providing local governments through revenue sharing and other programs. And I think that there's no accident to that. During the 12 years that preceded Jennifer Granholm, Governor Engler signed 32 tax cuts which substantially reduced the ability of the state to fund local governments and alternative modes of transportation for cities, towns.* (Public official, Ann Arbor, 2011)

Selling bonds offers a potential funding stream for special projects. For example, Ann Arbor used bonds to finance the Energy Revolving Fund and the Commercial PACE programs. However, the State of Michigan limits the amount of debt cities can take on and their schedule for repaying the debt. In Ann

Arbor, for instance, the debt coverage ratio (operating revenue minus expenditures divided by debt payments) cannot be less than 1.25 (Public official, Ann Arbor, 2011). Therefore, there are limits to the extent to which cities can use this as a funding stream.

Building wealth through institutions and social capital

In building wealth and financial capital to fund adaptation projects, Ann Arbor and Grand Rapids emphasized institutions and social capital respectively. The existence of an energy office helps both cities save money by identifying energy efficiency improvements across city departments (Public official, Grand Rapids 2011; Public officials, Ann Arbor, 2011). Grand Rapids' Office of Energy and Sustainability also identifies grants to fund projects, and the Ann Arbor Energy Office administers the internal revolving loan fund.

A former public official explained the origin and sustainability of the energy revolving loan fund, an example of Ann Arbor's institutionalized funding mechanisms. In 1988, the City issued bonds to pay for energy efficiency projects to 30 city buildings. By 1998, the involved departments had paid the bond, by allocating budget funds every year for debt service. Since departments were now receiving energy savings from the bond-funded efficiency projects, the energy office continued collecting funds from other departments, but they reduced the amount collected. As the official described:

> *What if we give them a break and they only have to pay half of it now and we capture the other half and we create an energy fund? They'll be happy because this line item [for debt service] that they don't even remember what it was for, got half as big —they still have the energy savings from it. They're still not paying as much as they would, but it creates this method to finance this energy fund which I sold to the city and that enabled me to do exactly what I said, to walk over to the fire department over there and go, "Look you guys, you could do way better by doing this and I'll pay for it." So that just night and day on what the energy office could do. Before it was always just grants and whatever and all of a sudden we have this energy fund where we could walk out and actually do energy projects and then they pay the money back into the energy fund.* (Public official, Ann Arbor 2011)

Essentially, the energy office saves city departments money through efficiency improvement projects that lower their energy bills. City departments then pay part of their savings back into the revolving loan fund, which allows the city to continue financing efficiency projects.

Ann Arbor's stormwater utility and Greenbelt millage also exemplify its reliance on institutional mechanisms for funding adaptation. Through the City's stormwater utility, property owners are charged based on the area of impervious surface on their properties. This utility provides funding for stormwater projects, including urban forestry, green infrastructure, permit compliance, engineering inspection, and system maintenance. Regarding the utility, one City Official said, "We are actually able to do projects other municipalities are struggling to do because they don't have funding to do it" (Ann Arbor, 2011). (Additional information about the stormwater utility can be found in Chapter 7 and Chapter 8.)

Through the Open Space and Parkland Preservation Millage (popularly known as the "Greenbelt Millage"), Ann Arbor property owners pay 0.5 mills[13]. The City uses the revenue to purchase new parkland in the City and purchase development rights to preserve agricultural land and open space outside of the City. Surrounding townships provide additional funding for the program. Likewise, the Greenbelt has secured grants from the U.S. Department of Agriculture's Farm and Ranchland Protection Program in order to extend the millage revenue and purchase development rights on additional farmland. (See Chapter 7 for additional discussion about Ann Arbor's Greenbelt program.)

In Grand Rapids, social capital and philanthropic support have served to supplement declining wealth and financial capital (Discussed in detail in Chapter 10). In part, this comes in the form of partnerships with non-profit organizations, such as Friends of Grand Rapids Parks, that help fundraise to supplement the City's resources. Several informants said that having a separate non-profit organization helped secure grant funding and volunteer hours, since individuals and foundations prefer to give to non-profits rather than to City departments.

Similarly, partnering with the Red Cross and Salvation Army on disaster preparedness and response brings "a workforce to the table that the city and county couldn't afford" (NGO representative, Grand Rapids, 2011). Further, to supplement these resources from non-profit organizations, Grand Rapids and Kent County enlist Community Emergency Response Teams (CERT), which train civilians to assist during emergencies, and Radio Amateur Civil Emergency Service (RACES), a group that provides emergency communication support during disasters. Officials estimated that these groups provide "up to a million dollars' worth of man-hours" through their service (Public official, Grand Rapids, 2011).

Moreover, Grand Rapids enjoys additional financial support as a result of area-based family foundations that invest locally. One City official said,

> *I think what's interesting with Grand Rapids, if there's a really great idea out there, part of it is I think the families that are here, the foundation, the families, the DeVos' and Van Andels and Frys and Weges and, they or other community members with assets or the Grand Rapids Community Foundation. If it's a really good idea and it's broadly supported, somehow it happens. You might have to work your butt off to get it, but you can make it happen*. (Public official, Grand Rapids, 2011)

Grand Rapids' rich stock of social capital complements and substitutes for deficits in wealth and financial capital to preserve the overall adaptive capacity of the community. (See Chapter 10 for additional discussion of how social capital contributes to adaptive capacity in Grand Rapids).

Wealth begets wealth

In both communities, having some level of wealth was necessary for acquiring additional wealth or maintaining resources. This occurred through three key mechanisms: securing local matches for grants, hiring specialized personnel skilled in securing grant funding, and adhering to a regular maintenance schedule for infrastructure to protect capital investments.

[13] A mill is 1/1000 of a U.S. dollar of assessed property value.

First, many grants require a local match, which limits the ability of cash-strapped communities to secure additional funding. For several projects in Grand Rapids, foundations and community groups provided the local match. For instance, for Urban Forestry grants from the State of Michigan's Department of Natural Resources, the Grand Rapids Community Foundation and the Dyer-Ives Foundation provided the local match. Ann Arbor, through its institutional funding sources, has similarly been able to find a match for grants. One interviewee said,

> *Most of the federal dollars we get are in the form of grants, so I mean, just competition for those grant funds increases so the good thing about Ann Arbor though is that they have put themselves in a position, typically when you get federal grants you have to have a local match, a local participating fund. A lot of communities can't come up with that local match. And the City has put* [itself] *in a position to secure those dollars because we are able to meet that local match.* (Public official, Ann Arbor, 2011)

In addition to securing grants, Ann Arbor has been able to qualify for loans by having local resources available. One official said Washtenaw County has been able to access the State Revolving Loan Fund (SRF) for stormwater management projects by having local matching funds available.

> *in the last couple of years we've been able to do a couple of projects that we wouldn't have been able to do if SRF money wasn't there and if we didn't have a stormwater utility so the county gets access to this low-interest loan money and we have the financial capability of paying it back* […]. *So they finance the projects, we pay them back. And we've gotten way more money than any other community in the state, like 75% of the money they've given away for the last six year.* (2011)

In addition to providing a local match, having enough financial resources to hire key staff people (or invest in human capital) has helped both Ann Arbor and Grand Rapids secure additional funding. For instance, one informant said, "We have a grant writer that kind of checks what is on the radar looking for grants that are available at the state and federal level and in writing grants to secure funding to supplement our project funds" (Public official, Ann Arbor 2011). Similarly, in commenting on Ann Arbor's success in pursuing innovative energy efficiency and renewable energy activities, a City official said, "there is a full time staff person whose job it is to think about energy issues and to go and write grant proposals to bring in money to do things and […] set up an internal revolving loan fund that we can use to pay for projects sometimes when we don't have outside funding" (Public official, Ann Arbor, 2011). Informants attributed their success in securing grant funding to having dedicated personnel who knew how to find opportunities and navigate the application process.

Finally, having access to financial resources is important to preserving infrastructure and maintaining cities' long-term financial stability. For instance, one City official said,

> *When funding dries up or gets limited, then our ability to do road reconstruction projects isn't feasible. That's when the condition of the roads goes down and it costs more than when you get the money to go back in and reconstruct* […] *we prioritize but if you don't have the funding, you can't knock off as many on the list as you would normally want to and you can't necessarily be in*

> *pure preventive mode; you end up being more reactive mode because you have to wait until the funding becomes available and you can afford it. And by that time, your infrastructure has gotten so bad, so degraded, that you have to just outright replace it and it costs way more money to do that than it does to do preventive maintenance*. (Public official, Grand Rapids, 2011)

Similarly, another City official said,

> *And the scary thing in that is that there's an exponential component to this; is that for every dollar you defer in maintenance, eventually you spend five to seven dollars to reconstruct the street. So if you're not doing joint repair and you're not resurfacing when you should, eventually the road system fails and you're down to the subgrain and you have to rebuild the whole thing. So by doing all this deferred maintenance and not doing what we should, we're going to pay more in the end. But by a lot.* (Public official, Grand Rapids, 2011)

As these officials note, maintaining a base level of wealth is important to preserving cities' capital assets and, consequently, their long-term financial health.

Limits to wealth and financial capital

Although interviewees suggested that, overall, wealth and financial capital was critical to the adaptive capacity in their City (primarily through enabling infrastructure, human capital, information, and technology), reducing wealth did not necessarily lead to a reduction in adaptive capacity in all instances. For instance, officials in Grand Rapids reported that the City had contracted its emergency management services out to Kent County to gain efficiencies, and the environmental services department consolidated its field staff to gain efficiencies (Public official, Grand Rapids, 2011). Officials suggested this consolidation would streamline service delivery and improve overall efficiency without compromising the overall resilience of the community. Similarly, interviews highlighted ways in which budget constraints forced them to think strategically about streamlining capital improvement projects to use resources more efficiently. One respondent said:

> *What we do is we try and maximize our reconstruction funds by saying, okay, well, if I got to go in and replace a water main and I have to replace a sanitary sewer, I'm going to use road dollars that I might have obtained a grant from the state to reconstruct road service and so then the water and sanitary sewer system funds are not taxed as heavily as if they were going in and just doing their particular element.* (Public official, Grand Rapids, 2011)

The City of Ann Arbor cross-trains its field personnel to gain efficiency (Public official, Ann Arbor, 2011). Another public official in Ann Arbor referred to Governor Snyder's use of incentives to encourage cities to share services (Public official, Ann Arbor, 2011).

The opportunities for untapped efficiency gains should not be overemphasized, however, as both communities have faced financial constraints for a long time. Indeed, several interviewees commented that the cities were at a point that further budget cuts would significantly constrain their adaptive capacity. One City official commented specifically about how State budget cuts were constraining the City as follows:

> *So most of the general fund activities in the city are mostly, I mean, the majority of it is the police and fire. And as you get less state revenue, you have less local dollars to fund those operations, so police and fire have experienced decreases. I mean, we've been in decrease mode for those dollars for years at this point. So I mean, you can look for grants and all those different kind of funding sources and decreasing your work force, but I mean, I think we're kind of at a point where you can get as much efficiency as possible and then you're kind of at the bottom. So I think that's kind of where we are right now. I think we've cut as much as we're going to be able to.* (Public official, Ann Arbor, 2011)

Additionally, an informant in Grand Rapids reported that consolidation has made working with the Parks and Recreation Department difficult, which may undermine the City's ability to rely on social capital to complement its work in the face of declining budgets. Parks staff has declined since 2002 from 80 full-time employees to 23 at the time of our interview, and both city staff and an NGO representative said that this had negatively impacted the department's functionality. An official explained that the Parks Department has been rolled into the Public Services Department for efficiency reasons, and that some parks functions had been moved to other departments (Public official, Grand Rapids, 2011). Due to the perception that parks functions have been dispersed throughout the city bureaucracy, an NGO representative expressed frustration that a partnership created through Green Grand Rapids has been difficult to maintain (NGO representative, Grand Rapids, 2011). This individual felt that his group lacked a strong support within the City's structure, due to the decentralization of parks functions and the City's failure to "follow through" on Green Grand Rapids initiatives because of budgetary limits. In this case, budget cuts and institutional fragmentation seem to undercut the social capital and political capital built through the Green Grand Rapids public engagement effort.

Our more optimistic informants reported that Grand Rapids has done an exemplary job of using social capital as a supplement for financial resources, as exemplified through the City's empowering of "champion" groups to implement Green Grand Rapids initiatives. The lesson may be that social capital can supplement institutions during hard economic times, but the City must provide some level of support to empower those groups. Otherwise, the City loses the groups' support (political capital). Therefore, although reducing wealth may not necessarily reduce a City's adaptive capacity, there are limits to Cities' abilities to adapt to such budget cuts. Wealth and financial capital remains a critical determinant of AC.

Key Relationships

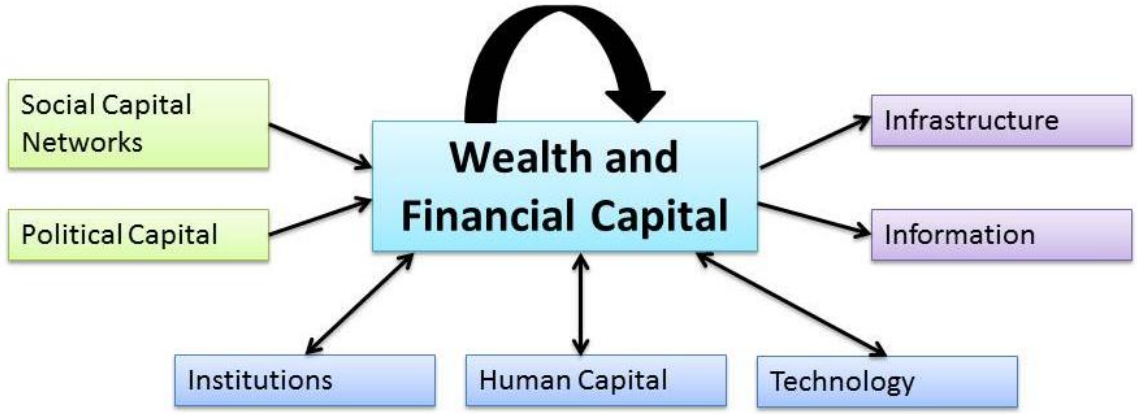
As described above, wealth and financial resources contribute critically to the adaptive capacity of Ann Arbor and Grand Rapids by funding the development and maintenance of infrastructure and resources, funding staff positions, and providing access to information and technology. Both case study cities drew financial resources from diverse sources although Ann Arbor emphasized institutional funding sources while Grand Rapids demonstrated a comparative emphasis on social capital to enhance financial capital. As these points illustrate, wealth and financial capital interacts with other determinants, enabling and constraining some and being enabled and constrained by others. **Table 9.2**.

and **Figure 9.2** summarize the most significant relationships between Wealth and Financial Capital and other determinants that emerged during this study.

Table 9.2. Key Relationships between Wealth and Financial Capital and Other Determinants in our Case Cities

Determinant	Relationship with Wealth and Financial Capital
Institutions	• Institutions at all levels (Federal, State, and City) key to building/providing wealth and financial capital • Bureaucracy (such as grant reporting requirements) viewed as barrier • Need disaster declaration to get FEMA money • Institutions can provide some level of security for funding sources (e.g., utility revenue as more stable than relying on grants or other sources)
Infrastructure	• Cost limits infrastructure investments and specifically green infrastructure investments (e.g., porous asphalt) • Availability of funding can drive infrastructure toward greener alternatives (e.g., funders requiring LEED certified buildings to support capital campaign)
Social Capital	• Social capital can supplement wealth (by using volunteer networks, for instance) • Community groups and foundations help with fundraising, building support for initiatives that were typically done by cities
Political Capital	• Congressional earmarks provide funding for special projects • Lack of political will to introduce new taxes/millage to support projects • Conversely high level of political capital can support millage/new funding streams • Tight budgets constrain political climate/ability to take on new initiatives (laying off firefighters and cops is not the time to talk about climate)
Human Capital	• Having dedicated staff positions helps cities find and secure additional funding • Budget cuts lead to layoffs
Information	• City has to pay to access certain information
Technology	• City needs money to access and use technology

Figure 9.2. Key Relationships between Wealth and Financial Capital and Other Determinants in our Case Cities



Social capital networks enable wealth and financial capital by providing volunteer labor and community support. Similarly, political capital builds wealth and financial capital; political leadership is needed to implement new taxes or for congressional earmarks, for instance. Human Capital has a mutually reinforcing relationship with Wealth and Financial Capital; wealth is necessary to pay staff and entrepreneurial and innovative staff build wealth. Similarly, wealth is used to purchase technology and some technologies, particularly energy efficiency technology, build wealth. Likewise, institutions (such as taxes and government grant programs) provide wealth and wealth is necessary for the functioning of institutions. Wealth and Financial Capital builds infrastructure and information as money is necessary to purchase information and build and maintain infrastructure.

Chapter 10: Social Capital Networks

Social Capital Networks Background and Definition

Scholars have routinely identified social capital as a critical determinant of adaptive capacity (Pelling & High, 2005; Adger, 2003b). Bordieu described social capital as "the sum of the resources, actual or virtual, that accrue to an individual or a group by virtue of possessing a durable *network* of more or less institutionalized relationships of mutual acquaintance and recognition" (Bourdieu & Wacquant, 1992, p. 119). Putnam, who considers social capital more as a collective social structure than the "private property" of benefited individuals, defines it as the "features of social life—*networks*, norms and trust—that enable participants to act together more effectively to pursue shared objectives" (Putnam, 1993, p. 170; Putnam, 1995, p. 664–665). Pelling and High (2005) strike a balance between these public and private conceptualizations, defining social capital as "informal *networked* relationships built on norms of trust and reciprocity" (p. 313).

The formation and definition of social capital is contextual and can vary widely across systems, culture, geography, and time and scale (Pelling, 1998; Leonard & Onyx, 2003; Pelling & High, 2005; Adger et al., 2007). Social capital may exist informally between individuals or collectives, in formalized and institutionalized organizations that create bonds amongst their members or in networks tied by shared interests or identities (Pelling, 1998; Pelling & High, 2005).

Social capital and networks build over time, through the cumulative effects of a series of positive interactions and growing rapport between participants. Social relationships form via "bonding ties" in which individuals "co-identify" with a social or cultural group (e.g., race, religion, gender, or political party) or via "bridging ties" which transcend identity and instead

SOCIAL CAPITAL NETWORKS

Social relationships, individual or collective, formal or informal, which function on the merits of trust, reciprocity, and shared interests

INCLUDES

Public-private partnerships, particularly those between city governments and civil society collaborators; organized community leadership and social networks; inter-jurisdictional and intra-government coordination and collaboration, as well as interpersonal connections between city staff and external organizations

KEY FINDINGS

- Access to, and participation in, personal and professional social networks can increase access to resources and improve public perceptions of political leadership's activities.
- Social capital networks can facilitate access to information, financial capital, human resources, technology, and political capital.
- During periods of challenging financial times, social capital networks can help cities to leverage financial and human resources and to access additional funding streams for urban adaptation initiatives.

bind people by shared interests and the potential for mutual gains (Pelling & High, 2005; Adger, 2003b). Many studies suggests that social capital and networks can enable actors to meet shared objectives through shared norms and trust and can provide mutually beneficial interactions (Putnam, 1995). Adger (2003b) points out that "at its core, social capital describes relations of trust, reciprocity, and exchange; the evolution of common rules; and the role of networks" (Adger, 2003b, p. 389). Such trust can build from a series of actions in good faith, through reputation and word of mouth, via perceived legitimacy as conferred by a particular role or title, as well as through positive interpersonal interactions. Social capital networks may help to supplement the resources one lacks be they human resources, material resources, financial resources, information, or political capital.

Social capital networks critically shape people's capacity to adapt to climate changes (Adger et al., 2007). The literature is rich with examples of the ways in which social capital both enables and constrains adaptive behaviors. Social capital networks serve as both formal and informal institutions and are shown to provide both physical and psychological benefits in managing risks, and in responding to, and coping with, adverse events. Development and expansion of social and organizational bonds and networks are generally thought to increase adaptive capacity by helping to reduce vulnerability and increase resilience and the coping mechanisms of systems (Adger, 2001). These networks also may allow access to additional capital and resources to enact successful adaptation strategies (Yohe & Tol, 2002; Eakin & Lemos, 2006; Adger et al., 2007).

The existence and density of government-civil society partnerships are thought to be an integral factor in providing synergistic benefits in coping with climate change because they allow greater access to assets and information beyond their individual means (Adger, 2001). For example, Semenza et al. found that increased social connections and social interactions correlated with lower rates of heat-related death in a Chicago heat wave (Semenza et al., 1996). Community-based disaster management strategies focus on highlighting the strengths that social networks can bring to bear in adapting to climate-driven events (Allen, 2006). A lack of sufficient social capital is thought to increase vulnerability to climate impacts, by having the effect of excluding some groups from access to beneficial information and asset networks (Adger, 2003b; Few, 2007; Cutter, Boruff, & Shirley, 2003).

Conversely, some evidence suggests that strong bonding ties can also increase vulnerability in certain contexts, for example, if individuals listen to the advice of peers in lieu of that of emergency response or aid personnel or local weather reports, and therefore effectively put themselves in harm's way (Wolf et al., 2010). In this way, social capital networks can function in a perverse role (Wolf et al., 2010; Rubio, 1997). Further, participation in some social or information networks may not be advantageous, or viewed favorably in public opinion. They may, in fact, be viewed adversely or exacerbate partisan or ideological divides.

Social relationships may include local networks, public-private partnerships, state-civil society relationships, organized community networks, as well as interpersonal relationships between city staff. Here we define social capital networks to include such social relationships, individual or collective, formal or informal, which function on the merits of trust, reciprocity, *or* shared interests. These networks can help to facilitate shared goals and objectives through more effective coordination and

integration (Ebi, 2008). As municipal governments are the foci of our research, in examining social capital networks we focus primarily on the partnerships developed between city institutions and civil society collaborators in these two case cities, as well as the interpersonal connections between governmental staff at various levels of government (e.g. city, county, state). Variables include the presence of civil society networks and collaboration amongst city government and external parties, as well as inter-jurisdictional collaboration, and intra-government coordination. At times it included the rapport that notable community leaders developed within and among organizations, governmental and non-governmental alike. For this study, community leadership was treated as distinct from political leadership, which is covered more fully in Chapter 11.

Informants were asked the following questions in order to assess the role of social capital networks in these case cities.

- Who are your collaborators on adaptation initiatives?
- In what ways do you work with other community partners on adaptation initiatives?
- How does these collaborations influence your work?
- How effective are those collaborations?
- Are there any barriers to those types of collaboration?

Social Capital Networks in Ann Arbor and Grand Rapids

Drawing on the literature, we made the assumption that social capital and social capital networks would play a formative role in cities' ability to adapt to climate change. Indeed, both case cities exhibited strong interactions between city government and community organizations, local academic institutions, as well as the private sector. Such alliances helped to build and expand upon city resources, but also to identify new opportunities for collaboration and exchange within the community. Networks with non-governmental organizations provided valuable resource-sharing prospects to local governments, including leveraging financial resources, adding human resources, expanding knowledge and information, and adopting technological innovations. They also sometimes helped to bolster public support and improve political capital on an issue.

