CLIMATE CHANGE ADAPTATION IN ELYRIA, OHIO

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Climate change is quickly becoming a planning and policy concern in Great Lakes region. The latest climate science focusing on this region largely supports these concerns. Climate models predict warmer temperatures, shifting rain and snow patterns, and an increased likelihood of extreme events by the end of the 21st century. Scientists also predict that lake levels will likely be lower, with additional impacts on aquatic species, as well as impacts upon the industries of tourism and trade. The anticipated impacts of climate change will likely not be distributed equally across each city in the region.

In order to anticipate and successfully respond to these impacts, there is a dire need for cities to better understand the opportunities and constraints within their current governance structures to build their adaptive capacity. To evaluate this capacity, we conducted an Integrated Assessment (IA) of the four cities of Dayton, Elyria, Avon Lake and Toledo in the state of Ohio by taking a broader view of the political, social, and ecological causes, consequences, and potential solutions to climate vulnerability and impact reduction. This report describes the capacities and constraints the City of Elyria possesses, as well as recommendations on how to take advantage of these capacities and overcome constraints to enhance its adaptive capacity.

During our analysis of Elyria’s capacities and constraints, several overarching themes emerged. First, decision-makers in the city expressed interest in adapting to climate change, though sustainability and adaptation are still not fully integrated into the policy and planning processes at the sector or departmental levels in the city administration at present. Leaders within the city government are working to accomplish broader adaptation and sustainability goals through collaborative networks at the city and regional levels. Employees in the city also demonstrated high trust in city governance and can mobilize social capital to achieve particular goals. Overall, building collaborative regional networks and the quality of current city employees emerged as key capacities in our study.

However, there are significant constraints to adaptation as well. Two broad trends identified are scarce financial resources and limited access to scientific knowledge. Interviewees reported financial resources significantly constrained action regarding the implementation sustainability programs and policies. Identifying methods to utilize co-benefits of standard operating procedures and practices to enhance climate adaptation needs, as well as increasing flexibility in funding structures, are strategies that can aid in minimizing this constraint. Moreover, consideration of the potential distribution of impacts from climate change when implementing adaptation and sustainability policies can increase the likelihood that the most effective, economic and equitable actions are taken. The availability of usable climate knowledge, along with other kinds of knowledge needed to inform decision-making about adaptation, is highly limited in the city. Knowledge in this case includes not only an understanding of anticipated climate change impacts, but also how it interplays with other kinds of knowledge (i.e. socioeconomic, health and ecosystem management related data) that inform the city’s decision-making.
In the summer of 2013, the city of Elyria accepted an invitation to participate in an interdisciplinary research project conducted by Master’s degree students in the University of Michigan School of Natural Resources and Environment. This project was a continuation of a research initiative focusing on climate adaptation in Great Lakes cities supported by the Great Lakes Adaptation Assessment for Cities (GLAA-C) through the Graham Environmental Sustainability Institute and Kresge Foundation. To better understand how the Great Lakes region can adapt to climatic impacts, an Integrated Assessment (IA) of the adaptive capacity of four cities in Ohio (Avon Lake, Dayton, Elyria, and Toledo) was carried out. In particular, we assessed the various capitals, capacities and constraints in these four cities to respond to climatic impacts.

To support the IA, we conducted a total of sixty-two interviews with city policy- and decision-makers between August and November 2013. In the interviews, we asked scripted questions, designed to elicit responses, elucidating each city’s ability to cope and adapt to climate change. Broadly, the questions we asked centered on the following issues:

- What are opportunities and challenges for Great Lakes cities to respond to climate change?
- What are the main drivers building adaptive capacity within Elyria and the other three identified research sites?
- What have individual research sites done to build adaptive capacity?
- What policies and projects are being implemented in the