We found partnerships to be particularly effective when the participants were able to capitalize upon the strengths and assets of one another, especially when complementarities of functions and resources were present (Evans, 1996). Partnerships functioned best when each party had something to offer that the others did not, such that the exchange was necessary, mutually beneficial, and invaluable. Partnerships can facilitate increasingly efficient division of labor between multiple parties with each specializing in their strengths. Complementarity also facilitates mutual benefits especially through collaboration. For example, civil society may have additional human capital to lend to projects through access to a strong volunteer base, or may have access to additional funding streams, whereas city governments have institutionalized structures, greater legitimacy, and jurisdictional rights.

Asset sharing through collaborative networks

Expanded collaboration in these cities often stemmed from the common impetus to leverage and mutually benefit from shared resources. One city official noted, "I think the critical piece for us, really, is the ability to partner and leverage resources…we've got so many great minds in the region and the state that you can tap into those resources without reinventing the wheel" (Public official, Grand Rapids, 2011). The official continued, "Well, it's always a resource issue, however, I think with good ways of integrating different players, different stakeholders, locally engaging community members…. there are resources out there that we just need to tap into….we don't need to invent anything" (Public official, Grand Rapids, 2011).

Financial resource sharing:

Several respondents cited the lack of sufficient funding as a significant constraint to adaptation activities (Public officials, Grand Rapids and Ann Arbor, 2011). Still, the lack of money was not always a constraint as creative and motivated people found innovative ways to work around it, particularly by using social capital networks. A city official commented, "You hear those excuses, well, we can't do it because we don't have any money, well, yeah, it's harder because you don't have any money, but it's not impossible" (Public official, Grand Rapids, 2011).

In the wake of the global economic crisis and budget shortfalls, external collaboration became an increasingly valuable resource to cities. Staff and budget shortages can motivate local governments to reach to seek new civil society alliances and forge new partnerships and networks. Partnerships with civil society and the private sector can help cities to access new funding channels, to gain added opportunities for leveraging funds, and to other cost-saving measures. In challenging financial times, social capital networks helped cities to leverage and pool both financial and human resources and also to access additional funding streams for urban adaptation initiatives.

Indeed, in challenging financial times respondents looked to unorthodox funding channels and both cities cited increased reliance on public-private partnerships. Ann Arbor has obtained such efficiencies by engaging in public-private partnerships for its recycling and composting needs (Public official, Ann Arbor, 2011). The city also collaborates with a local NGO, the Clean Energy Coalition, in the Property Assessed Clean Energy (PACE) on energy efficiency issues. The City of Grand Rapids has relied heavily on civil society for program implementation in several sectors. There we found the Friends of Grand Rapids parks implementing the Green Grand Rapids plan, the West Michigan Environmental Action Council working on stormwater initiatives, the Urban Forestry Committee working on tree canopy goals, along with local kayaking and biking groups implementing recreational programming (Public official, Grand Rapids, 2011).

Several of our respondents noted that civil society sometimes has access to funding streams that city governments do not, including grant funding as well as donations from the private sector or community members which the government would otherwise need pay for (NGO representatives, Grand Rapids, 2011). Community members were often more willing to voluntarily donate tax-deductible monies to a local non-profit than to commit to paying additional taxes to the city. The private sector has played such a role in emergency response efforts by providing construction material and transportation

aid much more quickly than those resources could have otherwise been galvanized (Public official, Grand Rapids, 2011). As a local NGO representative stated, "If the county needs a bull dozer, they are going to have to pay for a bulldozer. If [we have] a relationship with a business, we may be able to get that business to donate to us as a non-profit—you know what I'm saying? ….set up those kind of relationships…" (NGO representative, Grand Rapids, 2011). An emergency response official noted,

> *And that's a perfect example of what non-profits bring to the table….we could bring—between the two of us, we could bring 50 pallets of water into this community within two hours. And everybody else is looking around the table going we would never be able to do that much water. We can pull on not only our stockpiles but on our donor relationships… If we go into a store and say we are the Red Cross and we need your help, we will probably get a very positive response, whereas, a county official that goes I'm with [the County] and I need some donated water, it doesn't—it doesn't go quite as far.* (NGO representative, Grand Rapids, 2011)

Local community organizations were sometimes able to provide in-kind matches for grants, as occurred in Grand Rapids to facilitate a tree inventory, tree map, and urban forestry plan (NGO representative, Grand Rapids, 2011). Similarly, the West Michigan Environmental Action Council and Friends of Grand Rapids Parks were able to secure grant and philanthropic funding for water quality and green infrastructure projects, respectively. One interviewee commented, "It was real partnership of you, 'go look here, I'll go look there, and we'll come up with something'" (Public official, Grand Rapids, 2011).

Sometimes it is more efficient for cities to have civil society take the reins of certain projects. This was evidenced by the Radio Amateur Civil Emergency Service (RACES) team in Kent County, which is an independent team of "weather spotters" in the event of severe weather, who are some of the 'eyes and ears' on the ground (Public official, Grand Rapids, 2011). Such civil society efforts have emerged in both cities around water quality issues, urban forestry and green infrastructure, biking and alternative transportation, and around urban agriculture in Ann Arbor.

Several respondents in Grand Rapids cited that networks of public-private partnerships are long-held traditions in Western Michigan and that community collaboration helps to contribute to the local 'character' of the region. There, we found several examples in which private industry collaborated with the city to promote, create and maintain local green spaces and parks, sometimes even providing the initial capital and assuming responsibility for the upkeep and maintenance in exchange for the ability to schedule and host events on public lands (Public official, Grand Rapids, 2011).

Human resource sharing

By collaborating with local organizations, cities can save a great deal of resources on labor and human resource costs, while gaining an added knowledge base and expertise. For example, sometimes local academics are able to provide valuable services at a far lesser cost than would hiring additional staff (NGO representative, Grand Rapids, 2011). Grand Rapids exhibits strong evidence of the role of social capital networks in capacity-building through its collaborations with local academics. Examples include the "Mayor's Science Team," a team of local scientific "experts," and the "Transformation Research Analyst Team" which provides technical and economic expertise (Public official, Grand Rapids,

2011). The City of Grand Rapids has a partnership agreement with Grand Valley State University that allows the city to gain an influx of cost-effective human capital from internship programs, and the University to offer valuable 'real-world' learning experiences for their students (Public official, Grand Rapids, 2011). Similarly, the City of Ann Arbor partners with the University of Michigan in variety of capacities from energy research to transportation collaboration to internship and educational opportunities (Public official, Ann Arbor, 2011).

Our informants reported that civil society was more effective at summoning project volunteers and planning, coordinating and monitoring volunteer efforts than were city governments. This asset provided opportunities for partnerships between city governments and civil society. A community urban forestry group in Grand Rapids provided a strong example of this - they organized a large tree planting initiative by summoning a sizeable group of community volunteers. Another prime example was the Friends of Grand Rapids Parks, a prominent parks advocacy group who worked diligently with city government to forge a base of volunteers to aid with green infrastructure projects (NGO representative, Grand Rapids, 2011; Public official, Grand Rapids, 2011).

> *And, to us it made a whole lot of sense that the Friends group could help to do exactly as they are doing, you know, building advocacy, being able to respond to those volunteer groups that, unfortunately, we as a department—we were able to do some things, okay, depending on the organization and how many people. But we were limited. We did not have the capacity to be able to accommodate as many volunteers as wanted to be involved in their parks through various efforts.* (Public official, Grand Rapids, 2011)

Certain civil society groups can attract volunteers through personal or moral appeal or a sense of goodwill. The Red Cross noted, "But, especially as the community learns that Red Cross is responding, that Salvation Army is responding, that there is a response going on, then we will start getting the phone calls from people saying I have this resource I would like to put it to good use"(NGO representative, Grand Rapids, 2011).

We found that both cities rely on their partnerships with other jurisdictions and with civil society in emergency response. Grand Rapids in particular has a notably strong emergency volunteer base and effective networks and collaboration amongst a variety of partners,

> *So we also bring sort of that expertise of we have been doing it for 150 years; we know how to work with partners; we know how to help other non-profits have a role in this disaster. That means you don't have to have 3,000 seats in EOC [Emergency Operations Center]. You can have the Red Cross and the Salvation Army helping to coordinate the response of some of these smaller non-profits….And then, in terms of sort of resource coordination, we bring a workforce to the table that the city and county couldn't afford.* (NGO representative, Grand Rapids, 2011)

A key to success in effective disaster preparedness and management appears to be organizing and practicing with others, to draw and build upon one another's' strengths. An emergency management official stated,

> *There's a reason why they call them disasters. So if you practice regularly with other organizations, things tend to go better…. When bad things happen you end up in this room* [Emergency Operations Center] *and it's really chaotic; it's extremely stressful. But when bad things happen people come together. They work hard. There are generally not turf wars*. (Public official, Ann Arbor, 2011)

Grand Rapids also attested to the importance of civic groups in the implementation of many of its policies and programs; officials went so far as to suggest that implementation would not have been feasible without the support of local groups. The Green Grand Rapids Plan is as an example of positive synergy between institutions and social capital. Green Grand Rapids is a Master Plan update that set a community vision for three themes contained within the original Master Plan: "balanced transportation, city that enriches our lives, and city in balance with nature" (Public official, Grand Rapids,2011). Several public officials lauded the planning department's outstanding public engagement work through the Green Grand Rapids planning process. A project leader explained that partnerships with "champion groups" are key to the plan's implementation. Accordingly, lack of resources and drastic cuts to city staff caused the planning department to realize that it would not be able to implement all of the Green Grand Rapids' recommendations. Through the planning process, the city and the public worked together to form groups who would use the Green Grand Rapids as an implementation guide. Meanwhile, the planning department ensured that the city was "not in the way" and provides "credibility and support" for the champion groups (Public official, Grand Rapids, 2011). The champions carried the plan's vision forward, but the Plan provided a mandate and support—which proved critical to the groups' ability to raise funding (Public official, Grand Rapids, 2011). Additionally, the champion groups also supported each other, even on issues outside their particular areas of concern. A public official summarized the benefit of activating networks through Green Grand Rapids:

> *What's really nice is that we, the whole, one of the whole ways we've designed this is that we're setting this whole framework of a network of support among the various champions, as well as the city. And a plan, a vision that you can represent to funders about what you want to do. So they see the vision, they see the collaboration, and what's really interesting is depending on the topic, I mentioned earlier there's this, you know everything is kind of interrelated, so what's funny is that, I think almost all of the champions were all on Facebook together and so you'll see these Facebook postings of, or even the transit millage, when the transit millage was going, you saw the champions then championing the transit millage, even though it wasn't their particular parks topic, it's tied to Green Grand Rapids and it meets the overall Master Plan goals, so there's a piece of ownership in the transit millage, even though it might be the parks person*. (Public official, Grand Rapids, 2011)

Personal social ties

Strong interpersonal relationships and networks can serve to forge government-civil society alliances, and to help promote collaboration. This occurs functionally in terms of ease and efficiency, personal rapport and trust, but also serves to increase credibility and legitimacy amongst collaborators. Several respondents spoke to the role of close social bonds and interpersonal relationships in helping to create positive working relationships. Officials in Grand Rapids frequently cited long-standing personal

relationships and connections as influencing their professional collaborations. These types of personal friendship developed amongst several government staff, perhaps notably for City officials in high-level positions, and working relationships also developed with the business and NGO communities. In Grand Rapids, strong friendships were routinely cited as facilitating collaboration and working efficiency in emergency response between NGOs and city government, and even at the inter-jurisdictional level between city and county (Public officials, Grand Rapids, 2011). One official commented on how his personal friendship with another colleague improved emergency response collaboration across jurisdictions,

> *Actually, the emergency management coordinator…he and I have worked very closely ever since I was given the position, to help—I don't want to say coordinate but to simplify, and there was a very large disconnect between the county and the city. So because [he] and I know each other from church, our kids went to school together, a lot of those things, we said, hey, here's a great opportunity for us to mend all that stuff and kind of refocus. So where we've worked to get to this point is that we mirror each other—our programs do. So that it doesn't matter whether it's an incident that's outside of the city… or if it happens here, a lot of our processes and procedures are identical.* (Public official, Grand Rapids, 2011)

Time and again respondents noted that allies work with other allies; people tend to work most collaboratively with people they know and trust, "Practically, though, again, it's about relationships…there's all kinds of connections that are just there because somebody knows somebody else. Half the staff here went to [local university], which is a good, you know, connection…you know, so there are connections that get made" (Public official, Ann Arbor, 2011).

Building political capital through social capital networks

Local governments can bolster resource capacity as well as gain increased public buy-in and political support by reaching out to civil society collaborations. Civil society and community groups are sometimes more effective at galvanizing public support (or opposition) to an issue, or creating community buy-in for a proposal, than are city governments (NGO representative, Ann Arbor, 2011). Civil society may be more effective at stirring up public and media attention, drawing enough political momentum and traction to open a "window of opportunity" for city officials to act with public support (Public officials, Ann Arbor, 2011). Engaged populations in both cities organized and galvanized support for issues, which routinely resulted in increased political capital and community buy-in for projects generated from the ground up (Public official, Grand Rapids, 2011). The West Michigan Environmental Action Council has played such a role in Grand Rapids, helping to draw attention to storm water issues and to encourage public support for a fee-based water preservation structure (Public official, Grand Rapids, 2011). The City of Ann Arbor used citizen engagement in regional stormwater planning in which local interested citizens organized and drew attention to improving water quality in a local creek and successfully initiated a regional watershed plan. Their actions helped to draw attention to the issue and build political momentum for the cause. One city official noted, "If we didn't have this interested citizenry, it would have been much more difficult" (Public official, Ann Arbor, 2011).

Officials in both cities cited examples of grassroots groups' influence on policy decisions. For example, Ann Arbor's first energy plan—published in 1981—emerged out of the efforts of about 100 residents who created committees and wrote guidelines for energy management (Public official, Ann Arbor, 2011). Their guidelines included the creation of an energy office, to which several public officials attribute the City's success in setting and achieving efficiency goals. Similarly, a group of citizens in the Malletts Creek watershed organized themselves around the City's project to write a watershed management plan in the year 2000. A few years into the plan's implementation, the group—called the Malletts Creek Association—sent a list of additional recommendations to City Council. As a public official relays, "So they said, the council said, take these new recommendations and incorporate them into your efforts. And one of them was to regulate single family" (Public official, Ann Arbor, 2011). This official attributes the city's stormwater rules for single family homes to the Malletts Creek Association's advocacy efforts. The City now requires stormwater infiltration or detention if a single family or duplex homeowner adds more than 200 square feet of impervious surface to his or her property.

Similar examples of grassroots advocacy emerged during our interviews in Grand Rapids. One public official recalled that a neighborhood group had advocated for the City to start a program to disconnect footing drains from the sewer system. Footing drains contribute to system overflow during heavy rains, and the City is under state mandate to control combined sewer overflows. Supported by citizen advocacy, the City's engineering department spearheaded the creation of a footing drain disconnect program. The City also passed an ordinance allowing the department to require participation in neighborhoods where footing drain connections contribute significantly to sewer flow volumes. A different neighborhood group also conducted a tree inventory, establishing a model that the City followed when it conducted its wider scale street tree inventory. A leader from that neighborhood group recalled that a public official had "said that our neighborhood was really pushing the city in terms of its urban forestry efforts and sort of leading the way" (Public official, Grand Rapids, 2011). Simultaneous to the neighborhood tree inventory, the City created an Urban Forestry Committee, on which the aforementioned neighborhood leader served. The Committee worked with city staff to create an urban forest plan, which called for a citywide tree inventory. In Grand Rapids, civic groups have helped lead the City in its policy and planning efforts.

Figure 10.1. Community tree planting in Grand Rapids. Photo by: Santa Fabio. The Alliance for Community Trees. Source: The Rapidian "Grand Rapids to Celebrate National NeighborWoods Month." Accessed from http://therapidian.org/grand-rapids-celebrate-national-neighborwoods-month.

In Grand Rapids, The Community Sustainability Partnership (CSP), a network of over 200 organizations working in tandem on sustainability issues is a great example of how networks and social capital create adaptive capacity and promote community participation and increased buy-in. It emerged from a partnership between the City of Grand Rapids and local academic institutions, including Grand Valley State University, Grand Rapids Community College, Aquinas College, and Grand Rapids Public Schools, and subsequently expanded to include local businesses, NGOs, and religious groups (Public officials, Grand Rapids, 2011). The CSP provides members with the forum to aid one another in the design and development of sustainability goals, in implementation of their plans, and in deriving common metrics and assessment tools. In describing the partnership, one city official said,

> *What I'm really proud of is the ability to work with…other organizations in the community…on our CSP, people…work together on a common theme, common issue, which is sustainability. I think that's a huge accomplishment for any community, to have that kind of buy-in for an idea that may have been dismissed five, six, seven years ago as you know, liberal thinking… but I would say that our ability to just draw on different resources is a huge accomplishment. Not to mention we've got a lot of projects, but all of those projects would be nothing if you don't have that kind of support from the community and to have that kind of community engagement, in my experience, I really view, you know, these resource sharing and leveraging, our biggest accomplishment, biggest pride for me is our community, our engagement process, the ability to draw those people in and bring them together around a common goal.* (Public official, Grand Rapids, 2011)

Both cities also pointed out the strong involvement of key community leaders in jump-starting new initiatives. In addition to the role the Mayors and city leadership played, several respondents also cited the role of key civil society community leaders in the development of adaptation or adaptation-relevant projects. They mentioned notable community leaders including local philanthropists, businesspeople and NGO members have spearheaded and championed certain projects, and these individuals were often noted as being highly effective at forging social and organizational ties and forming networks to achieve their goals. Several individuals notably drove the success of urban forestry and parks initiatives, urban agriculture, as well as alternative transit programs. Some were philanthropists, some local business people, and others community members,

> *There are a handful of leaders who really believed in this community. They built their businesses here and raised their families here and they really had a desire for Grand Rapids to… stay the best small city in the US. So they've stayed here, they've given back here, they've raised their families here, they love this community and they have put a stake down and said we're not going anywhere. We're going to stay here and make a difference here.* (NGO representative, Grand Rapids, 2011)

Both political capital and social capital networks functioned synergistically to promote inter-agency coordination and collaboration, as one respondent described,

> *Cooperation and collaboration is the only way that you can be successful, and frankly you don't want to try and do it on your own because it's better when you mix it up and you diverse demographically well-represented, socioeconomically well-represented, and from a resource standpoint, a wide array of resources available from across the community that are coordinated and ready in the event of a significant incident. So you want all those tools in the toolbox. You want the toolbox open at all times. …..And anyone that tries to do it any other way, they get met with a lot of political resistance and oftentimes are isolated and very ineffective*. (Public official, Ann Arbor, 2011)

Still, in some circumstances civil society partnerships can have unexpected or perverse outcomes. One respondent noted that participation in a regional urban information collaborative was proving increasingly contentious in the current political climate. Far Right Conservatives were "demonizing" the organization as part of a broader "one-world government" agenda and, consequently, participation in the network could be viewed unfavorably by some members of the populace (Public official, City of Ann Arbor, 2011).

Our data reveal a great deal of interaction between political capital and social capital in these two case cities. These two determinants appear interconnected in a positive feedback loop where, functionally, the interchange works both ways: political capital can enable social capital, yet social capital can summon political capital. Several respondents cited the interwoven fabric between political and professional relationships; political ties and appointments were sometimes wedded closely with interpersonal relationships. Well-connected political leaders often came to be that way through social

networks, and work to maintain public perception through continued engagement (Public officials, Grand Rapids and Ann Arbor, 2011).

Networks for exchange and innovation

In addition to providing cost-savings and the addition of human resources, strong social capital networks can also improve and facilitate greater information exchange—whether amongst government employees, between city government and the community, or from city-to-city. Networks may facilitate the transmission of information and the development of new ideas and innovation (Public officials, Grand Rapids, 2011).

Partnerships with local universities and research institutes, the NGO community and the business community can all provide valuable sources of information exchange and collaboration (Public officials, Ann Arbor and Grand Rapids, 2011). Officials in Grand Rapids noted that both the Great Lakes and St. Lawrence Cities Initiative and "ICLEI - Local Governments for Sustainability" provide excellent forums for cities to exchange adaptation information with other cities both regionally and nationwide, while respondents in Ann Arbor emphasized the USDN network as an important exchange (City officials, Grand Rapids and Ann Arbor, 2011).

Moreover, social and information networks can help officials to reach out to vulnerable populations (e.g., the hearing impaired, blind, elderly, homeless, and refugees). Public health officials cited informal networks and word of mouth as integral to their public safety and emergency management precautions (Public officials, Grand Rapids, 2011). When asked how vulnerable populations were identified an interviewee replied:

> *That's one of those areas, too, where we don't want any one agency to do it alone. Oftentimes, counties are really keeping tabs on where the trailer parks or low-income communities, where there are clusters of elderly population or clusters of disabled populations. So Red Cross doesn't need to be out trying to map that out but a lot of times we are asking—Red Cross, Salvation Army and the emergency managers are kind of asking disability advocates, hey, what can you tell us about this community. And if there is a power outage in this community, how many people are going to have medical issues and things like that. So it is a really collaborative approach and it's typically coordinated by emergency management at the city or county level to try to do some of that creative mapping of where are the people that are going to be most vulnerable during this disaster. And heat wave is a good one that most heavily impacts either people with advanced medical conditions or the poorest of the poor, a typical thing like a tornado wiping out Joplin affects everybody. It takes everybody down to zero. So there are some disasters that seem to sort of pick out—you know, we talk about tornadoes targeting trailer parks. There do seem to be some disasters that affect a certain segment of the population more and then there are those disasters that just devastate everybody equally. (*NGO representative, Grand Rapids, 2011)

Conversely, respondents also suggested that the lack of effective coordination and social capital exchanges deteriorated the availability and exchange of information (Public official, Ann Arbor, 2011).

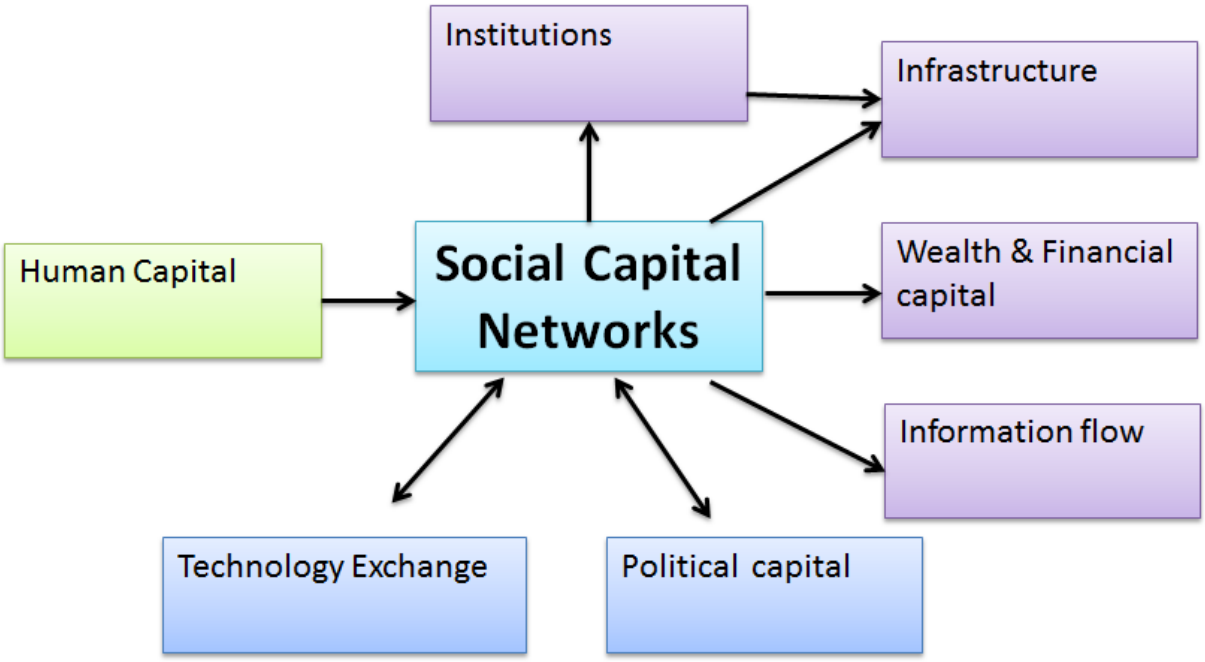
Key Relationships

Table 10.1 and **Figure 10.2** summarize our findings of the interconnections between social capital networks and the other determinants of adaptive capacity.

Table 10.1. Relationships between Social Capital Networks and Other Determinants in our Case Cities

Determinant	Relationship with Social Capital Networks
Institutions	• Cites collaboration and integration with external partners can improve access to resources • Home rule, jurisdictional, organizational and personal 'turf' impedes collaboration and deters integration across individuals or departments
Infrastructure	• Social capital in both cities has promoted the development of green infrastructure (i.e., urban forestry, parks, green roofs) • Social capital networks may have enabled the creative networks which improved design collaboration and innovation leading to leadership in LEED certified buildings • Inter-jurisdictional collaboration can improve public works projects
Wealth and Financial Capital	• Partnerships provide access to new funding channels, including grants and donations of money and goods • Public may be more willing to donate to an NGO than to City government
Political Capital	• Interpersonal connections help forge political ties • Partnerships can increase public perceptions and community "buy-in"
Human Capital	• Partnerships can provide additional labor and/or volunteers for projects • Expertise, skills and interests of individuals can facilitate social ties • Human capital of notable community leaders is favorable to social capital
Information	• Partnerships with other cities, local universities, NGO's and the business community serve as important information transfer channels. • Relationships between City staff and other organizations and entities (e.g., National Weather Service) improve access to information, which enhances emergency response • Information transfer between various emergency response entities from city to county to Red Cross to Salvation Army to NGOs to churches • ICLEI serves as an informational network, providing information exchange amongst cities • Grassroots networks, community organizing, social communication all speed the transmission of information • Lack of social capital/coordination can deteriorate information exchange
Technology	• Social capital may lead to effective information sharing, leading to innovation and technological adaptation • Social media speeds communication with networks, and promoted technological innovation • Enhanced social capital may facilitate acquisition of technological resources • Technological devices help to keep social communication lines open

Figure 10.2 Relationships between Social Capital Networks and other Determinants in our Case cities



Human capital contributes to building social capital. Social capital networks, in turn, can augment information flow, add to a city's base of wealth and financial resources, and contribute, along with institutions, in the creation of infrastructure. Technological media can provide the forum for social capital networks while social capital networks can, too, provide cities access to additional technological resources. Similarly, political capital can pave the way for new social networks; yet social capital networks can also forge greater political ties.

Chapter 11: Political Capital

Political Capital Background and Definition

While definitions and emphases vary across the adaptive capacity literature, several scholars have theorized political capital to be an integral factor in shaping a system's adaptive capacity. The importance and role of political capital may vary at different scales, manifesting differently at the municipal scale than at the state or federal level. Drawing on Hicks and Misra's work (1993) in political resource theory, Birner and Wittmer (2000) highlight two critical types of political capital: public and private. Birner and Wittmer (2000) term the private as "instrumental political capital" which they define as the "resources which an actor, i.e. an individual or a group, can dispose of and use to influence policy formation processes and realize outcomes which are in the actor's perceived interest" (p. 6). They distinguish it from public political capital, or "structural political capital" defined as "the structural variables of the political system which influence the possibilities of the diverse actors to accumulate instrumental political capital and condition the effectiveness of different types of instrumental political capital" (Birner & Wittmer, 2000, p. 6).

Building on the work of Smit and Pilifosova (2001) and Yohe and Tol (2001), Eakin and Lemos (2006) include political capital among a list of seven determinants of adaptive capacity. They define political capital to include, "modes of governance, leadership legitimacy, participation, decentralization, decision and management capacity, and sovereignty" (Eakin & Lemos, 2006, p. 10). Birner and Wittmer (2000) also include democratic electoral processes in their descriptions of political capital, and Booth and Richard (1998) further include democratic norms, voting, and access to public officials in addition to campaign activism.

POLITICAL CAPITAL

"Resources which an actor…can dispose of and use to influence policy formation processes and realize outcomes which are in the actor's perceived interest" (Birner & Wittmer, 2000)

INCLUDES

Leadership, motivation and vision, electoral and local politics, reputation and legitimacy, public perceptions of political leadership, political support gained through public participation and engagement efforts

KEY FINDINGS

- Climate change remains a politically charged, sensitive, and somewhat partisan issue in the region.
- The presence of motivated, visionary leadership enables adaptation action.
- Perceived public support for climate initiatives equates to strong political capital and increases the likelihood of adoption.
- Public engagement efforts can increase political support.

A large literature on stakeholder engagement and public participation in adaptation and natural resource management suggests it may better incorporate local knowledge and capacity, increase community buy-in and support and improve overall management outcomes (Few, 2007; Ebi, 2008). This literature also suggests that public engagement processes may improve the political reception of policies and programs and may lead to more successful project implementation, monitoring, and enforcement (Parkins, 2005). In a study of vulnerability and capabilities related to disaster emergency response, Anderson and Woodrow (1999) found participatory practices to improving coping capacity. Similarly, Allen (2006) found that community-based disaster preparedness (CBDP) strategies held promise for lessening vulnerability and augmenting adaptive capacity. Our research provides empirical data to bolster these claims and highlight their materialization in these case cities.

For the purposes of this study, we focus specifically on highlighting the dimensions of political capital that emerged from our data. We examined several dimensions of political capital, including the key role of leaders and champions in driving adaptation efforts, the public's perception of leadership's initiatives as well as their role and legitimacy, and leadership's efforts to attract additional political support using public engagement strategies. Here we define political capital to include leadership, motivation, and vision; electoral and local politics, which are closely tied with reputation and public perceptions, and the stock of improved public favor that may be gained through public participation and engagement approaches. In this study, political leadership was treated as distinct from community leadership, which is discussed more fully in Chapter 10.

Questions intended at targeting the role of political capital in these case cities included:

- What factors enabled [the city] to tackle adaptation issues? (e.g., leadership, political momentum, funding, human resources, etc.)
- Can you speak to any relevant political influences (positive or negative) on this work in [the city]? Leadership/lack thereof?
- In your opinion, is there political support or opposition for climate mitigation and adaptation efforts in [the city]? (If yes) How have you handled that?
- What challenges or barriers has the city faced in adopting or implementing climate adaptation work? (e.g., political, legal, etc.)
- Related to climate adaptation planning, what is your vision for the future of your city?

Political Capital in Ann Arbor and Grand Rapids

We found political capital contributes critically to the presence of adaptation initiatives in both Ann Arbor and Grand Rapids. Several components of political capital emerged in our interviews, and each influences the overall adaptive capacity of our case cities. Though the specifics differed slightly in each city, both communities exhibited similar strengths and challenges in drawing political support for adaptation projects. Foremost we found that both cities cited the role of strong leadership in enabling adaptation action in their cities. Moreover, both case cities have effective leaders and champions of climate adaptation work with sufficient motivation and vision to promote forward-thinking innovation. Public reactions to climate initiatives were mixed, with some ideas drawing wide support and others viewed less favorably. This was particularly acute in light of the politically charged nature of the climate

issue currently in the United States, as well as partisan divides and ideologies around the appropriate role government should play. While both cities noted the politicized nature of climate change and the challenges that poses in taking adaptation action, this was perhaps more notable in Grand Rapids which is, like most cities in Southwestern Michigan, a traditionally Conservative community. Finally, we found that officials sought to mitigate or reduce public skepticism for city initiatives using public engagement tools and efforts to greater involve the community. Such efforts typically resulted in improved public reception for proposals and greater community buy-in. One respondent remarked, "being very proactive in the community involvement side makes all the implementation stuff so much easier" (Public official, Grand Rapids, 2011).

Leadership and local action: Motivation, vision, and innovation

Leadership is one of the most dominant facets of political capital that emerged in our research. Political leaders have played a key role in prioritizing adaptation activities in our case cities. Data collected from in-person interviews in both cities suggests that leadership formed an essential component of the impetus for adaptation action. The majority of Grand Rapid's interviewees believed the Mayor's leadership to be a critical enabling factor in driving the city's environmental and climate-related initiatives. One respondent remarked, "I think the most important work of a mayor in a city is to be the vision-bearer…to say this is where I think we can go as a community and this is where I want to lead us and if you think it's a good vision, then let's work on it together." The interviewee went on to remark, "I think it does take a key leader in the community to…consistently hold it in front of people and say, folks, this is important to us" (Public official, Grand Rapids, 2011).

When asked to what to credit Grand Rapids' success in the field, respondents routinely cited leadership-and the Mayor's leadership specifically- as a vital factor in propelling climate-forward thinking. One interviewee stated, "If there's not a champion, it's easy to get lost." In Grand Rapids, changes in the government departmental leadership and city management helped facilitate more progressive, flexible, and forward-thinking urban forestry projects than had previously taken root under prior administrations (NGO representative, Grand Rapids, 2011). There, notably strong ties amongst political leadership, in and outside of city government, seemed to considerably drive policy setting, the establishment of new public-private partnerships (PPP), and sometimes, even hiring practices. High-level political ties amongst city government and community leaders were cited as crucial to forming social collaborations and partnerships, to facilitating information exchange, and sometimes to drawing in funding sources (Public officials, Grand Rapids, 2011).

The Community Sustainability Partnership (CSP) is a prime example of the myriad ways political capital and social capital networks intertwined in Grand Rapids. In speaking of the advent of the CSP, which draws a diverse set of community stakeholders together in collaborative efforts, an interviewee commented, "You know, quite honestly, you have to be giving credit where credit is due and a lot of this can be credited back to the mayor's initiative" (Public official, Grand Rapids, 2011). Another respondent noted,

> *The great thing I'm happy to report is that there's really a staggering amount of leadership….One thing this community has learned is that… that leadership comes at a lot of*

> *different levels, shapes and sizes. The other thing we've learned is that [it] really can't be about one person leading everyone; it's about people making changes to their daily practices, so it has to be about everybody getting on board.* (NGO representative, Grand Rapids, 2011)

Officials in both cities credited the mayor's leadership for prioritizing sustainability planning. An NGO representative in Grand Rapids said, "We're very lucky to have a mayor who sees this as a key focus of his civil service –that sustainability is going to be a part of his message and his leadership" (NGO representative, Grand Rapids, 2011). The mayor's leadership has helped to integrate sustainability into the City's culture. Specifically, in Grand Rapids, officials referenced the mayor's substantive role in initiating The Sustainability Plan and in setting a target for the City to achieve 100% renewable energy by 2020 (Public official, Grand Rapids, 2011). Several respondents also cited core political and administrative leadership as being critical in Ann Arbor. Ann Arbor respondents, in particular, perceived their city as a 'leader' in the environmental field and out 'ahead' of other communities. An interviewee stated,

> *In stormwater control, we're probably the leader in the state on that. Energy, we're the leader in the state on that. Our conservation program is pretty renowned; we're the only city – there's 25 Solar America cities and Ann Arbor is one of them. And that was based on work that had been done around energy and the climate in the past. We were able to win that award which came with some federal funding, not very much, but it opened up a pipeline for us with the Department of Energy that has proven, I think, to help us a lot*. (Public official, Ann Arbor, 2011)

Another said, "And that's our goal, a lot of the stuff we do environmentally is to set an example and to provide a model and share all of that information of how we got to where we are with other communities so that they can come along too" (Public official, Ann Arbor, 2011). Both cities referenced that this leadership sometimes related to the unique human capital of individuals, or in having dedicated staff in key positions, for example, having a dedicated energy or sustainability manager. In Ann Arbor, officials also referred to their mayor's leadership in creating a vision for renewable energy, which then became institutionalized in a City Council resolution and helped generate support for establishing the Energy Office in the City (Public official, Ann Arbor, 2011). The Mayor also was "the public face and the main proponent in the political arena for the Greenbelt Program" (Public official, Ann Arbor, 2011). Sector specific champions were also cited as spearheading novel and innovative projects in their fields. As an example of such sectorial leadership, in Ann Arbor, the city is ahead of the curve in using a technologically innovative braking system on its low-sulfur diesel trucks, helping not only to mitigate carbon emissions, but also to improve air quality, with the added benefit of proving cost-effective for the city (Public official, Ann Arbor, 2011).

Respondents in both cities believe adaptation to be mostly a local issue, and that local governments were more expeditious and nimble in providing leadership on climate issues than were Federal or State governments. An Ann Arbor interviewee remarked, "It's local government that is making all the change here. I mean, we're doing it…. so we are one of those cities, there's probably 25 or 30 of us that are pushing the envelope on it" (Public official, Ann Arbor, 2011). Another stated, "I think people have to lead….local community by local community. If you lead, it's maybe a better process than trying to get

federal legislators to say this is important.... I really don't see it being a national policy right now" (Public official, Grand Rapids, 2011). Moreover, city officials spoke to a sense of responsibility to be forward-thinking and engage in long-range planning,

> *The federal government is not going to be solving any problems in terms of climate change or climate issues, but the local level governments and state governments in some areas have taken actions and taken these issues very seriously. So this is where the rubber meets the road, and we really believe that climate change is occurring based on scientific data. There is, how impactful and how much of damage or change this would cause in Michigan specifically, there are reports that there's actually a report that talks about economic development impact, or economic impact on Michigan, and the general idea is that, to be prepared. It's better to be prepared and assess your vulnerabilities and risks related to climate change than not be prepared. Now, whether these occur, these changes occur in 10, 15, 20 years, I think it's irrelevant from the standpoint of long-term planning. It's what drives any good community...any good citizenry... being good citizens is really good long-term planning.* (Public official, Grand Rapids, 2011)

Another interviewee pointed out, "I think innovation is going to happen at the local level and I think there are networks of cities that are starting to develop this Urban Sustainability Director's Network—is the kind of ... the place to watch (Public official, Ann Arbor, 2011). The U.S. Conference of Mayors, of which both cities are a part, serves as another forum for political leadership to discussion innovative (and adaptive) planning. Similarly, ICLEI - Local Governments for Sustainability, also helps to summon leadership to the forefront of adaptation thinking, and offered Grand Rapids a seat at the table in piloting its new web-based Adaptation Database and Planning Tool (ADAPT).

Political reputations and public perceptions

Vocal constituents and public outcry can impel swift government action. One respondent commented, "I mean, it really does take the noisy or the attentive public to make sure that these things come up, that they're implemented because resources are so scarce" (Public official, Ann Arbor, 2011). Indeed, a vocal public served as the impetus for the footing drain disconnection program and citywide ordinance in Grand Rapids, which helps to re-route excess stormwater to prevent sewage backups that cause sanitary and human health concerns. One official remarked,

> *It creates a lot of havoc. It creates basement backups for people that are in low lying areas and they actually—there was one neighborhood that came to City Hall during a City Commission meeting and really [rose] this to a high level. They said we want our quality of life improved and this department got heavily involved in creating a footing drain disconnection program and study of their areas and designed a project to separate the footing drains in two neighborhoods. We created an ordinance, a citywide ordinance that allows us to go into certain neighborhoods that have significant influence on the sanitary sewer system with the footing drains connected to there and go in and mandate separation.* (Public official, Grand Rapids, 2011)

Politicians and city staff alike recognize the importance of community concerns and are sensitive to the public's perceptions of their work (Public officials, Grand Rapids and Ann Arbor, 2011). As one city official noted, politicians in particular are very cognizant that they are accountable to public opinion, "as an elected official they are obviously not going to support something that the community doesn't support. So having that public support is huge for a program" (Public official, Grand Rapids, 2011). Politicians' cautiousness or fears of adverse public opinions can hinder more progressive adaptation decision-making. Both elected officials and city staff need to be conscious of the political calculus involved in supporting regulatory or program changes. When describing intended changes to zoning density codes, an Ann Arbor official stated, "Because neighbors tend to complain about development projects, council members are very sensitive to neighborhood concerns, and they didn't want to take that risk"(Public official, Ann Arbor, 2011). Another interviewee remarked that local governments were hesitant to enact stringent land use regulations for fear of public reaction, "they know they'll get, the hordes will be pounding at the gates politically, or they'll get voted out of office. So politically they're worried about not exercising that authority too much" (Public official, Ann Arbor, 2011). Another interviewee in Ann Arbor observed that the City is reluctant to approve site plans for dense developments, because of potential public opposition. One official remarked that the most engaged "sub-group" of the public is the "homeowner, single-family, traditional, high-education, high-income neighborhoods" (Public official, Ann Arbor, 2011). We may be tempted to write this phenomenon off as typical NIMBYism, but in the adaptive capacity framework, it becomes much more complicated. We find that both wealth and high levels of education help to build adaptive capacity. However, this example demonstrates that these factors can also constrain sustainable land use efforts.

Framing climate change

Climate change remains a highly politicized issue in the United States and these case cities are no exception. Both city officials and the NGO community spoke to the politically charged and contentious nature of discussion of climate change in these cities, particularly in troubling economic times. Several informants stated that they were reluctant to discuss climate issues, or at least, to label them as such at this time, with one noting, "Especially I think at a local government level, people are very sensitive to the politicization of this issue" (NGO representative, Ann Arbor, 2011). Many respondents commented that the subject remains politically unpalatable with many subsets of the population. Some mentioned that political leanings and partisan politics contributed to this sensitivity. One informant stated,

> *Definitely political leanings.... Definitely some of it falls between Republican and Democrat, Liberal and Conservative. And that's partly because I think it's, government should do more and government should do less, so especially in our more rural conservative communities they want government to do less and to be more hands-off.* (NGO representative, Ann Arbor, 2011)

This was particularly true in traditionally Conservative Western Michigan where climate change remained a particularly partisan issue. An NGO member in Grand Rapids observed, "In terms of how we're actually addressing… we don't talk much about preparedness for climate change these days. West Michigan is still a very conservative community and most people still struggle with these large-scale

global climate issues" (NGO representative, Grand Rapids, 2011). The NGO community in both cities was very sensitive to the use of climate language in press and publications for fear of public backlash. One Ann Arbor respondent even spoke to the loss of a Board Member over a publication that discussed climate change (NGO representative, Ann Arbor, 2011). The respondent went on to say, "We are very sensitive in terms of how we talk about it… and which audiences we're with. Funders, the same thing. I sent it to a foundation that we always go to and the woman sent it back to me and said, 'I love this idea…But I still can't get my board to even think about this issue'" (NGO representative, Ann Arbor, 2011). Government officials also spoke to using caution in discussing climate change. One city official stated,

> *So we've gone around the politics but—you know, council—there's been a lot of focus on budget. Cities have less money. Politically, I don't think now is the time if you are laying off cops and firefighters to talk about where you are investing in climate change and adaptation. It doesn't mean you're not doing it; you're just going to do it in a different flavor.* (Public official, Ann Arbor, 2011)

And later remarked,

> *Ann Arbor, we benefit from a pretty educated community and a community that is interested in these things and has some time on their hands to both invest in public meetings and commissions . . . but still, I think if I were asked whether we ought to go out with a big public engagement process on climate change or climate adaptation right now, I would say no. I just don't know that it would be that effective.* (Public official, Ann Arbor, 2011)

Officials also disclosed how the political nature of the climate issue shaped their routine communications and framing of city programs. We found that they frequently were addressing adaptation-related issues, though often not labeling it as such. For some projects, this was simply the product of falling under the umbrella of other city planning initiatives, such as emergency response or urban forestry, while for others it was more of a conscious effort on the part of staff to frame the programming in a politically palatable light. A public official commented, "You don't have to call it climate adaptation, but you have to address issues related to climate change, so that's heat waves, that's extreme snow events, extreme rain events" (Public official, Grand Rapids, 2011).

Building political capital through public engagement and participation

Social capital networks and public-private partnerships were found to be closely interlinked with political capital in these two cities, both positively and negatively. Participation in local organizations, public leadership, and recognition in the community helped increase leadership's political odds in the future (Public official, Ann Arbor, 2011). Social capital networks facilitated political capital by improving public perceptions of city projects and helping to provide political support for officials' policies. Networks and social and political organizations were successful in both cities in garnering political support for their ideas, often drawing enough public attention and support to create a political "window of opportunity." We found, notably in Grand Rapids, public engagement to be the nexus between

political capital and social capital exemplified by the role played in the City by the local NGO, Friends of Grand Rapids Parks (Public officials, Grand Rapids, 2011).

The NGO, a prominent parks advocacy group in Grand Rapids, arose from the joint suggestions of passionate community members and members of the City of Grand Rapids City Commission. It was designed as a means to increase public activism and support for green infrastructure projects and to elicit and community buy-in through community engagement and involvement (Public official, Grand Rapids, 2011). In explaining why the City saw the emergence of the Friends group as a be nefit, one official commented:

> *A Friends group…could gather volunteers to help with volunteer efforts and, of course, the benefits that you reap from having volunteers helping out in your parks are huge because they come in, they see the condition of the facilities, they come in and they help with the clean up or improvement of those facilities and, therefore, you have buy in by those volunteers and ownership. And those, we think, are the folks in the future that will be the determining factor in the development and improvement of parks in the future, however that takes place. Whether it continues to be on a volunteer basis or whether it continues to be in the form of some sort of —if there is a dedicated park millage. You know, those are the folks that you are going to need to turn out to vote in favor of something like that. So how better to educate them and have them gain that buy in by saving the parks for themselves and getting their hands dirty helping to fix them up.* (Public official, Grand Rapids, 2011)

Grand Rapids' public engagement process helped forge coalitions within civil society, but it also built support for, and helped to define, the City's priorities. The City's Master Plan process in 2000 serves as an excellent example. According to one public official, the process included 250 meetings, and 3,000 people participated from across the city (Public official, Grand Rapids, 2011). Through the planning process, the City engaged in productive discussions around values, neighborhood form, and the City elaborated a form-based zoning structure that called for a complete overhaul of the city's zoning code. Due to the extensive public engagement process, the zoning code passed easily through the approval process, whereas "usually zoning can be pretty controversial" (Pubic official, Grand Rapids, 2011).

Ann Arbor experienced a similar phenomenon when it rewrote its area height and placement standards, although the degree of public participation did not meet Grand Rapids' numbers. After receiving sparse attendance at public meetings but working closely with a "technical advis ory committee," planners proposed their revisions to City Council. Council sent planning staff back to obtain greater public input, and, according to a public official, about 100 individuals participated cumulatively in eight public meetings. The official recalled,

> *So I think it was value added, because by the time we got to council, not a single person spoke out against it. These are the biggest changes we've ever made to zoning, as long as we have the zoning code. Massive increases in density, we wound up uncapping height in office districts; that came out of council. Council wanted that. We wound up shrinking our setbacks down, posing maximum setbacks, and increasing height –I mean, big time changes, and we didn't have a*

> *single person peep in opposition. So I would say public outreach is helpful.* (Public official, Ann Arbor, 2011)

Similarly, improved information resources or confidence in that information provided officials with greater grounding to promote initiatives and tended to enhance public perception of projects, consequently building political capital. In discussing strengthening floodplain regulations to increase setbacks, a city official suggested that improved information would be helpful in garnering public support,

> *It helps us to be able to have some of that data to be able to say, yeah, we get it, but look, here are some very reputable people that are saying that this is what's likely to happen, you know, we want to go into this with our eyes open and so this is what we're doing. So we need that data to back us up.* (Public official, Ann Arbor, 2011)

An official in Ann Arbor emphasized information's importance for lending legitimacy to the City's decision, in case it were to change its floodplain ordinance. If the city were to restrict building in a wider floodplain area, property owners would likely claim that the policy encroaches on private property rights. Public officials believe that they need scientific data from "a reputable source" to support their decisions, and a science-based NGO representative confirmed that cities look to that organization for data on which to base regulatory decisions. In lending legitimacy to decisions, then, information builds political capital for enacting climate-relevant policies.

In response to the question of whether information played a role in building support for possible city ordinance or regulatory changes, a city official stated, "Yes. Absolutely. Because it would be, any skeptics, when you go to propose changes could just point out that, 'You haven't measured this stuff. It's all theoretical.' It's like, well, now we have measured it and we really need to do this. It's a lot easier sell to get things done" (Public official, Ann Arbor, 2011). Still, even with ample information, a skeptic public and media can be difficult to convince. When asked if additional data would aid with communication of climate information to the public, a city official said, "No, it's still going to be a problem. [laughter] I mean, it's really, it's hard, especially in these economic times to get people to think beyond the more immediate future" (Public official, Ann Arbor, 2011).

In reaching out to the community to gain political support, cities often used traditional public meetings, community forums, focus groups and sometimes stakeholder interviews to solicit input, and generally found those processes helpful over the long term (Public official, Ann Arbor, 2011). Some departments were beginning to experiment with digital and web-based approaches to public engagement, soliciting online surveys and public opinion through social media tools,

> *Yeah, when we updated the Parks plan recently, which is probably about a year ago, we went to a more digital approach to trying to get feedback from people, so we created a website, I should say Parks created a website that asked people to fill out a survey about what their preferences were, what their problems were. And I think we got hundreds and hundreds and hundreds of responses. They were actually very helpful in letting us know what the issues were.* (Public official, Grand Rapids, 2011)

Political constraints

Chapter 7 discusses the political/institutional constraints that cities noted in association with Michigan's government structure. Since the State of Michigan enables almost 3,000 local government units with zoning authority, inter-jurisdictional politics prevents regional planning in some instances. Still, successful regional planning has emerged in the emergency management and transportation sectors.

Key Relationships

As the discussion above suggests, political capital plays an important role in both cities' abilities to undertake adaptation activities. Our case study cities exhibited similar political constraints in beginning adaptation planning, by virtue of the economic times as well as the highly politicized nature of the issue at present. Still, both cities exhibited important examples of political leadership and local government navigating through these obstacles.

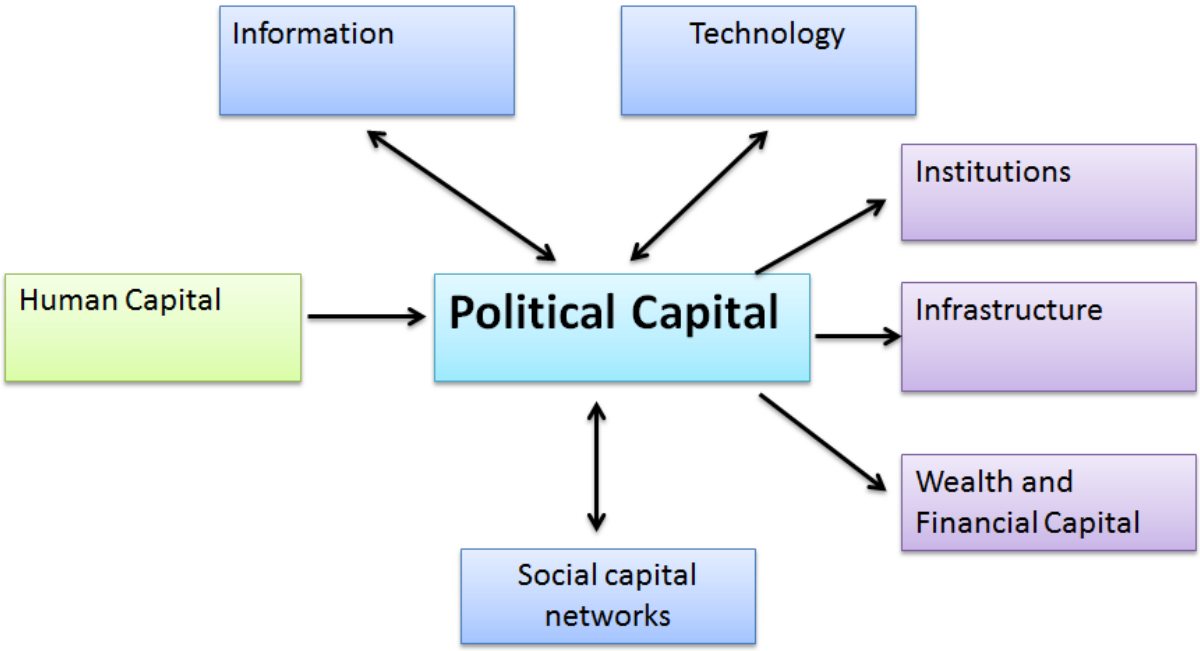
Additional factors work in tandem with political capital in shaping adaptive capacity in these cities. For example, expanded social capital and networks can help to drive political support and garner improved public reception and endorsement for leadership's ideas. While not a comprehensive list of all the examples that emerged, **Table 11.1** and **Figure 11.1** highlight some of the key examples of the complex relationships between political and the other determinants of adaptive capacity which emerged from our various interviews.

Table 11.1 Relationships between Political Capital and other Determinants in our Case Cities

Determinant	Relationship with Political Capital
Institutions	• Jurisdictional turf wars premised on institutional arrangements reduce collaborative exchange (e.g. Home Rule) • Partisan politics and jurisdictional turf wars led to Michigan being one of five states without comprehensive septic regulations • Change in state political leadership led to loss of Brownfield Redevelopment Tax Credit, a politically and socially popular program in Grand Rapids
Infrastructure	• LEED certification and energy efficient buildings supported by political leadership and incorporated into city building and zoning codes • Infrastructure projects and repairs are generally publically (politically) supported • Political support for sustainability projects that enable more creative and innovative infrastructure projects to take place • Political leadership can serve as champions for project initiation and completion
Wealth and Financial Capital	• Financial capital and political capital are positively related, each can enhance the other • Political leadership enabled access to additional funding streams in both cities
Social Capital Networks	• Networks and personal connections can increase political power • Uncooperative collaborations reduce political capital • Participation in regional political networks such as the Green Cities

	initiative or Mayor's Climate Initiative builds political capital
Human Capital	• Higher education levels tend to be associated with a more organized and politically engaged public • Human capital can enable or constrain political capital, depending on political leanings
Information	• Additional data and the dissemination of information, particularly of economic benefits, can facilitate political capital • Informational and social networks can develop and expand political capital • Positive political capital or leadership can result in additional information access (.e.g. Mayor's Climate Initiative) • Lack of information or uncertainty about information can constrain political support
Technology	• Political capital can facilitate implementation of technological innovation • Positive political capital or leadership can result in additional technological access (e.g. Grand Rapids participation in ICLEI's ADAPT program)

11.1 Key Relationships between Political Capital and Other Determinants in our case cities



Human Capital contributes to building political capital. Dual relationships exist between social capital networks and political capital with political capital allowing access to added social networks and social networks sometimes enhancing political capital. Similarly both information and technology can help to build political capital, yet having greater stocks of political capital can increase cities access to additional information and technological sources. Political capital is needed to build infrastructure, garner additional financial resources for the city and sufficient political capital is prerequisite to building new institutions.

Chapter 12: Human Capital

Human Capital Background and Definition

Researchers often include human capital as a significant determinant of a system's adaptive capacity. The IPCC's Fourth Assessment Report, for instance, concludes that social factors such as human capital shape adaptive capacity (AR4, 2007). According to the literature, this determinant has two key dimensions: the overall education levels of the population and the skill, education, and competence of official staff and decision-makers. For the first dimension, a well-educated population can understand climate risks and impacts and respond appropriately; countries with higher levels of human knowledge and literacy have higher adaptive capacity than developing or less educated nations (Smit & Pilifosova, 2001a). For instance, in principle, in an urban context, it is reasonable to expect a well-educated population to understand flood risks and make educated choices about where to construct homes relative to floodplains. Similarly, having trained and skilled staff means a City would be able to adopt and successfully implement adaptation strategies; lacking this type of human capital makes those options unavailable (Smit & Pilifosova, 2001a). For example, employing trained and highly educated engineers may enable a community to design a sewer system that effectively handles stormwater and mitigates flood risk.

HUMAN CAPITAL

The overall education levels of the population and the skill, education, and competence of official staff and decision-makers

INCLUDES

Communities' overall education levels and the skill and knowledge of City staff

KEY FINDINGS

- Strong institutional knowledge bolsters AC
- Layoffs and staffing cuts have constrained staff's ability to address adaptation
- Professional effectiveness of key staff cited as an enabling factor
- High education levels of Ann Arbor community cited as enabling factor

In this study, we look at both dimensions of human capital. Specifically, we look at how the communities' overall education levels and the skill and knowledge of City staff are shaping adaptive capacity in both case cities. Information about human capital emerged in response to the following questions:

- To what would you attribute the City's success in implanting that program or policy?
- How long have you been in your position?
- Can you describe how your position/office/organization originated?

Human Capital in Ann Arbor and Grand Rapids

In both communities, many key staff have been in their positions or similar fields for 15 years or longer and have developed strong institutional knowledge and expertise about how the City's systems operate. Further, many staff members had strong academic and professional credentials and high technical competence. In both communities, however, budget cuts have forced significant staffing reductions. In the Grand Rapids planning department, for instance, the staff has shrunk from 24 to nine over the past ten years. Staffing cuts were reported across departments and cities. One interviewee noted:

> *In my 37-year career […] here, they have been hiring people most of those 37 years but the last four years […] that's something like I have never seen. I mean, we're not just losing people through attrition; we're sending people home and that hurts because these are good people. They do a great job. But times are changing*. (Public official, Grand Rapids, 2011)

These cuts have limited City officials' ability to address new issues, such as climate change. One interviewee said, "From a staffing standpoint, I really believe that the budget cuts have hamstrung the department's ability to create and reinvent and evolve to keep up with the latest trends" (Public official, Grand Rapids, 2011). However, an Ann Arbor interviewee said the City is in a better position than others in Michigan because it "still has staff paying attention to this and most cities don't" (Public official, 2011).

Many Ann Arbor informants spoke about the high education level in the community as enabling innovative environmental programs and policies in various ways. When asked why Ann Arbor was able to adopt innovative environmental policies (such as PACE, the Greenbelt program, or supporting an Energy Office), informants regularly cited high education levels in the community as an enabling factor (Public official, Ann Arbor, 2011). For instance, one interviewee suggested that Ann Arbor's high education level meant it was able to implement rational, cost-saving energy efficiency measures instead of falling victim to political pressures (Public official, Ann Arbor, 2011).

Similarly, several interviewees said the high education levels in Ann Arbor facilitated deep and meaningful public engagement. Some of this engagement comes through formal channels, such as the various advisory commissions. For instance, one city official said, "If you look at the people that [Ann Arbor is] able to choose from to point to things like the Planning Commission, the Parks Commission, the Energy Commission, we have a really highly qualified and motivated pool of people to work with" (2011). Other public engagement through less formal channels still draws on the high skill base within the community. For instance, many Ann Arbor informants spoke about the deep level of interest and engagement in issues ranging from the landscape ordinance to floodplain maps and attributed this interest to having a highly educated community (Public official, Ann Arbor, 2011).

In Grand Rapids, interviewees from both the public and non-profit sectors spoke frequently about the strength and professional effectiveness of City and County personnel across sectors. For instance, one city official said, "I consider her [the Planning Director] to be a genius when it comes to planning and she does an awesome job" (2011). This official emphasized her talent for public engagement, and

lauded her role in activating social capital through the Green Grand Rapids (Public official, Grand Rapids, 2011). The City's restructuring of the urban forester position also serves as evidence that individuals' level of talent matters: city staff and a committee member stressed that they had designed the position to attract a highly talented, dynamic individual. One official even suggested that human capital could serve as a stand-in for institutions. Discussing regional planning, he argued that regional collaboration does occur in the Grand Rapids Metro area, but he attributed this to Grand Rapids' Planning Director's "influence" (Public official, Grand Rapids, 2011). Similarly, an NGO representative remarked that the City Manager's interest in urban forestry had helped raise that issue to priority status in recent years (NGO representative, Grand Rapids, 2011).

The Ann Arbor case also demonstrated that talented individuals can make an institution successful. The City's first Energy Manager, according to two public officials, played a major role in carrying the energy office to prominence and developing innovative programs like the internal revolving loan fund (Public officials, Ann Arbor, 2011). Two public officials referenced the role that the former City Administrator and Public Services Area Administrator had played in restructuring the City and forming the integrated Systems Planning Unit, respectively. On the other hand, one public official recalled the major hurdle that the City faced when the City Administrator—looking to downsize in the face of a recession—offered early retirement bonuses. The City effectively incentivized "about 10% of our staff" to retire, "And they were the longer-serving staff so the brain-drain, and the institutional knowledge went right out the door" (Public official, Ann Arbor, 2011). After recovering from that hit (and several years later), the City now "cross-trains" its field operations personnel so that they can respond to a variety of maintenance needs (Public official, Ann Arbor, 2011). In Ann Arbor too, we find that people and the knowledge they carry are critical elements to community success.

Grand Rapids informants also cited high levels of education and training specifically about green building as an enabling factor. Several interviewees cited the high number of LEED™ (Leadership in Energy and Environmental Design) Accredited Professionals (a personal accreditation signifying green building expertise) and the strong understanding of green design and construction principles and techniques within the community as helping to establish norms around green construction within Grand Rapids (Public official, Grand Rapids, 2011). These norms have led to a proliferation of green buildings within the community.

We categorize partnerships with universities and knowledge-based NGOs as both human and social capital. The Huron River Watershed Council, for example, advocates for certain policies, but it also provides data and technical advice to the City of Ann Arbor in drafting planning documents and ordinances (NGO representative, Ann Arbor, 2011). A public official also referred to the Climate Action Plan's technical advisory group, including representatives from knowledge-based NGOs, the transit agency, and an energy professional (Public official, Ann Arbor, 2011). Both the Mayor and a public official commented that the community's strong knowledge base improves the effectiveness of city commissions, since the Mayor can appoint local experts to the energy, environmental, parks, and planning commissions (Public officials, Ann Arbor, 2011).

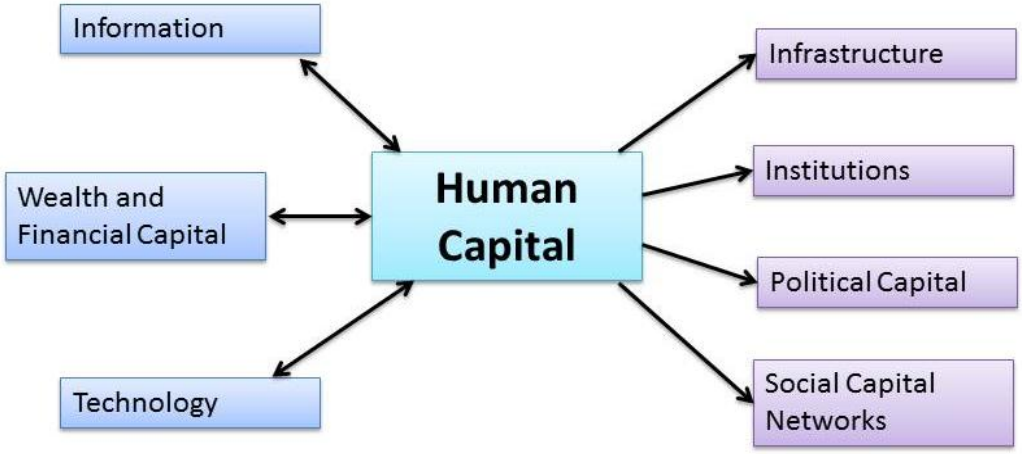
Key Relationships

Table 12.1 and **Figure 12.1** summarize the relationships between human capital and the other determinants of adaptive capacity that emerged in this study.

Table 12.1 Relationships between Human Capital and Other Determinants in our case cities

Determinant	Ann Arbor
Institutions	• Able to support and push innovative programs (e.g., stormwater utility, greenbelt, PACE) through educated and engaged citizens. • Systems Planning Unit successful in part because it brings together people with technical expertise. • Effective staff are instrumental for successful public engagement, integration across departments, and implementing. • City commissions are effective due to strong knowledge base within the community.
Infrastructure	• Green building leadership and expertise.
Wealth and Financial Capital	• Budget cuts lead to significant staffing reductions. • Able to draw on interns, volunteers and pro bono work to stretch money. • Dedicated staff positions and entrepreneurial City staff fundraise to support innovative projects and programs.
Social Capital	• Perception that higher education levels lead to higher levels of engagement and engagement on more issues. • Having an educated community also informs the City's outreach strategies. Sustainability outreach strategy is focused on forums because the educated community wants dialogue and "values education." • Partner with local colleges and universities; able to draw on the skills and expertise from local higher education. • Use volunteers to fill gaps due to staffing shortages; these volunteer programs build the human capital of the community.
Political Capital	• Perception that educated community means City is able to make logical decisions, more immune from political pressures; however, higher education levels may mean the City has to deal with greater scrutiny and engagement. • Higher education levels lead to a more organized and politically engaged public.
Information	• Skilled and trained personnel are able to solicit and understand climate change information. • Layoffs and competing tasks mean that staff do not have time to access and use climate change information.
Technology	• Need Human Capital to operate and use technology. • Technology provides additional information and resources that build Human Capital.

Figure 12.1. Key Relationships between Human Capital and Other Determinants in our Case Cities



Information, wealth and financial capital, and technology have mutually reinforcing relationships with human capital. Human capital contributes to infrastructure, institutions, political capital, and social capital networks.

Chapter 13: Information

Information Background and Definition

Although the boundaries, definitions, and components of "information" as a determinant of AC vary across studies, access to knowledge in its many forms has been proposed as an essential factor to build AC at various scales. For instance, "Information and skills" is among the eight determinants of adaptive capacity outlined in the IPCC's Third Assessment Report (TAR) (Smit & Pilifosova, 2001a). In the TAR, "information and skills" includes scientific understanding of climate change impacts and potential adaptation strategies as well as having skilled and trained personnel available to identify and implement adaptation measures. Similarly, drawing on the work of Smit and Pilifosova (2001a) and Yohe and Tol (2002), Eakin and Lemos (2006) elaborate that "Information & Technology" (one of seven determinants identified) includes communication networks, freedom of expression, technology transfer and data exchange, innovation capacity, early warning systems, and technological relevance (p. 10).

Drawing on the TAR, Yohe and Tol (2002) write that information as a determinant has three component parts: "the ability of decision-makers to manage information, the processes by which these decision-makers determine which information is credible, and the credibility of the decision-makers, themselves" (p. 26). For instance, in assessing adaptation options to protect against increased risk of flooding in the Rhine Delta in the Netherlands, Yohe and Tol find that the highly educated and competent Dutch bureaucrats, trust of the public in civil servants, and the openness of civil servants to new ideas all enhance the adaptive capacity in that context. It also includes the ability to share information. Gupta and Hisschemöller (1997) found that having systems in place to share climate change and adaptation information nationally and regionally and having

INFORMATION

Scientific understanding of climate change impacts and potential adaptation strategies as well as having skilled and trained personnel available to identify and implement adaptation measures

INCLUDES

Early warning systems that provide information; scientific understanding of climate change impacts (projections and scenarios) and potential adaptation strategies; and having systems in place to share, discuss, and communicate climate change information and adaptation strategies at various levels

KEY FINDINGS

- Access to reputable and timely information about extreme weather events enables a proactive response and mitigates harm.
- Lack of information about and understanding of impacts and adaptation strategies means climate change has not been incorporated widely into decision making.
- Participation in peer-to-peer information-sharing networks and partnerships with local universities and other organizations improve information access.

"forums for discussion and innovation of adaptation strategies at various levels" is an important dimension to adaptive capacity.

Efforts to prioritize among determinants highlight the importance of information access. Alberini et al. (2006) surveyed climate change and public health experts and used a conjoint choice analysis to identify and prioritize which factors were most important in influencing a country's resilience to public health impacts of climate change. The authors found that changing a hypothetical country's access to information from "low" to "high" was considered by the experts to be equal to a change in per capita income of $14,107. Thus, access to information was a crucial determinant.

The importance and role of information may be different for adaptive capacity at the city level. For urban systems specifically, lack of information about local impacts on specific areas is often cited as a hurdle in promoting adaptation (Satterthwaite, 2008). Bulkeley et al. (n.d.) argue that having knowledge and information about projected climate change impacts and effective adaptation strategies is a prerequisite for many adaptation measures. Further, they argue that lack of access to information may be crippling for local adaptation efforts because "capacity for climate change research and adaptation is generally low at the local level and is often concentrated at the national level" (p. 34).

While information have been posited as an essential determinant of adaptive capacity, researchers also note that information alone is not sufficient for building adaptive capacity. Indeed, information is mediated through cognitive processes that may inhibit taking adaptation action. The IPCC Fourth Assessment Report outlines four informational and cognitive barriers to adaptation. First, individuals' experiences, values, social context, and other factors influence their comprehension and discernment of information. Second, the psychological dimensions of interpreting risk may similarly impede adaptation, as individuals have an inclination to prioritize and focus on the risks they deem most immediately significant; since climate change is not perceived as an immediate risk for most people, adaptive behavior and policy are less likely. Third, individuals' perceived vulnerability and ability to adapt likewise influences adaptation decision-making. Fourth, ineffective communication techniques (e.g., appealing to fear and guilt, failing to connect climate change to personal context) similarly inhibit adaptation action (Adger et al., 2007). Furthermore, the use of knowledge, particularly scientific, may feedback negatively with other determinants of AC either by creating unequal access to information among decision-makers or by fostering inaction as, for example, when decision-makers offer the uncertainty of climate information as a reason not to act (Engle & Lemos, 2010; Lemos & Rood, 2010).

For this study, "information" includes: early warning systems that provide information; scientific understanding of climate change impacts and potential adaptation strategies, and; having systems in place to share, discuss, and communicate climate change information and adaptation strategies at various levels. To understand how our cities use knowledge relative to climate adaptation, we asked the following questions.

- What types of climate change impacts do you think will be most significant for your city?
- Where do you get information about climate change?
- Is the information adequate?

- What additional information would be useful?
- Is climate change incorporated into decision-making processes? If so, how?

Information in Ann Arbor and Grand Rapids

Three components of information emerged in our interviews and each influences the overall adaptive capacity of Ann Arbor and Grand Rapids. First, do the cities have access to early warning and real-time notification systems that provide information? Second, do City personnel have access to information about climate change impacts and adaptation strategies to inform decision-making practices? Third, are there networks and systems in place that facilitate sharing and discussing climate change information and adaptation strategies?

Information contributes critically to the adaptive capacity of both communities. Overall, although the specific approaches in each City differed slightly, both communities exhibited similar strengths and challenges regarding the access to and use of information. Having access to reputable and timely information about extreme weather events enables a proactive response and mitigates harm. In general, lack of understanding climate change impacts and adaptation strategies has meant that climate change has not been incorporated into decision-making, although considering adaptation has emerged as a new priority in both cities and will likely play an increasing role in informing decision making. Finally, both Cities participate in information-sharing networks and platforms that bolster access to information about climate change and adaptation strategies.

Real-time information and warning systems

Having access to reputable and timely information about extreme weather events enables a proactive response and mitigates harm in both Ann Arbor and Grand Rapids, thus enhancing the adaptive capacity of both communities. In both places, officials cited the National Weather Service as the most important information source during emergency weather events and spoke highly of the detail and timeliness of information the agency provides. For example, one informant said, "the Weather Service, they provide a gold standard service. They are absolutely stellar and not just floods, in all their services" (Public official, Grand Rapids, 2011). For instance, the agency's website includes a hydrology scale that "gives current conditions, gives projections. So if you live in a flood zone and the Weather Service projects you're going to get flooded, you've got time to leave." This interviewee went on to describe the Weather Service's engagement during a recent blizzard. In addition to regular updates and information throughout the blizzard, the Weather Service held a webinar for emergency responders, City government, road commissions, social service agencies, and other key personnel before the event about what to expect. This advance notification gave all involved parties time to coordinate response and communication strategies (Public official, Grand Rapids, 2011).

In Ann Arbor, personal relationships enhance information access from the National Weather Service. One official said:

> *From the beginning of the weather service their state headquarters has always been in Ann Arbor, up until '94. So that's how far back our relationship goes. And then we meet frequently. We talk on the phone all the time. And it's not just the guys that are in charge; we talk to the*

forecasters all the time about things. We have conference calls whenever there is a risk of significant weather, both summer and winter. (Public official, 2011)

In addition to formal notifications from the National Weather Service, respondents in Grand Rapids discussed the City's use of tracking both 911 emergency and 211 calls to know when to open a cooling center during extreme heat. The 2-1-1 hotline, operated by the Heart of West Michigan United Way in the Grand Rapids region, is a free information and referral service open 24 hours a day, seven days a week that serves as a clearinghouse for local social services and programs. City and County emergency management personnel are in regular communication with United Way staff so they are able to open a cooling center if community members begin to express a need (Public official, Grand Rapids, 2011).

Informants cited various methods for sharing information and warnings with the public. Strategies include distributing NOAA Weather Radios to community members and enlisting the help of social service agencies. Cities have used new strategies for sharing information as well. One interviewee said:

The City has a system that can call 60,000 people in an hour. What we generally use it for is if there's a water main break, we know where the water is going to be shut off or you need to boil water. It used to be we would print that in the paper; that's kind of old school. So now […] if you register an address with a phone number so wherever you are living—most of you have cell phones from different area codes—we do a locate. So I can draw circles, I can draw all kinds of shapes on the map and say go with a message. You will get that message. (Public official, Ann Arbor, 2011)

In addition to providing warnings, several interviewees stressed the importance of providing accurate and practical advice for how residents can be safe during extreme events, such as tornadoes and heat waves. The cities provided this advice through fact sheets and online resources as well as partnerships with the local media, which one informant described as follows:

one of the first things we do is we start anticipating days in advance and we like to put out an informational letter to the news media, you know, please put this information out to the public. A couple things we like to stress is personal safety. You know, stay out of the sun, hydrate, you know, all those tips you get on personal safety. We also encourage people to take care of their non-ambulatory neighbors, the shut-ins, you know, the elderly, the young—bear in mind they are going to need your help. So please check on them. (Public Official, Grand Rapids, 2011)

However, another informant discussed the challenges of disseminating accurate information through the media with the following:

One of the news agencies came out with sort of a top ten list of places to go during the heat wave. The problem was all ten of them were outdoor water facilities, you know, water parks or splash pads or public pools and the Health Department and Red Cross and some of the agencies who sort of pay attention to the health stuff kind of cringed at that. You don't want people to be outside exposed to the sunlight; you don't want them to be running around heavily active; and you don't want them to spend a lot of time in the water where the light is actually magnified;

you know, the sunlight is actually magnified by the water. So we then worked with the public information officer to come say actually, what about the local library? What about going and walking around at the mall? What about some other opportunities to just get people inside, in air conditioning, away from the direct sunlight. So it's things like that where every time we go through this we learn a little something new, like we need to be a little bit more proactive about trying to help monitor what the news agencies are going to provide in terms of tips and advice. (NGO representative, Grand Rapids, 2011)

Understanding impacts and adaptation strategies

In general, officials in both cities exhibited an understanding of global climate change impacts and potential adaptation measures, but expressed a desire for more detailed information about local impacts and corresponding locally tailored adaptation strategies. When asked what impacts they think will be most significant for the region, most respondents pointed to increased temperatures and more frequent and intense storms. **Figure 13.1** shows a springtime lightning storm in Ann Arbor. Real time weather information and public warning systems can be critical components in maintaining public safety during storm events.

Figure 13.1. "Lightning strikes over Michigan Stadium early Saturday morning." May 2010. Photo by Mark Bialek. AnnArbor.com. Accessed from: http://www.annarbor.com/news/numerous-thunderstorms-headed-toward-ann-arbor-as-obama-commencement-dawns/.

Several respondents, however, said they did not know enough about the issue or did not feel qualified to speak to specifics, particularly when it came to discussing adaptation options their departments might pursue. We did discover specific ways in which cities would use climate-relevant information.

Data underlies stormwater management in the form of design-storm standards for infrastructure. The cities expressed a need for information concerning what tree species to include in their urban forestry management plans, and FEMA's floodplain maps inform zoning regulations (both existing and proposed).

Nearly all City officials said that climate change was not factoring into their decision-making and was only beginning to be considered. For instance, one official said, "we're keeping [climate change] in the back of our mind, obviously, like we're well aware that climate change is happening, but […] we haven't really started with the plan to sort of figure out how to change […] to address climate change. We're not quite there yet" (Public official, Ann Arbor, 2011).

In several instances, officials pointed to the need for better information before climate change can inform decision making. Respondents in both cities mentioned Chicago's climate adaptation work, which *The New York Times* covered in a feature story a couple months before our interviews, and the access to information that informed Chicago's planning. For example, one interviewee said, "I would love to have the kind of data they must have drawn on in Chicago to make up their plan" (Public official, Grand Rapids, 2011).

Similarly, interviewees spoke to the need for local projections that inform the decisions cities make:

> *It has been hard to kind of get climate change into planning without good planning scenarios. So, you know, how do you create a long range plan without, you know, like my storm water people would say, I designed the storm water system to a 10 year storm. I'm an engineer. I can design that, you know, and so if you tell me the 10 year storm is going to change and I can tell them, well, the scientists are telling me yes, the 10 years storm will change but I can't tell you what the 10 year storm will look like. So the engineers are like, well, I can't really design a system for you then. So what we're really getting at is trying to get some better planning scenarios around there.* (Public official, Ann Arbor, 2011)

The City of Grand Rapids was able to learn from tactics utilized by other cities to consider improvements in drawing vulnerable populations to cooling centers. After a summer heat wave city officials learned that the City of Kalamazoo was coordinating with public transit to bring vulnerable populations to cooling centers,

> *One of the very interesting things that Kalamazoo managed to do was coordinate with their public transit system to provide free rides to people to and from the cooling centers, and that is something that we, as a local community, said, oh, yeah, we need to make that happen next time because we were envisioning the people would be able to find transportation to some of these shelters but, as you are talking about the poorest of the poor who may not even have a window fan to their name, getting from their home which is blistering hot to these cooling centers is an issue.* (NGO representative, Grand Rapids, 2011)

Accessing reputable information is especially important given the politically controversial decisions cities must make. For instance, in the case of land use planning, one informant noted:

So if we're talking about changing a code that applies to private development and we're going to increase the size of the storm that people have to deal with, you know, the development community would of course fight back and say, "You don't have enough data, you shouldn't be doing that." (Public official, Ann Arbor, 2011)

Similarly, efforts to restrict development in a floodplain as part of a "no regrets" adaptation strategy, would meet political opposition, which underscores the need for reputable and reliable information. The City depends on information from climate scientists who may produce downscaled climate models that cities can plan around. One Ann Arbor public official referred to the importance of "planning scenarios," for understanding how climate change could alter the size of the 100-year and 500-year floodplains. Federal agencies play a key role in providing this information; FEMA provides floodplain maps and design storm information that the city uses to inform its standards. Some officials emphasized information's importance for designing technically appropriate standards that will ensure that infrastructure withstands climate impacts.

When it comes down to an economic climate where you're saying "no regrets […] stay out of this area" and that person says "Well, that's most of my site. I'm sorry, but you know, you're hampering my use of my property or economic development in this area." So it helps us to be able to have some of that data to be able to say, "Yeah, we get it, but look, here are some very reputable people that are saying that this is what's likely to happen, you know, we want to go into this with our eyes open and so this is what we're doing." So we need that data to back us up. (Public official, Ann Arbor, 2011)

This desire for more information has motivated both cities to participate in the Great Lakes Regional Integrated Sciences & Assessments Center (GLISA). GLISA is a collaborative effort between University of Michigan, Michigan State University, and others to develop usable science for decision-makers. One interviewee said:

We're trying to figure out how we integrate [climate change] into the way we do business because we manage risk all the time and that's what climate adaptation is. It's risk management. We just need good data and as good data we can get is why we are working with [GLISA]*, I just need the smarter noggins in the state to tell me this is a likely scenario and these are the probabilities associated with it. Give me all the caveats you want but this is the best data we've got for you to make planning decisions in 25 or 50 year—because this is a lot that we do that will last that long: putting pipes in the ground, certainly tree planting, you know, whether we should be removing buildings from the flood plain, flood way. We can pass an ordinance that says we ought to be planning around a 500 year flood plain, not a 100 year flood plain. We build a storm water system to meet a 10 year storm. What's a 10 year storm look like? My guess is it's not going to look like the storm we think it is. So having those data then gives us the ability to then integrate that into our planning process.* (Public official, Ann Arbor, 2011)

Staff not having time to access, interpret, and apply climate change information emerged as a major barrier. For instance, one interviewee said, "I know where to go to find information [about climate

change], I just don't have the time to go there" (Public official, Grand Rapids, 2011). Indeed, several informants said they regularly received information from their professional organizations, co-workers, and others about climate change impacts, but that dedicating time to learn more about the issue had not been a priority in their already busy schedules.

Sources and platforms for sharing and discussing information

The cities cited five key sources for obtaining information: local universities, technically oriented non-profits, peer cities, state and federal agencies, and city departments themselves. Officials in both cities described partnerships with local universities to obtain information. In Ann Arbor, a student group conducted an emissions inventory and helped create a climate mitigation plan for the city. Ann Arbor also works with research programs at the University of Michigan, including the Graham Environmental Sustainability Initiative and the Center for Sustainable Systems (Public official, Ann Arbor, 2011). The City of Grand Rapids has actually created a formal partnership with Grand Valley State University, which supplies interns for the Office of Energy and Sustainability (Public official, Grand Rapids, 2011).

Knowledge-based NGOs also provide information to cities. For example, officials in Ann Arbor referred to the Huron River Watershed Council (HRWC) as a helpful source of information. A HRWC representative confirmed that the organization provides technical assistance for communities in developing stronger floodplain, wetlands protection, and stormwater management rules (NGO representative, Ann Arbor, 2011).

Higher-level government agencies often provide data to form the basis for city plans and regulations. For example, the Department of Natural Resources provides financial and technical support for the City of Grand Rapids' tree inventory project. Out of this tree inventory, the City will articulate detailed urban forestry management strategies.

City departments generate information as well. For example, both Ann Arbor's Energy Office and Grand Rapids' Office of Energy and Sustainability track and monitor energy data for city departments, and help them identify energy saving measures.

According to the literature, having platforms to share and discuss climate change information and adaptation strategies bolsters a community's adaptive capacity. The Ann Arbor and Grand Rapids cases suggest that this is true. Both communities are well connected to various networks, which enhance their understanding and opportunities for learning about climate change.

Inspired by initiatives in other states, including California, Pennsylvania, New Jersey and Maryland, Grand Rapids' urban forestry group is developing an open source tree map and inventory. This project helps to draw in community participation and improve the knowledge base of the community (Public officials, Grand Rapids, 2011; NGO representative, Grand Rapids, 2011). As one public health official observed the value of such exchanges,

> *The best thing that you can do in public health to really be successful is to build relationships and to figure out that you don't have to know everything about everything; you just have to know who knows. And that really saves you a lot of time in trying to navigate these things because it's really easy to want to be the person to reinvent the wheel, but there are people with a wealth of knowledge who have already done it and gone through that process and I think sometimes the fun part is finding the right person.* (Public official, Grand Rapids, 2011)

In light of the mostly pessimistic outlook on State and Federal government activity around climate change, public officials said that they mostly look to peer cities to inform their decisions. Addressing Ann Arbor's pedestrian safety ordinance revision, an elected official in Ann Arbor said that the city looks to its peers for model ordinances: "Legislation is always easier if someone else has done it. And sometimes we have to invent it ourselves, but we're always happy if someone else has done it, and then we model that" (Public official, Ann Arbor, 2011). An official in Grand Rapids remembered that the City began its Sustainability Plan process by looking at how similarly sized and progressive cities handle sustainability planning (Public official, Grand Rapids, 2011). Officials did say that limited staff time constrains their ability to conduct extensive research with peer cities or otherwise.

Some information comes through professional organizations. For instance, planners spoke about trainings and resources available through the American Planning Association, while water managers spoke about the American Water Works Association. Similarly, state-level networks among urban foresters facilitate information-sharing and dissemination of information relevant to those professionals.

National networks played a similar role. In Grand Rapids, participation in ICLEI-Local Governments for Sustainability has meant participating in trainings and events. Grand Rapids was one of eight communities selected to pilot test ICLEI's Adaptation Planning Tool (ADAPT), which put climate adaptation on the radar for many city officials. Similarly, the Grand Rapids' participation in the Community Sustainability Partnership (CSP) connects City officials to information from the university, business, and non-profit sectors regarding climate change. The CSP has provided information about measuring and benchmarking greenhouse gas emissions and other relevant topics (Public official, Grand Rapids, 2011).

In Ann Arbor, participation in the Urban Sustainability Directors Network (USDN) meant the City was eligible to participate in an event organized by the Institute for Sustainable Communities (ISC) that brought together planning, environment, and non-profit staff to discuss climate change adaptation. In addition to building relationships among participants, the event highlighted climate change impacts and adaptation options. Similarly, Ann Arbor participated in an ICMA (International City/County Management Association) exchange in which the City hosted local government officials from Indonesia to discuss climate change adaptation strategies and then traveled to Indonesia to learn more about adaptation (Public official, Ann Arbor, 2011).

Individuals who felt sufficiently satisfied with the level of their information base appeared less likely to seek new information. This tack can lead to a level of insularity and complacency that may

compromise adaptive capacity. Several respondents mentioned difficulty in reaching out to and providing the public with adequate information, and expressed concerns about public complacency,

> *During a blackout, we had a significant public information challenge there because I don't want to say this in too sharp of a way, but there's a lot of complacency in the community and because of a strong sense of complacency, there's an overall lack of preparedness. We can't break that seal.* (Public official, Ann Arbor, 2011)

Key Relationships

As described above, information contributes critically to the adaptive capacity of both communities. Our case study cities exhibited similar strengths in accessing information about real-time weather events and connecting with other communities to share information. The cities faced similar challenges in incorporating climate change information into decision making (lack of staff time and lack of locally tailored climate change projections), although both expressed a beginning working knowledge of potential impacts and adaptation strategies.

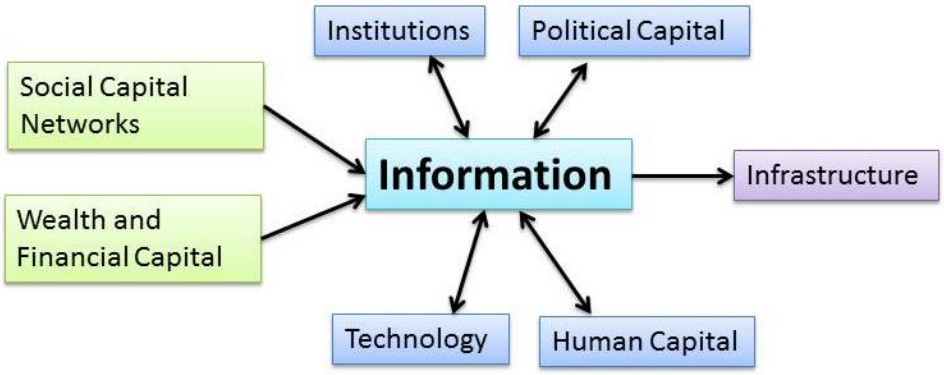
Information, however, does not operate in a vacuum. Other determinants may either enable or constrain the development and use of Information in these communities. For instance, by partnering with local universities to generate usable climate projections, social capital and knowledge networks play a role in making information available and accessible. Similarly, budget cuts and decreased staffing levels (other drivers of AC) inhibit the development of information and City staff members' ability to use information. **Table 13.1** and **Figure 13.2** summarize the most significant relationships between information and other determinants that emerged during this study.

Table 13.1. Relationships between Information and Other Determinants in our Case Cities

Determinant	Relationship with Information
Institutions	• State and federal government agencies and departments are key information sources for City staff • Having information about climate change informs institutional decision-making procedures
Infrastructure	• City needs reputable climate scenarios and projections in order to plan for and design resilient systems that incorporate climate change impacts
Wealth and Financial Capital	• Cost is a prohibitive barrier to updating and generating some information, such as revised floodplain maps
Social Capital	• Partnerships with local universities and participation in boundary organizations (such as ICLEI and Huron River Watershed Council) provide information about and facilitate understanding of climate change impacts • Relationships between City staff and other organizations and entities (e.g., National Weather Service) improve access to information, which enhances emergency response • The United Way's 211 calling system and relationships with social service agencies provide information about vulnerabilities and trigger when the

	City should take immediate action, such as open a cooling center
Political Capital	• City needs credible and authoritative information in order to take politically controversial action, such as prohibiting construction in an expanded floodplain, because individuals and groups opposed to limiting development claim there is not sufficiently reliable information for political leverage
Human Capital	• Skilled and trained personnel are able to solicit and understand climate change information • Layoffs and competing tasks mean that staff do not have time to access and use climate change information
Technology	• Technology is crucial for collecting and disseminating information

Figure 13.2. Key Relationships between Information and Other Determinants in our Case Cities



Social networks and wealth and financial capital enable the acquisition of information (the presence of these determinants builds information while the absence of the determinant hinders development of information). Information both enhances and is enhanced by human capital, institutions, political capital, and technology. Information is essential for building infrastructure.

Chapter 14: Technology

Technology Background and Information

Technology is a significant driver of overall adaptive capacity and can either enable or hinder a system's ability to adapt to climate induced changes. Some authors define technology as an agent's or an organization's ability to create and utilize technical means or knowledge for practical purposes. Others bundle technology with other determinants; for example, Eakin and Lemos (2006) combine technology with information and include communication networks, freedom of expression, technology transfer and data exchange, innovation capacity, early warning systems, and technological relevance.

Regardless of how technology is defined, it contributes to adaptive capacity and can vary tremendously across different systems, times, sectors, and locations (Smit & Pilifosova, 2001a). Abundance or lack of technology can either significantly facilitate or impede one's ability to adequately adapt to climate change by expanding or restricting adaptation options (Scheraga & Grambsch, 1998). For example, the literature on adaptation has noted a myriad of ways that technology could or already has successfully allowed adaptation via technological means including forecasting extreme weather conditions and adapting health provisions, developing heat-resistant rice cultivars, using more efficient cooling systems, and implementing desalinization systems (Iglesias et al., 1996; Ebi et al, 2005; Adger et al., 2007).

The government and private sectors contribute to research and development of technology, which shapes the ability to develop and utilize technological adaptations (Smit & Skinner, 2002). Technological adaptation is facilitated by innovation, which Bass (2005) identifies as a major component of adaptation and refers to the development of new strategies and technologies, or the rejuvenation of past ideas in

TECHNOLOGY

The application of scientific knowledge for practical purposes and encompasses early warning systems, technology transfer, innovation, and communication networks.

INCLUDES

The utilization of geographic information systems (GIS), porous pavement materials, hybrid vehicle technologies, Doppler radar, web-based communications, and much more.

KEY FINDINGS

- Technology depends heavily on other determinants of adaptive capacity, specifically information and wealth and financial capital.
- Both Ann Arbor and Grand Rapids value and invest in technology.
- Technology enables Ann Arbor and Grand Rapids to be more adaptable and bolsters the other determinants of adaptive capacity.

response to new and different conditions. A nation's, states', or cities' existing level of innovation and technology as well as their ability to create and expand upon existing technologies greatly determines their adaptive capacity. This is because numerous adaptation strategies include employing technologies such as warning systems, protective structures, crop breeding techniques, irrigation systems, settlement and relocation plans, and flood control measures (Smit & Pilifosova, 2001a).

Although technology can enable successful adaptation, it can also lead to maladaptation and should be used with caution. Scheraga and Grambsch (1998) caution that technology used to mitigate human health risks could lead to maladaptation. For example, the increased use of air conditioning to mitigate the impacts of heat waves will release more greenhouse gas emissions and other air pollutants.

As mentioned in Chapter 5, and according to Adger et al. (2007), some dimensions of adaptive capacity are generic and other dimensions are specific to particular climate change impacts. Technology is considered specific to distinct impacts, while factors such as education, income, and health are considered to be generic (Yohe & Tol, 2002; Downing, 2003; Brooks et al., 2005; Tol & Yohe, 2007).

In the context of this paper, technology as a determinant of adaptive capacity is defined as the application of scientific knowledge and information for practical purposes and encompasses early warning systems, technology transfer, innovation, and communication networks. Some examples of technology that emerged in both Ann Arbor and Grand Rapids include the utilization of geographic information systems (GIS), porous pavement materials, hybrid vehicle technologies, Doppler radar, and web-based communications.

As Engle and Lemos (2010), Adger et al. (2007), Forsyth (1999), and many others have noted, technology will play a pivotal role in adapting to future climate change challenges. Hence, it is not surprising that technology plays a significant role in Ann Arbor and Grand Rapids. In both cities technology, or the absence of sufficient technology, had both direct and indirect effects on the city's adaptive capacity.

Questions that elicited information pertaining to technology include the following:

- Is climate change adaptation a priority?
- Where do you get your climate information?
- What is the city doing to prepare for climate impacts, or what are some of your current projects?
- Who are your important allies or key collaborators?

Technology in Ann Arbor and Grand Rapids

Several key examples of technology's importance for enhancing cities' ability to adapt to climate change emerged during our interviews. Examples include the utilization of GIS technology, implementation of hybrid vehicle technologies, use of Doppler radar systems, web-based communications, early warning systems, advanced technologies in infrastructure, and mass communication networks. It is useful to highlight the importance of technology as a stand-alone determinant. Still, technology's importance seems more pronounced in the context of relationships and

interactions with the other determinants of adaptive capacity. The following section will describe technology's influence on adaptive capacity, both independently and through its interactions with the other determinants.

How cities use technology to adapt to climate change

The ability to forecast climate events will help cities prepare for and adapt to climate change impacts. Successful forecasting will require adequate information, and technologies that use that information to foresee storm events and communicate the information to emergency response teams and the general public. Ann Arbor and Grand Rapids have these technologies and capabilities; mo reover, both cities utilize technology and human capital to conduct simulations in order to be better prepared. One Ann Arbor interviewee discussed the protocols for weather-induced emergency responses and the technologies used to detect storms, including Doppler radar systems (Public official, Ann Arbor, 2011). Additionally, the interviewee described the technologies used to inform the emergency response team and the public, such as pagers, cell phones, and special call back systems. Other ways that the utilization of technology allowed adaptation to climate change was shown in Grand Rapids, were officials were using technology and infrastructure together in order to adapt to some of the effects of climate change. Officials were accomplishing this by installing solar panels on top of buildings to generate electricity, reflective roofs to aid in cooling interior temperatures of the building, geothermal technology to heat buildings, and double pane windows to improve climate control capabilities (Public official, Grand Rapids, 2011).

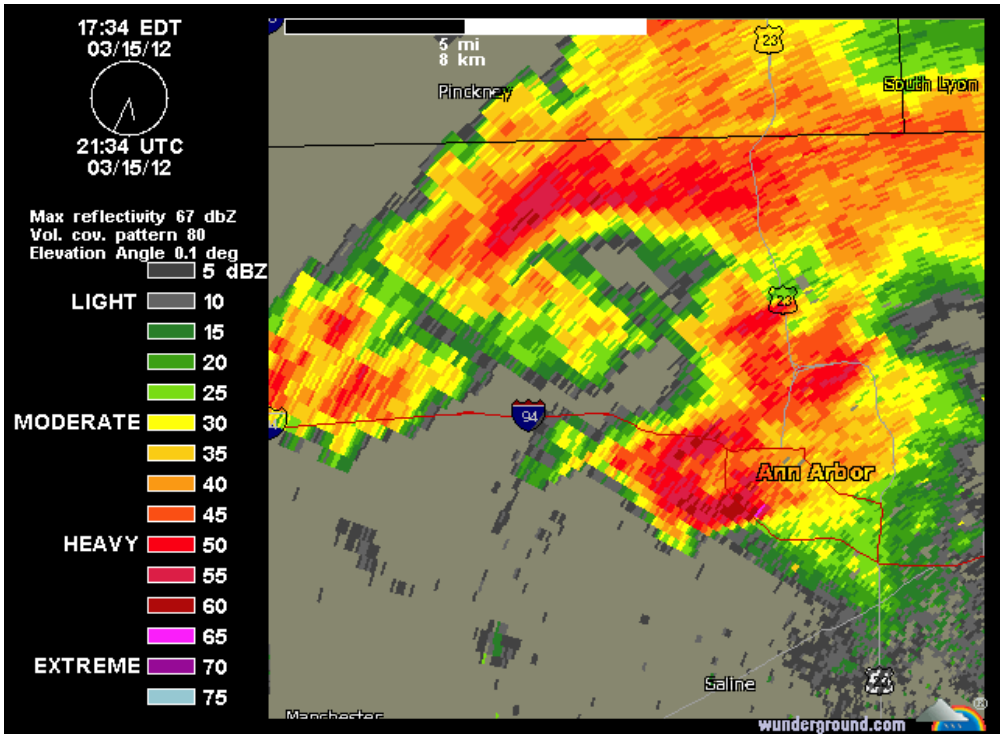


Figure 14.1 Radar reflectivity image of the March 15, 2012 Dexter, Michigan tornado. Source: Jeff Masters, Wunderground. Accessed from: http://www.wunderground.com/blog/JeffMasters/comment.html?entrynum=2052&page=4

Technology usage has proved vital for emergency response as well. During prolonged blackout or power failure events an interviewee explained how certain technologies aid human capital in crucial emergency response units to continually be prepared:

> *During power failure or blackout, we had generators activated so that police, fire, and EMS (emergency medical service) units could go in and refuel. We noticed that during the blackout, two pumps didn't work without electricity – gas pumps. So we installed generators for road commission, obviously, because it's their property, but for emergency response vehicles to go and refuel during an extended blackout as well.* (Public official, Ann Arbor, 2011)

The cities utilize opt-in early warning systems that individuals sign up for through the city website. The system notifies participants in the event of an emergency (Public official, Ann Arbor, 2011).

According to informants in both communities, modern society's dependence on technology opens up risk for climate change to cause wide-ranging disruption. When asked about strong storms in future events an interviewee said:

> *If it* [severe storms] *gets stronger then, we're in real trouble. If we continue to have wild weather swings, I think that that's an economic challenge for sure, but we're so dependent on technology that it will be a real threat, I think, to the business economy. I'll give you an example. So I got a call today from my alarm company, they said, "We wanted to let you know that our alarm center that monitors your home alarm will be offline"; they're in Rhode Island, because the hurricane washed away all their T1 lines. "So we're going to be offline until further notice, and we thought we'd let you know." It's that kind of thing that I'm thinking about. What climate changes would lead to actual emergencies? Where flooding leads to erosion which leads to failure of technologies and that's a turn-off for business, you know, that kind of thing. It's not always about life safety. Sometimes it's about economic and quality of living issues* (Public official, Ann Arbor, 2011)

According to this individual, the implication of technological dependence is that, when a local (potentially climate-related) natural disaster strikes a technology hub, its impact reverberates widely.

Although they don't name their preparations "climate change adaptation," both Ann Arbor and Grand Rapids are expanding cooling centers to prepare for future heat waves. The cooling centers are strategically placed, and technologies help the cities determine where they are needed most. One Ann Arbor interviewee (Public official, Ann Arbor, 2011) noted that two cooling centers were activated during the last heat wave and they were opened in areas they thought would be most socioeconomically beneficial, such as near residences without air conditioning.

However, in employing air conditioning, the cities need to be cautious of maladaptation. Increasing the usage of air conditioning systems to mitigate the effects caused by heat stress will release more greenhouse gas emissions as well as other air pollutants. Cities are aware of these tradeoffs, and, as mentioned in previous chapters, their energy efficiency improvements may help offset increased energy usage from air conditioning. In an Ann Arbor interview a public official noted that things often

considered mitigation (e.g. solar panel installations, hybrid vehicle implementation, reducing fossil fuel use, etc.) also have significant adaptation advantages:

> *If you are going to have higher temperatures in the summer months and folks do have air conditioning, you are going to tend to put more strain on the electric grid, so anything you can do to reduce electrical use during those periods—maybe by reducing base load or other usages to sort of make room for air conditioning on the grid—is going to mean the electric grid is going to be more reliable during those heat waves and you are going to be less likely to have brown outs, black outs, and things like that when the grid is stressed*. (Public official, Ann Arbor, 2011)

In the stormwater sector, cities cited rain gardens and permeable pavements as technologies that enable adaptation. An interviewee (Public official, Ann Arbor, 2011) revealed that Ann Arbor has a rain garden program that helps interested citizens with design work, coordination of purchasing plants, and removes the unknowns surrounding rain gardens (Public official, Ann Arbor, 2011). This has facilitated the installation of rain gardens, which allow rainwater to infiltrate during storms instead of running into the stormwater sewers. Similarly, permeable pavement systems and porous asphalt promote greater infiltration of water and reduce surface water runoff in streets and sidewalks (Public official, Ann Arbor, 2011). Swirl concentrator technology is also utilized in order to remove suspended solids from water that does enter the cities' stormwater system. Rain gardens, porous and permeable pavements, and swirl concentrators represent three technologies that could help cities adapt to increased precipitation and flood events.

Figure 14.2 Porous pavement in the Fifth and William Parking lot in Ann Arbor. "Porous Pavement for Cold Climate Storm Water Management." Source: GreenTalk. Accessed from: http://farm2.static.flickr.com/1140/5122398204_8479c2756b.jpg.

Although porous pavements have proved beneficial thus far in both cities, we note the potential of maladaptation with respect to porous pavements; for example, if porous pavements are implemented in areas that were previously used for industrial purposes, there could potentially be contaminated soils they will now be exposed to more percolating groundwater. If the porous pavement is installed in these conditions, it could exacerbate the leaching of contaminants from soils (Public official, Grand Rapids, 2011). Additionally, using porous pavement and other technologies to reduce the impacts of flooding and excessive runoff is not always financially feasible (Public official, Grand Rapids, 2011).

The application of technology has also proved beneficial for Ann Arbor's urban forestry department. For example, the utilization of GIS to store and analyze tree data has facilitated the process of identifying and addressing areas with low canopy cover as well as expediting the development of an urban forestry management plan (Public official, Ann Arbor, 2011). Additionally, a technology (ITree) was used to analyze and quantify the benefits of Ann Arbor's urban tree canopy, which was valued at 4.6 million dollars annually.

An additional approach Ann Arbor and Grand Rapids are pursuing to increase efficiency and spread of technology includes the promotion of green buildings. Both cities are actively promoting and building Leadership in Energy and Environmental Design (LEED) certified buildings. An informant in Ann Arbor noted that the City cannot require LEED certification because of the State building code. Still, by incentivizing redevelopment through higher density allowances and lower parking requirements, the City believes that it forces developers to improve building efficiency. Simply complying with the modern building code improves building efficiency because of updated insulation, energy efficiency, and lighting standards, all of which will incentivize greener building (Public official, Ann Arbor, 2011).

Ann Arbor and Grand Rapids also both recognize the importance of utilizing local governments to bolster technological advancement. This was exemplified by an interview in Ann Arbor where an official pointed out that most of the innovation and application of technology did not start with federal and state governments, but rather through local institutions and governance and quoted Ann Arbor's recycling program as a prime example:

> *There hasn't been much of anything progressive that's come out of Lansing or Washington in a long time and what's usually been the case is that innovations started at the local level and percolated its way up so programs that Ann Arbor and other communities have modeled have become popular and occasionally become popular around the state, around the country, and have spread to other places. I mean the most dramatic example of that would be, if you go way back, would be recycling programs.* (NGO representative, Ann Arbor, 2011)

Officials from both cities stated that they use municipal buildings and operations to lead by example, demonstrating green building technologies for the community to adopt. For example, the City of Ann Arbor's procurement policies promoted the purchasing of clean and alternative fuel vehicles for the City

fleet (NGO representative, Ann Arbor, 2011). Moreover, the same interviewee (NGO representative, Ann Arbor, 2011) pointed to other cities throughout the country including Berkeley, Boulder, and New York City where the same pattern took place.

Thus far, many of the implications of having technology have been immediate and direct effects; however, it should be noted that having a high or low technological capacity could also have indirect and future effects. For example, an Ann Arbor interview (Public official, Ann Arbor, 2011) revealed that technologies contributing to sustainable development, improved transit, and other services indirectly assisted in preserving the agriculture land and green space surrounding Ann Arbor. Simply stated, investing in sustainable technologies in the city limits and accommodating some density will inhibit the sprawl into rural area and encourage urban growth (Public official, Ann Arbor, 2011).

On occasion, the lack of sufficient technology or information to accurately predict future scenarios impinges upon a city's ability to deploy the appropriate technology and, therefore, adequately adapt. An Ann Arbor interview (Public official, Ann Arbor, 2011) revealed uncertainty around what future floods will look like and how frequently they will occur. This uncertainty is problematic when making decisions about flooding and the appropriate coding for sufficient infrastructure in order to accommodate future events (Public official, Ann Arbor, 2011).

In some instances, it is actually beneficial to refrain from using too much technology; for example, when asked about future climate change impacts one interviewee (Public official, Ann Arbor, 2011) disclosed information about farmers in the Ann Arbor area that are employing sustainable practices that don't rely heavily on technology (i.e. unheated greenhouses). Therefore, if there is future stress on the electrical grid and brownouts and blackouts do occur there will be no adverse effects or losses from the absence of electricity; moreover, it lowers costs and contributes significantly less CO_2 emissions.

Lack of technology also has direct implications with regards to cities adapting to climate change. The lack of past technology has led to the absence of past data and therefore makes it difficult to determine if impacts on cities are becoming more severe (Public official, Ann Arbor, 2011). This was revealed during one of the interviews when we asked, "have you noticed a change in the impacts on the system? Is that something that you can monitor?" Moreover, the interviewee responded by saying, "since we don't have really good data prior to that being implemented, it's hard to say. "

In addition to these current adaptation projects and strategies, cities are considering technological components for future adaptation as well. For example, an interview in Ann Arbor (NGO representative, Ann Arbor, 2011) noted discussion on future usage of public rail line technologies connecting Ann Arbor and Detroit. This would create a more efficient transit system, decrease air pollution, and eliminate some greenhouse gas (GHG) emissions.

Key Relationships

In the absence of other determinants of adaptive capacity, technological adaptations would not be so successful; for example, an interviewee in Ann Arbor explained that financial support and political capital enabled the City to establish an energy office. The energy office then applied technology to improve energy efficiency in buildings and across municipal operations, and install solar panels (Public

official, Ann Arbor, 2011). Similarly, participating in information networks can help with technology uptake. For instance an Ann Arbor interviewee (Public official, 2011) said working with the Municipal Solid-State Street Lighting Consortium allowed Ann Arbor to expedite their LED lighting projects, which increased overall efficiency and saved the City money.

Although technology proves to be extraordinarily beneficial for adaptation, sufficient information is often critical for technology to function properly. For example, Ann Arbor utilizes GIS technology to model and analyze the effect of large precipitation events on its stormwater system. The City relies on top-quality information pertaining to the structural layout of the piping system and the pipe sizes – without accurate data the model would produce less reliable results.

A similar trend with the relationship between technology and information was noted in Grand Rapids. The city of Grand Rapids is one of eight inaugural communities that are using a climate change adaptation software, which is a technology provided by International Council for Local Environmental Initiatives (ICLEI) and it is called Adaptation Database and Planning Tool (ADAPT). The ADAPT software provides an avenue for cities to assess and evaluate their strengths and vulnerabilities. Interviewees in Grand Rapids spoke very highly of the relationship with ICLEI and the quality of the product, but they made sure to emphasize the point that the technology is only as good as the information and data that inform it. Moreover, they noted that the information provided from the software wasn't specific enough. The output was difficult to use because it focuses on the entire Midwest and Grand Rapids needs more specific and downscaled data (Public official, Grand Rapids, 2011).

Human capital and social capital networks facilitate the spread and use of technology. For example, an Ann Arbor interview revealed that instead of local governments informing an organization that it needs to improve its energy efficiency by incorporating new technologies, a third party (i.e. University of Michigan) would work with the local government to inform and expedite technological advancement in other organizations (Public official, Ann Arbor, 2011). In Grand Rapids, partnerships with local corporations have led to the development of technology to determine carbon footprints. Ultimately, this technology will help organizations find ways to reduce their carbon footprint while concurrently lowering costs and bolstering savings (Public official, Grand Rapids, 2011).

Partnerships in Grand Rapids help develop, enhance, and promote existing technologies. For example, Grand Rapids has been working to create a robust forest plan, interactive tree map, and local tree website that would allow the city and community to identify trees and their associated benefits. The city is relying on partnerships with local corporations and universities to contribute information to enhance the technology and also generate interest and knowledge pertaining to trees and their respective services (Public official, Grand Rapids, 2011). One interviewee stated that without community dedication and involvement many of the City's sustainability projects would not have been feasible (Public official, Grand Rapids, 2011). The official cited projects including geothermal energy, large-scale wind projects, and the glazed windows at City Hall. This interviewee spoke proudly about the community engagement associated with these technology-advancing projects (Public official, Grand Rapids, 2011).

Another example of social capital networks facilitating the advancement of technology is in Ann Arbor's partnership with the Detroit Edison Energy Company (DTE). Together, Ann Arbor and DTE implemented a landfill gas capture system, which burns landfill methane emissions, produces electricity and sends it to the grid. The gas capture system achieves the mitigation benefit of preventing methane (a greenhouse gas) from entering the atmosphere.

Without wealth and financial capital, projects like the landfill gas capture system would not be feasible, but the benefits from the application of this technology will also bolster wealth and financial capital. This feedback loop—wealth and financial capital enables technology and technology then bolsters wealth—also emerges through energy efficiency projects in Ann Arbor. One interviewee (Public official, Ann Arbor, 2011) stated, "It just made sense economically to invest in energy efficiency and renewable energy projects because if you give me $10 you'll get $30 back."

Similarly, in Grand Rapids, one interviewee (Public official, Grand Rapids, 2011) attributed the success of solar panel, motion sensor lighting, and geothermal projects to both sufficient funding and the savings that these technologies create. In this example, the money that is saved by employing these new technologies is captured and invested into future energy efficient and renewable energy technologies, so that technology and wealth reinforce each other in enhancing adaptive capacity.

Both cities have adopted programs to promote or fund efficiency improvements by private organizations, which also demonstrate the reinforcing relationship between wealth and technology. Ann Arbor's Technical Energy Analysis, sponsored by the DDA, is an energy audit that that offers an individual or company information on technologies that provide energy savings, estimates the costs of those technologies, and projects a payback period. The Comprehensive Energy Strategy in Grand Rapids is a similar program that analyzes how investments in energy saving technologies could provide short and long-term benefits as well as the payback period on the investments. Ann Arbor's Property Assessed Clean Energy (PACE) program, which finances efficiency improvements in commercial industrial properties, should also facilitate the advancement of technology.

Wealth and financial capital, information, human capital, and infrastructure operate in tandem to determine the success of a planned Ann Arbor project that will rely on technology. The project will use GIS technology to analyze low-income housing, vulnerable populations, and tree canopy cover in an attempt to determine if increasing tree canopy cover would reduce the amount of heat-induced stress for vulnerable populations. The project will require an adequate funding source as well as ample human capital, and information to deploy technology for the study. Later, if technology enables the study's completion, the City will need to mobilize financial and human capital to plan material resources (tree canopy) in a manner that benefits vulnerable populations (Public official, Ann Arbor, 2011).

Technology has helped bolster other determinants of adaptive capacity as well. For example, an Ann Arbor interviewee (Public official, 2011) noted that the city used technology to increase public engagement in the planning process:

> *We do try to reach out… to solicit public comment, but try getting somebody to come out at 7 o'clock on a Wednesday night to provide feedback isn't easy. So, we went to a more digital*

approach in an attempt to get feedback from people. So we created a website that asked people to fill out a survey about what their preferences and problems were. And I think we got hundreds of responses. They were actually very helpful in letting us know what the issues were.

In some instances, technology could be beneficial for climate change adaptation, but the absence of other determinants may prevent the use of technology. A Grand Rapids interviewee explained that adapting to future 50 or 100 year precipitation events will require accurate information to inform technology, the appropriate material resources and infrastructure, and the ability to use to these determinants together. Without appropriate wealth and financial capital, the necessary adaptation projects would not be possible. Moreover, if the project was to proceed and the technology or material resources and infrastructure were inadequate the reverberations would be borne by wealth and financial capital. For example, if down spouts and footing drains are connected to the sanitary storm system and a large-scale rain event occurs, the waste water treatment plants and pump stations endure the costs of running pumps and using chemicals to meet discharge requirements set by the Department of Environmental Quality (DEQ) (Public official, Grand Rapids, 2011).

As the discussion of technology in Ann Arbor and Grand Rapids shows, relationships between technology and the other determinants of adaptive capacity exist. **Table 14.1** shows some examples of relationships between technology and the other determinants, which emerged from our various interviews. It should be noted, however, that this is not a comprehensive list of all relationships, but examples that highlight the key relationships that revealed themselves.

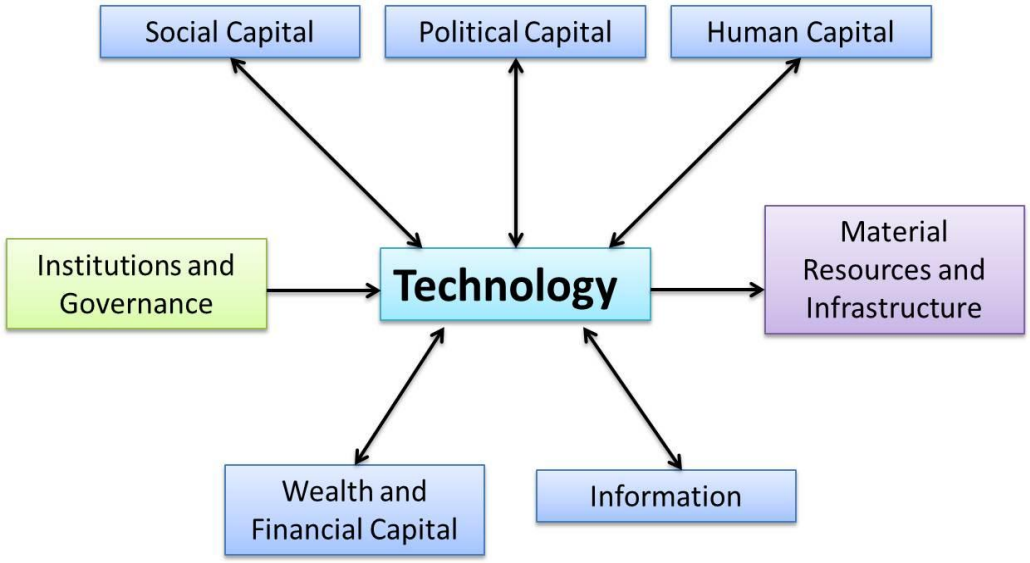
Table 14.1. Relationships between Technology and Other Determinants in our Case Cities

Determinant	Relationship with Technology
Institutions	• Innovation and application of technology promoted by local government
Infrastructure	• Implementation of porous pavements and stormwater/sanitary systems • Testing LED streetlights • Energy efficient technologies incorporated into LEED certified buildings
Wealth and Financial Capital	• Essential for development and implementation of technology • Monetary returns from investing in energy efficient technologies
Social Capital Networks	• Information exchange between government agencies and local organizations • Social networks bolster technological innovation
Political Capital	• Sufficient technology is pivotal in providing information for political action • Advancement in technologies made possible via political capital/leadership

Human Capital	• Use technologies and provide feedback regarding technology • Essential for developing and applying technology
Information	• Robust information informs and bolsters technology • Information is necessary for properly functioning technology

Although this study found key interactions between determinants that emerged, the relationships of the determinants differed. For example, the presence or absence of a determinant could either bolster or hinder another determinant; what's more, a determinant can influence another determinant, be influenced by another determinant, or both. **Figure 14.3** depicts the aforementioned relationships amongst determinants.

Figure 14.3. Key Relationships between Technology and Other Determinants in our case cities



Institutions contribute to building Technology (the presence of this determinant builds technology while the absence of this determinant hinders development of Technology). Social capital networks, Political Capital, Human Capital, Wealth and Financial Capital, and Information both enhance and are enhanced by Technology. Lastly, Technology is essential for building Infrastructure.

Chapter 15: Conclusion

This exploratory study applies an adaptive capacity framework to two Great Lakes cities — Ann Arbor and Grand Rapids, Michigan. We defined eight determinants of adaptive capacity in the urban context, identified examples of those determinants in our case cities, explored their relevance for climate adaptation (based on anticipated climate impacts), and highlighted feedback loops and interrelationships among them. From this investigation, we conclude that climate change adaptation is happening in our case cities, cities capitalize on different determinants to achieve adaptation goals, people matter, and an integrated approach to policy and planning promotes effective and efficient adaptation actions.

Climate Change Adaptation Is Happening

Our case cities are pursuing adaptation-relevant activities. However, this conclusion is far from trivial: we find that the cities do not always call what they are doing "climate adaptation" and our informants did not all recognize existing initiatives' relevance for adaptation. For example, one informant said that Ann Arbor's PACE program exclusively addressed climate mitigation, but we consider that the program could achieve adaptation benefits ancillary to its mitigation goals. Readers will not find a climate adaptation plan for either of our case cities, yet both cities are pursuing projects with direct relevance for adaptation. They either refrain from using the words "climate adaptation" for political and cultural reasons, or adaptation happens as an ancillary benefit from current plans, policies and programs with other primary objectives.

With this caveat, we find examples of adaptation or adaptive action in the energy, stormwater, land use, emergency response, building, and urban forestry sectors. The energy sector presents a clear example of adaptation as ancillary benefit. Our case cities have developed robust programs to fund and implement energy efficiency improvements. The cities frame these programs around cost saving and greenhouse gas mitigation goals. However, given projected temperature increases, reducing base load on the energy grid represents an important adaptation strategy. Future research could evaluate the efficiency improvements these cities have achieved, and compare efficiency gains with projected energy spikes due to heat waves.

Stormwater management is another adaptation strategy that cities do not explicitly call "climate adaptation." Here, we include the narrowly defined stormwater system—pipes, green infrastructure like rain barrels and green roofs, and pollution controls. We also include land use regulations that promote compact urban development and require private developers to mitigate impervious surface additions. Without explicitly referring to "climate adaptation," these cities design their infrastructure with the goals of minimizing stormwater runoff, managing the watershed, and mitigating flood risk. Although these activities may not have originated as climate adaptation measures, they will improve both communities' resilience if and when stronger rainstorms occur. Further, both cities recognized opportunities for improving stormwater management in light of climate change: Ann Arbor raised the possibility of adapting building regulations in the floodplain or changing infrastructure design standards to accommodate more intense storms. Grand Rapids officials highlighted green infrastructure as a strategy. Still, both cities already address flood risk and incorporate precipitation projections into their

planning; the challenge lies in updating their standards and programs to incorporate projected climate changes.

Different Roads, Similar Outcomes

We examined eight determinants of adaptive capacity – institutions, infrastructure, wealth and financial capital, social capital networks, political capital, human capital, information, and technology. Using this framework as a lens, we discovered projects and plans through which the cities are preparing for climate change, and the unique roles each determinant plays in the adaptation process. Several stories emerged that highlight the interplay between determinants in enabling or constraining adaptive capacity, and we find that no determinant operates independently of the others. We also find that the two communities capitalize on different determinants in achieving goals in certain sectors. We emphasize interrelationships between determinants and the cities' different strategies to show that different approaches can achieve similar positive outcomes.

The Ann Arbor and Grand Rapids cases demonstrate that all eight determinants contribute to adaptive capacity in important ways. Institutions consist of the rules and regulations ensuring that adaptation becomes a priority for public and private actors. Infrastructure systems ensure cities' resilience to climate impacts. Still, the long-term, fixed nature of infrastructure creates path dependence, reducing cities' ability to adapt in the short term. Wealth contributes to adaptive capacity since cities need money to pay staff, purchase technology and information, and build and maintain infrastructure projects. Social capital and networks boost adaptive capacity since collaboration and resource sharing helps stretch city resources. Political capital, in the form of leadership and public support, allow the cities to pursue adaptation activities. Human capital in the form of knowledgeable, talented individuals plays a critical role in developing and implementing adaptation programs. Timely information about extreme events help cities respond to climate-related impacts and scientific projections about future climate impacts would enable cities to plan systems that will accommodate future events. Technology enables the collection and communication of climate data, and it bolsters the effectiveness of the other determinants in enabling adaptation. Indeed, it is difficult to separate technology as an independent determinant of adaptive capacity, since its effective use depends on other determinants (e.g. human capital, financial capital), and its usefulness primarily consists in boosting other determinants' strength (e.g. information, infrastructure).

While technology most strongly demonstrates the interrelationships between determinants, no determinant operates independently of the others. Instead, we find complex relationships and feedback loops between them. Some determinants enable or bolster others. For example, institutions generate wealth and channel it towards adaptation-relevant material resources and infrastructure systems. Thus, Ann Arbor's stormwater utility fee and greenbelt millage both raise revenue that the City then invests in stormwater infrastructure and natural areas conservation, respectively. In a similar chain of causation, information can boost political capital to support new institutions that promote infrastructure's resilience. The City of Ann Arbor has considered expanding the area within which developers must comply with floodplain regulations, to protect buildings from flooding. However, the city claims that it needs finely scaled data supporting projections that climate change will cause wider floods. By providing

a scientific backing that an area faces greater flood risk, this information could help counter public opposition. It would also provide the necessary legal basis for the city to pass a new ordinance.

We find that some determinants can serve as supplements to one another. For example, both cities have faced budget cuts and reduced staff (restricted financial capital causes institutional and human capital limitations). The City of Grand Rapids has countered these shortfalls by activating social capital, networks and civic engagement. Community groups have mobilized to implement many of the initiatives contained in the Green Grand Rapids plan, effectively using social capital to supplement the government's work to implement its plans, in the face of restricted wealth and financial capital.

Some determinants mutually reinforce each other. For example, wealth and human capital can create a positive feedback loop with institutions. Cities need money to create and staff city departments like Ann Arbor's Energy Office and Grand Rapids' Office of Energy and Sustainability. Entrepreneurial staff (human capital) who work in these organizations innovate by pursuing creative funding mechanisms and capturing grant funding, generating more financial capital for the cities. Many of these new resources are also flexible (when compared with city budgets) and allow for investment in areas that otherwise would not get funding, especially in times of economic hardship. Similarly, some determinants are self-enabling. Wealth begets wealth: a certain baseline level of financial capital enables cities to protect their assets, and leveraging and institutional funding mechanisms enable initial wealth to grow.

We find that more of a determinant does not always lead to better outcomes. For example, additional information is not helpful if staff do not have time or energy to analyze and incorporate it into their activities. Similarly, technology is only as good as the information fed into it and the minds using it (human capital).

While we identify many similarities between the communities, each city emphasizes different determinants in achieving its goals. We do not conclude that either city fundamentally lacks any element of adaptive capacity. Still, different stories emerge in the two cities. For example, many informants in Grand Rapids referred to the usefulness of public engagement—political and social capital—for achieving positive outcomes. Meanwhile, we find several examples in Ann Arbor of institutionalized funding sources enabling adaptation. The complex relationships between determinants and different strategies used (both within and between the cities) make it difficult to prioritize between determinants. Instead, the important story lies in the interrelationships between the determinants and the possibility of combining them differently to achieve adaptation goals.

People Matter

Throughout our analysis, we find that people matter: human capital, political capital, and social capital bolster the effectiveness of every other component of adaptive capacity. In both cities, we find that political leaders play a critical role in setting priorities, which helps institutionalize and build public support for adaptation. Informants referenced the Mayor of Ann Arbor's renewable energy goal as fundamental to establishing an energy office. Grand Rapids' mayor's leadership helped the city embark on an impressive sustainability planning journey, despite initial unfamiliarity with sustainability

concepts. Now, the City incorporates the "triple bottom line" into every department's work through well-defined metrics. Positive relationships and shared values between political leaders can also help forge institutional relationships. For example, this occurred between the Washtenaw County Water Resources Commissioner and the Mayor of Ann Arbor, whose organizations share a watershed planner.

Social networks also help to define priorities and implement programs. For example, a group of concerned citizens in Ann Arbor's Malletts Creek watershed proposed a series of reforms including regulating impervious surface on single-family properties. At City Council's direction, the city adopted their proposals and codified the single-family impervious surface regulation as a city ordinance. In Grand Rapids, champion groups have played a critical role in implementing the Green Grand Rapids. Friends of Grand Rapids Parks recruits volunteers for park maintenance, raises funding for new parks, and contributes to parks planning. The group is critical in light of drastic reductions and restructuring of the City's Parks & Recreation Department.

Human capital is critical in that talented staff develop good ideas; many of our informants attributed the cities' successes to specific highly skilled individuals. The Ann Arbor Energy Manager who developed the internal revolving loan fund, Grand Rapids' Planning Manager who shines in the public engagement role, and the design professionals who have made Grand Rapids a leader in green building: these individuals have played an essential role in bringing sustainability and adaptation to the forefront in their communities. Notably, in Grand Rapids we find an example of an institution designed to attract human capital. When the City's Urban Forestry Committee re-imagined the position of Urban Forester, it wrote the job description with an eye towards attracting specific skills like public engagement and planning. Human capital also improves the effectiveness of civic groups and city commissions —talented and knowledgeable individuals form successful groups.

Integrated Approach to Planning

Integration emerges as a key tool for successful adaptation. In the context of this study, integration refers either to spreading concepts through the many departments of an organization, or to bringing together various disciplinary perspectives to solve problems. Both cities claimed to accomplish the first type of integration—incorporating adaptation concepts across many sectors—through institutions. The City of Grand Rapids has instated a series of metrics for achieving sustainability goals through its Sustainability Plan. The Office of Energy and Sustainability works with other city departments to track progress on the Plan's objectives, some of which are relevant for climate adaptation. Similarly, the City of Ann Arbor hopes that its Sustainability Framework will help all departments incorporate sustainability objectives into their work.

Complementary to the integration of priorities across city functions, integration also refers to incorporating diverse perspectives into decision-making, to reduce redundancies and improve efficiencies. The clearest example of decision-making integration concerns infrastructure maintenance in the public right of way. In planning road-resurfacing projects, both cities determine if water main pipes or stormwater pipes need replacement, to avoid ripping up the pavement more than once. The City of Ann Arbor believes that its Systems Planning Unit facilitates integrated decision-making, by pulling together managers responsible for a diversity of city systems. While City officials said that daily "cross-

pollination" may not occur, the institutional structure allows the City to capitalize on opportunities for integrated decision-making and discussions. For example, the Systems Planning Unit manages the City's capital improvements planning process, incorporating diverse perspectives into infrastructure investment decisions.

Integration can reduce costs by improving efficiencies, and it can increase staff knowledge by facilitating collaboration and discussion across disciplinary boundaries. However, communication takes time, and long-term, integrated planning conversations can fall to the bottom of busy staff's priority lists. Institutional systems like the metrics contained in Grand Rapids' Sustainability Plan and Ann Arbor's capital improvements planning process help to ensure that integration occurs.

Constraints and Considerations for Moving Forward

Throughout our research, we identified constraints that cities face in adapting to climate change. As noted in our analysis and conclusions, cities have devised creative mechanisms for working around these constraints. Still, we note the constraints to adaptation, along with some suggested considerations for moving forward in light of these barriers.

Our informants repeatedly referenced the difficulty of achieving interagency collaboration, in light of both institutional and political obstacles. Informants cited Michigan's governance structure as a significant barrier to regional planning efforts, since the State grants zoning authority to all local governments. While parochialism and mistrust between jurisdictions do act as obstacles to collaboration, nothing legally prevents cities, townships, and counties from engaging in regional planning efforts. Still, incentives from the state and federal governments could foster collaboration. Some informants referred to initiatives introduced by Michigan's current Governor as signs that higher levels of government could be moving in that direction. Informants also cited a general lack of national and state policy direction to encourage climate change adaptation and mitigation activities at the local level. Encouraging interjurisdictional collaboration represents one area where the state and federal governments could provide incentives to shape local policy.

While some institutional obstacles to adaptation lie outside cities' capacity to change, they can continue developing creative mechanisms for working around those barriers. Informants cited the State of Michigan's building code as a barrier to adaptation, since cities cannot mandate structural standards more strict than the state code. This restricts cities' ability to impose energy efficiency requirements, or structural regulations on buildings in flood-prone areas. Still, the City of Ann Arbor suggested that it could use its zoning code to restrict building uses in an expanded floodplain, achieving a similar end — mitigation of flood risk—that structural regulations would. Speaking to the efficiency question, informants in Grand Rapids noted that market demand and designers' innovation have contributed to the high number of green buildings in Grand Rapids. The City of Ann Arbor has developed a PACE program to fund energy efficiency improvements, which marks a positive step forward for allowing the market for green building to operate unrestricted. Even while the cities may not be able to impose *regulations* stronger than the State's, they should continue to *incentivize* and to ensure that local regulations do not restrict markets for adaptation-relevant elements of the built environment.

Within the local institutional context, the cities continue to encounter constraints. For example, although we find that integration in planning and decision-making helps foster adaptation, our case cities continue to experience imperfect integration. Silos remain within the city bureaucracy, either because staff lack the time to discuss issues with their colleagues in other disciplines, or because certain city systems have not been fully integrated. For instance, informants from Ann Arbor commented that land use planning has not been incorporated into the City's Systems Planning Unit structure. Additionally, informants commented that Ann Arbor could incorporate adaptation as an institutionalized priority through its Sustainability Framework or its capital improvements planning process. Integrating adaptation as an institutional priority could ensure that it does not lie above and beyond staff's normal responsibilities, but is instead incorporated into them.

Related to our finding that "people matter" in enabling adaptation, we also find certain ways in which individual or community perceptions constrain adaptation. Some adaptive actions rely heavily on behavior change. For example, successful emergency response depends partially on individuals' actions in response to information they receive. Cities may do everything right to notify the public about emergency preparedness measures that individuals should take, but if people do not act on the information they receive, a climate-related storm may cause a dire impact. Still, cities should not trust that information alone will enable household-level adaptation, since behavior change is motivated by factors beyond simple information. As climate risks become more severe, the cities should evaluate individual-level adaptive response and develop programs to enable a strong response.

Cities did note certain ways in which uncertainty about climate change inhibits their ability to adapt. Perceived lack of climate information presents both technical and political constraints to adaptation. On the technical side, system managers said that they needed downscaled data about precipitation patterns and flood risk, in order to update infrastructure design standards and floodplain ordinances. This data would also help the cities counter political opposition from groups who perceive climate risks as either nonexistent, remote in time and space, or of dubious scientific validity. Because of the varied perceptions of risk associated with climate change —whether due to politics, culture, or other factors— members of the public and officials may calculate the costs and benefits of adaptation options differently. To obtain the best available data for making and supporting adaptation decisions, cities should continue working with the universities and science-based NGOs that have provided technical assistance to date. Still, given the range of confidence intervals with which scientists are able to project global climate change impacts, locally scaled projections are likely to remain relatively imprecise. Thus, careful framing of issues and flexibility will remain crucial components of cities' adaptation strategies. Additionally, both cities would benefit from creating a decision framework that identifies data points each system manager needs to make decisions.

Economic conditions pose a serious constraint to adaptation, especially given the aforementioned political challenges and information limitations. Informants expressed the perception that "green" alternatives such as permeable pavement systems and green buildings may be more expensive than traditional alternatives. While an up-front cost comparison may make this statement seem true, a long-term cost-effectiveness analysis that incorporates climate change considerations may reveal that the "green" alternative would be economically efficient. Still, defining methods for comparing new

technologies' costs and benefits in light of uncertain impacts will remain challenging for cities. Adaptive management represents one approach to confronting this challenge. Within this framework, cities implement pilot programs to test new technologies. After monitoring the results from pilots, cities choose whether to implement the technology more broadly. Adaptive management allows cities to test new techniques in low-profile, low-risk locations, so that they can design broad adaptation strategies based on local conditions.

Opportunities for Future Research

We close by identifying opportunities for future research that would build on our findings. Most immediately, our conclusions will inform the Graham Environmental Sustainability Institute's integrated assessment of climate adaptation across a large sample of Great Lakes cities. Our findings reveal variables that the integrated assessment should consider, and inform hypotheses for quantitative analysis of determinants of adaptive capacity. By defining the determinants of adaptive capacity in the urban context, identifying examples of each of them, and exploring their relevance for adaptation and their relationships to each other, we hope to inform the integrated assessment's questions for a closed-response survey.

Embedding adaptation within other city initiatives presents important implications for future research and planning. Researchers may need to dig deeper into city policies and programs, beyond those that are called "climate adaptation." As we have done, future research should identify programs that address a region's anticipated climate impacts. Meanwhile, cities may integrate adaptation into ongoing initiatives for efficiency or political reasons, or achieve adaptation as one ancillary benefit through a program designed around a different primary objective.

Our methodology defined our scope to focus on how these determinants relate to city government institutions, from a top-town perspective. We identify factors that city and NGO officials consider to be critical, without conducting a thorough evaluation of policies, programs, and activities' results for the systems concerned. A bottom-up analysis could examine data associated with programs like Ann Arbor's greenbelt, Grand Rapids' Sustainability Plan's performance metrics, and the Ann Arbor DDA's energy efficiency retrofits. Program evaluation would help to quantify these initiatives' outcomes—our conclusions indicate only how our informants *think* these programs are influencing adaptation outcomes. Similarly, case studies in other cities could verify our conclusions or raise new hypotheses. Smaller cities, those facing different climate impacts, cities who are newer to environmental initiatives: these present interesting opportunities to apply our adaptive capacity framework.

Future research could also seek to answer the question: if people matter, how can cities build social, political, and human capital? How does education relate to climate adaptation, and how are other communities' civic groups helping to bolster adaptive capacity? Informants in both our case communities stressed the tremendous importance of peer-to-peer sharing between cities. Future research on how to bolster the people-centric determinants of adaptive capacity provides an important learning opportunity for cities.

Finally, we hope that our conclusions provide insight into how our case cities can improve their work. Both cities could incorporate lessons from the other, and capitalize on opportunities noted in our analysis.

Appendix 1: List of Interviewees

Grand Rapids

- Haris Alibasic, Director, City of Grand Rapids Office of Energy and Sustainability
- Tom Almonte, Assistant to the City Manager, City of Grand Rapids
- Rick Baker, President and CEO, Grand Rapids Area Chamber of Commerce
- Norman Christopher, Executive Director, Sustainable Community Development Initiative, Grand Valley State University
- Dotti Clune, Chair, Urban Forestry Committee
- Mark DeClercq, City Engineer, City of Grand Rapids
- Pat Draper, Kent County Health Department
- Steve Faber, Friends of Grand Rapids Parks
- George Heartwell, Mayor, Grand Rapids
- Rachel Hood, Executive Director, West Michigan Environmental Action Council
- Lisa Locke, Coordinator, West Michigan Sustainable Business Forum
- Mike Lunn, Director, City of Grand Rapids Environmental Services
- Lauren Lynch, Intern, City of Grand Rapids Office of Energy and Sustainability
- Ellen Satterlee, CEO, The Wege Foundation
- Steve Schipper, Manager of Fleet and Facilities Management, Interurban Transit Partnership, "The Rapid"
- Suzanne Schulz, Director, City of Grand Rapids Planning Department
- Sara Simmons, Kent County Health Department
- Jay Steffen, Director, Parks & Recreation, City of Grand Rapids
- Tyler Stevenson, City Forester, City Grand Rapids
- Lieutenant Jack Stewart, Emergency Management Coordinator, Kent County Sheriff Department
- Gary Szoktko, Deputy Chief, City of Grand Rapids Fire Department
- Joellen Thomson, Director, City of Grand Rapids Water System
- Peter Varga, CEO, Interurban Transit Partnership, "The Rapid"

Ann Arbor

- Wendy Barrott, Systems Planning (Energy), City of Ann Arbor
- Marc Breckenridge, Emergency Services Division Director, Washtenaw County Sheriff's Office
- Ed Dreslinski, Director of Emergency Management, City of Ann Arbor
- Dan Ezekiel,
- Mike Garfield, Executive Director, Ecology Center
- Jerry Hancock, Stormwater & Floodplain Program Coordinator, Systems Planning, City of Ann Arbor
- John Hieftje, Mayor, City of Ann Arbor
- Jeff Kahan, City Planner, City of Ann Arbor
- Dave Konkle, Former Energy Office head, City of Ann Arbor
- Melinda Koslow, Regional Campaign Manager, Great Lakes Regional Center, National Wildlife Federation
- Jennifer Lawson, Water Quality Manager, Systems Planning, City of Ann Arbor
- Matthew Naud, Environmental Coordinator, Systems Planning, City of Ann Arbor
- Dick Norton, Chair of the Urban and Regional Planning Program, University of Michigan
- Marti Praschan, Financial Manager, City of Ann Arbor

- Laura Rubin, Huron River Watershed Council
- Cresson Slotten, Systems Planning Manager, City of Ann Arbor
- Harry Sheehan, Environmental Manager, Washtenaw County Water Resources Commissioner
- Chris White, Ann Arbor Transportation Authority
- Kerry Gray, Urban Forestry and Natural Resources Planning Coordinator, Systems Planning, City of Ann Arbor
- Jennifer Fike, Executive Director, Food System Economic Partnership (FSEP)
- Andrew Brix, Energy Program Manager, Systems Planning, City of Ann Arbor

Appendix 2: Template Interview Questionnaire

Climate Mitigation and Adaptation

1. How did climate change work become a priority for the city?
2. What are the city's main sources of information about climate change?
3. Is that information useful? How can the information be improved and what additional information would be useful?
4. Are there any challenges or roadblocks you face when gathering the information you need to make decisions?

Mitigation

1. Has the city implemented any policies or programs to reduce emissions? How effective has that been?
2. What incentives exist at the city level to curb or decrease emissions?
3. Does the city coordinate with the private sector in mitigation efforts?
4. Can you tell me more about plans and goals related to renewable energy sources?
5. Does the city have plans to promote energy efficiency or energy conservation as well?
6. How are decisions about energy use and production made at the municipal level?
7. Have concerns about climate change influenced the city's energy planning?
8. What opportunities for climate mitigation activities do you see (e.g., federal or state funding, regulatory mandates)?
9. How much has the city budgeted for climate mitigation work over the past 5 years?
10. What do you see as the challenges or constraints to climate mitigation in the city (e.g., political, financial, human resources, etc.)?
11. What additional mitigation projects might the city undertake if there were no constraining factors?

Adaptation

1. Does your department do any work on preparing the city for climate change or climate adaptation?
   i. (if yes) Can you tell me a little more about that work?
2. What other departments are working on climate change issues? About how many staff people are involved in adaptation work?
3. What types of potential climate impacts do you feel are most relevant to your city?
4. Has the City adopted any policies or plans regarding climate adaptation?
   i. (If yes) What types of adaptation strategies is the city working on?
   ii. (If yes) Do you think the existing plans will be effective in helping the city to adapt to impacts?
   iii. Has any legislation mandated adaptation work?
   iv. If no: Looking down the road, what do you think is going to be most important
5. What enabled the city to take these actions? (e.g., leadership, political momentum, funding, human resources, etc.)
6. Tell me about the political climate in this city. In your opinion, is there political support or opposition for climate mitigation and adaptation efforts?
7. How do you go about communicating or framing climate relevant issues to public or to policy-makers?

8. What challenges/barriers has the city faced in adopting or implanting climate adaptation work?
   i. Has any public opposition or support occurred? At what scale? (Local, state, national)
   ii. (If yes) How have you handled that?
9. We're interested in knowing more about how budgeting works, Can you tell us more about that process?
10. How much has the City budgeted for climate adaptation work over the past 5 years?

Response to Extreme Weather Events

The next section of this interview deals with extreme climate events – things like droughts, floods, blizzards, heat waves, and tornadoes. The impacts of the event could include things like a blackout during a warm day.

1. Have you been involved in disaster management or emergency preparedness?
2. Who handles these issues in the city?
3. How does the city define extreme weather events?
4. Has the city experienced any extreme weather events in the past 10 years?
   a. Which of these events had the most severe impact? How and why?
5. Was an official emergency declared for any of these events?
6. Can you describe the city's response to the event – from the early warnings and notification to what happened during the event to any assessment or policy changes that occurred after the event took place?
   a. What agencies, departments, and key individuals were involved? What did each do?
   b. How much did the response cost? Where did the funding come from? Where there any factors that aided or constrained access to funding resources?
   c. Was technical or scientific information used? (If yes) What kinds of information were used and how? Was any of this information climate specific? (If no) Why not?
   d. Was the response successful? In what ways? How did it contribute to lessening impact? What factors contributed to that success? What criteria are you using to evaluate the success? What were the constraints?
7. How many people were directly impacted by the event? In what ways, and to what degree of severity? Deaths? Injuries? Lost or damaged property?
8. What types of emergency warning systems are in place in your city?
9. Has the intensity and frequency of extreme weather events changed over the last 10 years?
10. Did any past extreme event lead to change in policy or planning? Which?
    a. (if yes)
        i. Can you describe those changes and how they came about?
11. Can you identify any risks or vulnerabilities your city may have with respect to extreme weather events in the future?
    a. In what ways is the city attempting to reduce these risks, or improve its capacity to respond?
12. How and when was an emergency response plan developed and how effective has it been? May we have access to a copy?(get examples)
13. Do you think the plan is adequate? If not, what do you think needs to change?
14. What is the emphasis of the emergency response plan? (emphasis on people, infrastructure, natural environment?)

15. Does the city have plans in place to handle power outages from severe storms, or strain upon the grid due to increased air conditioning use?
16. Can you tell us more about the Extreme Heat program, and any other emergency response plans for vulnerable populations during extreme heat events the city has in place?
17. How effectively have different departments responded to extreme weather events? How well coordinated between different departments were they?
18. Is there money set aside in the budget for emergency response and is that money adequate? How effectively can you mobilize it?
19. Is technical or scientific information used to prepare for emergency planning? How is the information used?
20. What were the financial and social impacts of the event?

Infrastructure

1. How does the city plan coordinate and implement infrastructure maintenance and repairs (drinking water, stormwater, roads, bridges, electric, etc.)? Is maintenance between these systems coordinated?
2. How effective is the process the city follows for updating infrastructure, such as pipes and roads?
3. Where does the majority of infrastructure funding come from, and what is the process for obtaining it? What are the barriers to obtaining funding?
4. How are projects prioritized?
5. Has preparing for or adapting to climate change influenced this process of updating infrastructure?
    a. (If no)
        i. Why not?
    b. (Yes)
        i. In what ways?
6. Has preparing for or adapting to climate change influenced building codes? What's the process for updating/changing them and how effective is that process?
    a. (If no)
        i. Why not?
    b. (Yes)
        i. In what ways?

Governance and Policy Climate

1. Who do you work with? Who are your collaborators on adaptation initiatives?
2. In what ways does [the Office of Energy and Sustainability/Systems Planning Unit/Etc.] work with or influence other city departments?
3. How effective are those collaborations?
4. Are there any stumbling blocks in such collaborative efforts? Any political or institutional or bureaucratic barriers?
5. How has the local, state or federal government enabled or constrained your ability (to respond to extreme weather events)? To climate adaptation planning?
6. Can you speak to any relevant political influences (positive or negative) in the city?
7. Leadership? (local, state or federal)

External Networks

1. The city is a member of ICLEI.
    a. How has this membership impacted the way the city works?
    b. Can you tell me more about ADAPT, the online climate adaptation tool ICLEI has created? Has this tool been useful to Grand Rapids?
2. Mayor Heartwell/Hieftje is a participant in the U.S. Conference of Mayors' Climate Protection agreement.
    a. What has participating in the agreement meant for the city?
3. Can you tell me more about the other planning or environmental networks, organizations, or partnerships the city participates in and their scale of collaboration?
    a. How does this participation influence your work?
4. In what ways does the city work with other community partners and how effective are those collaborations?
5. Are there any barriers to those types of civil society collaborations?
6. Does the city work with other cities on climate mitigation and adaptation? In what ways?

Transportation

1. What is the city's process for planning and updating transportation infrastructure?
2. How is the transportation planning department planning for climate adaptation? How could climate change be relevant to transportation planning?
3. Does the city have plans for expanding its public transportation system or infrastructure?
4. Is any of the city's transportation fleet fueled by renewable energy resources (e.g. Biodiesel)?
5. Does the city have an evacuation plan built into the Emergency Response Plan?

Natural Systems and Urban Planning

1. Has the city considered climate change or sustainability in land use planning?
    a. Does the city have plans to expand into existing green space or agricultural land? How are such expansions planned or managed?
    b. Are there incentives in place either to protect or develop existing green space or agricultural lands?
    c. Does the city engage in planning of green spaces or green building techniques (such as passive solar, green roofs, etc.)?
    d. Wetlands Does the city have any protections in place for natural wetlands?
2. Has the city done anything to protect natural resources and ecosystem services (e.g., provision of clean air and water, biodiversity, nutrient cycling) from climate change impacts?
    a. Are there specific concerns? What ideas do you have about what the impacts will be?
3. In your opinion, will changes to the water levels in the Great Lakes affect your city?
    a. (If yes)
        i. How so?
4. Has preparing for or adapting to climate change influenced land use decision-making?
    a. (If no)
        i. Why not?
        ii. What would help the city consider climate change when making land use decisions?

b. (Yes)
    i. In what ways?
    ii. What made it possible to consider climate change in these decisions?

Human Health

1. Is the city taking preventative measures to prepare for future climate change induced human health issues (e.g., increased heat wave frequency, intensity, and duration impairing health)?
    a. If no…
        i. Why not? What are the main obstacles to future planning?
        iii. What would be needed to encourage pre-emptive preparations?
    b. If yes,
        i. Can you describe the precautionary measures taken and for what health issues?
2. Are there systems in place or resources available to citizens who need assistance during such extreme weather events?
3. What do you consider to be vulnerable populations? Where are they located? Is any thought going into protecting these populations?
4. What systems are in place or agencies are working on protecting air and water quality in your city?

Future Vision

1. Related to sustainability and climate adaptation, what is your vision for the future of the city?

Appendix 3: Letter Requesting Participation in the Study

July 15, 2011
Mayor George Heartwell
Grand Rapids City Hall
300 Monroe Avenue NW
Grand Rapids, MI 49503

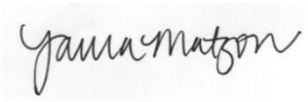
Dear Mayor Heartwell,

I'm writing on behalf of a team of five MS students from the University of Michigan's School of Natural Resources and Environment (SNRE). Our team is conducting a year-long master's project evaluating climate change adaptation in Great Lakes cities. In particular, we are interested in governance and institutional structures, and how they may enable or constrain Great Lakes cities' adaptive capacity to respond to climate change impacts. Our project is advised by SNRE faculty members Dr. Maria Carmen Lemos and Dr. Arun Agrawal who are both PI's on the Great Lakes Adaptation Assessment for Cities (GLAA-C) sponsored by the Graham Environmental Sustainability Institute and the Kresge Foundation. Our study is nested within that larger research project and data collected will inform the GLAA-C findings and focus.

Given your city's leadership in the climate change field and previous conversations with the GLAA-C, we would be delighted for Grand Rapids to be one of the project's first case study cities. If you agree, this would involve our team carrying out a series of interviews with available City staff members in-person (in Grand Rapids) and by telephone about climate and environmental planning, emergency response protocols and experience, infrastructure maintenance, and related areas. The interviews will last approximately one hour and take place over the next four months, scheduled at the convenience of City staff. The main goal of the project is to understand adaptation and adaptive capacity to climate change response in Grand Rapids as well as foster an on-going two-way relationship between GLAA-C and the City of Grand Rapids that could inform current and future decision-making regarding climate adaptation. We anticipate sharing our data with Grand Rapids through a report as well as through academic publications.

We are excited to begin interviews and look forward to your confirmation that Grand Rapids is interested in participating. Please do not hesitate to contact me if you have any questions and thank you for considering this request.

Sincerely,



Laura Matson
M.S. | M.U.P. Candidate 2013
University of Michigan
School of Natural Resources and Environment | Taubman College of Architecture and Urban Planning

Appendix 4: Consent Form

NATURAL RESOURCES AND ENVIRONMENT
UNIVERSITY OF MICHIGAN

Protocol Title: Urban Climate Change Adaptation Planning in the Great Lakes Region

IRB #: HUM00049983

Faculty Advisors:

- Dr. Maria Lemos, lemos@umich.edu
- Dr. Arun Agrawal, arunagra@umich.edu

Investigators: glstudents@umich.edu

- Parrish Bergquist
- Zane Hadzick
- Jen Kullgren
- Laura Matson
- Jennifer Perron

Thank you for meeting with us. We are graduate students at the University of Michigan's School of Natural Resources and Environment working on a year-long project researching climate change adaptation planning in Great Lakes cities.

INFORMATION: We invite you to participate in a research study which strives to develop a better understanding of how cities are preparing for and adapting to climate change. Your participation is voluntary and you have the right to withdraw your consent or discontinue participation at any time. If you agree to participate you will be asked a series of questions about your climate change preparedness. Some of our questions are very detailed and we welcome your suggestions for whom else we could interview.

BENEFITS: While there are no guaranteed benefits of your participation, and no financial remuneration is offered for participation in this study, your assistance will help contribute to the body of knowledge on urban climate adaptation in the region. Moreover, the research team has a personal interest in working with your community to provide value and reciprocity for your voluntary participation.

RISKS: The risks associated with this research study are minimal, and are unlikely to cause any foreseeable harm different from your daily experiences in your professional capacity. Study risks include expenditure of time, and potential discomfort in answering certain questions. You may decline to answer any questions you do not wish to answer.

CONFIDENTIALITY: Your participation in this interview is voluntary and confidential. By participating in this interview you are agreeing to let us use the information you provide. We plan to publish the results of this study. Your name and the information you provide during this interview will be combined with information provided by other people, and may be used in written reports. If you wish to share confidential information, however, simply inform us and your comments can be made anonymous. You are not obligated to answer any questions, and you may leave the interview or ask us to destroy our interview notes at any time. The results of this and other interviews will be used to write a report for our Master's Project opus (which will be shared with you) and scholarly articles. If you have any follow-up or need clarification at a later date, please do not hesitate to contact us.

CONTACT: If you have questions about this research you can contact the research team at glstudents@umich.edu. If you have any concerns, complaints, or general questions about research or your rights as a participant and wish to contact an authority independent of the research team, please contact the University of Michigan Behavioral Sciences Institutional Review Board, (734) 936-0933, 540 E. Liberty St., Suite 202 Ann Arbor, MI 48104-2210, irbhsbs@umich.edu.

CONSENT: in this research is completely voluntary. Even if you decide to participate now, you may change your mind and stop at any time. Your signature authorizes your agreement to participate in the study.

X _____

Interviewee name (printed): _____
Current Position: _____

Appendix 5: Coding Structure

I. Climate Events

- Temperature change
  - Increase
  - Decrease
- Wind storms
  - Intensity
  - Frequency
- Precipitation changes
  - Flooding
  - Droughts

II. City Systems

- **Energy** (includes energy production, energy efficiency, energy conservation)
- **Infrastructure**
  - **Water**
    - Drinking water
    - Storm water
    - Waste water
  - **Roads**
  - **Urban Forestry**
  - **Energy**
- **Land use**
    - Planning
      - Building codes
      - Green Design
    - Parks & Rec
    - Greenbelt
- **Emergency management**
    - County sheriff
    - City Police
    - Fire
- **Human health**
    - County Health
    - Vulnerable populations
    - Urban heat island
- **Transportation**
    - Access
    - Regional transit
- **Food systems**
    - Planning
    - County food security

III. Determinants of Adaptive Capacity

- **Wealth and Financial Capital:** (income and wealth distribution, accessibility and availability of financial instruments (insurance, credit), fiscal incentives for risk management)
    - **Public (government sources of funding)**
    - **Private (non-government sources of funding)**
- **Organization and Social Capital:** (local coping networks, social mobilization, density of institutional relationships)
    - **civil society** (NGOs, businesses, universities, public-private partnerships, state-civil society relationships—organized networks within the community; grassroots initiatives)
    - **Leadership (non-political):** references to the leadership of specific individuals or organizations outside of government
- **Institutions and Governance:** (norms and rules-formal and informal: governance mechanisms, rules and regs, institutional frameworks, city, state, and fed govt)
    - **City governance + integration (includes policy):** includes laws, funding mechanisms, internal governance structures, informal rules, or formal rules; include proposed policies or missing policies as well. Integration within city government (includes collaboration between city departments, city planning between systems —anytime city systems or functions are looked at with more than one at a time.)**Planning**—includes asset management, sustainability or other plans; often used in combination with another code (sector, or integration, or funding)
    - **State governance and integration(includes policy)** (both state and federal policy are often used in combination with the wealth/financial capital nodes)
    - **Federal governance and integration (Includes policy)** (both state and federal policy are often used in combination with the wealth/financial capital nodes)
    - **regional governance + integration (Includes policy)** (partnerships between governments in a region, or the sharing of services between governmental jurisdictions—this node refers to governments only)
    - **Accountability and metrics**: (having clearly defined goals, timelines, and reporting protocols, benchmarking, progress reporting, verification of efforts)
- **Information** (communication networks, freedom of expression, innovation capacity)
    - **Information sources** (where do cities get their information about climate change, what information do they base their decisions on; ex: HRWC flow information, FEMA flood maps, etc.)
    - **Intercity networks (**ex: ICLEI, USDN, informal networks and sharing of information between cities, or between cities and non-government organizations)
- **Technology** (technology transfer and data exchange, early warning systems, technological relevance)
- **Political Capital:** (leadership legitimacy, political climate, public perceptions and public engagement decision and management capacity, sovereignty)
    - **Leadership (political):** any reference to the leadership of specific leaders, either political or within government agencies, public reception
    - **public perceptions** --public support (or not) for climate change work;
    - **public engagement**—includes outreach, communication, education directed towards public, inclusion of the public in planning and decision-making processes (whether genuine or superficial)

- **Human capital:** (scientific, "local," technical, political), education levels, health, individual risk perception, labor)
    - **Community personality**—demographics, attitudes, population characteristics, education levels
- **Material resources and Infrastructure** (transport, water infrastructure, buildings, sanitation, energy supply and management, environmental quality)—often used in combination with other nodes.

Appendix 6: Climate Change in the Great Lakes Fact Sheet

GLISA

Climate Change in the Great Lakes Region

There is a high level of scientific certainty that climate has changed in significant ways in recent decades and that climate will continue to change in the future. This is a summary of the potential changes and impacts of climate in the Great Lakes region using the best peer-reviewed literature available from many sources and experts across many fields of research.

Temperature

- Average temperatures increased by 2.3 °F (1.3 °C) from 1968 to 2002 in the Great Lakes region.
- By 2050, an average air temperature increase of 1.8 to 5.4 °F (1 to 3 °C) is projected.
- By 2100, an average air temperature increase of 3.6 to 11.2 °F (2 to 6.2 °C) is projected.
- Winter temperatures will likely experience a greater increase than the summer months.

Precipitation

- Projections of future precipitation vary widely.
- Annual average precipitation will likely increase slightly or remain nearly stable.
- Winter and spring precipitation may increase more significantly.
- Warmer temperatures will lead to less precipitation falling as snow, and more falling as rain.

Extreme Weather Events

- The frequency and intensity of severe storms has increased, and current models suggest that this trend will continue as the effects of climate change become more pronounced.
- More severe storms may have a negative economic impact due to resulting damages and increased costs of preparation, clean up, and business disruption.

Snow and Ice Cover

- Since 1975, the number of days with land snow cover has decreased by 5 days per decade, and the average snow depth has decreased by 1.7 cm per decade.
- Snow and ice levels on the Great Lakes and on land will likely continue to decrease overall.
- Reduced lake freezing will result in more exposed water that could increase lake-effect precipitation.
- Earlier spring warming may decrease the length of the snow season and cause precipitation in some lake-effect events to fall as rain rather than snow.

Lake Levels

- Water levels in the Great Lakes have been decreasing since a record high was reached in 1980.
- Lake levels are rising and falling a month earlier than during the 19th century.
- Other factors, such as land use and lake regulations also affect lake level, however, and it is still unclear how much of the recent trend in lake levels may be attributed to climate change.
- Future projections of Great Lakes lake levels vary, though most indicate a greater decline in lake levels with increasing greenhouse gas emissions.

Lake Temperature and Stratification

- Both inland lakes and the Great Lakes will likely experience a lengthened warm season.
- Warmer water surface temperatures may increase the stratification of the lakes, decrease vertical mixing in the spring-winter, and potentially lead to more low-oxygen, hypoxic "dead zones."

Water Availability

- Overall, the Great Lakes region is expected to become drier due to increasing temperatures and evaporation rates.
- More frequent droughts could affect soil moisture, surface waters, and groundwater supply.
- The seasonal distribution of water availability will likely change. Warmer temperatures may lead to more winter rain and earlier peak streamflows.

GLISA

Forests

- Climate change will likely have mixed effects on forests that vary based on the species involved and other factors.
- With increasing atmospheric CO_2, forest productivity will likely increase until other impacts of climate change, such as increased risks of drought, forest fire, and invasive species present additional stressors to forests.
- As temperatures rise, the distribution and composition of tree species will likely shift northward.

Fish and Wildlife

- Coldwater fish populations will likely decline in population as warmwater fish populations become more abundant.
- Overall biomass productivity in lakes and waterways could be reduced by lake stratification and increased frequency of hypoxic conditions.
- In general, many animal species may need to migrate north to adapt to rising temperatures, and increased evaporation rates may decrease total wetland area in the region, both of which may lead to additional stresses on some species.

Water Quality and Stormwater Management

- Increased risk of droughts, severe storms, and flooding events may increase the risk of erosion, sewage overflow, lead to more interference with transportation, and more flood damage.
- Future changes in land use could have a far greater impact on water quality than climate change. The coupling of climate change and land use change could therefore result in even stronger effects in some areas.

Agriculture

- The growing season will likely lengthen and positively impact some crop yields.
- Increased frequency and intensity of severe storms, increased flooding and drought risks, as well as more pests and pathogens will likely negatively impact crop yields.
- Water availability and quality will likely pose challenges for agriculture.

Energy and Industry

- Drier summers may lead to reduced hydroelectric output during periods of peak usage.
- Reduced water availability may interfere with some industrial operations.
- Warmer temperatures and more frequent heat waves will likely increase electricity demands, particularly in urban areas and during the summer months.

Transportation

- With increasing temperatures, damage to paved surfaces due to expanding and softening pavement is more likely.
- The most significant impact on roadways will likely be the increased risk of flood damage.
- Shipping lanes will likely be open earlier and longer due to reduced ice cover on the Great Lakes.
- Lower lake levels may lead to decreased depth of navigation channels and a reduction in the maximum loads carried by vessels.

Public Health

- Increased risk of heat waves and increased humidity may increase the number of heat-related deaths and illnesses.
- Increased frequency of flooding events may lead to watershed contamination, while warmer surface waters could mobilize pollutants in sediment and contaminate fish.
- Diseases such as West Nile virus and Lyme disease may become more widespread since carrier insects will be more likely to survive milder winters.

Tourism and Recreation

- Winter recreation and tourism are likely to suffer due to reduced snow cover.
- Many species of fish important to recreation are likely to decline while the populations of some warmwater species may grow.
- Increased lake contamination and decreasing lake levels may lead to less desirable shorelines, but increasing summer temperatures and a longer summer season, may increase demand for beaches and some summer activities.

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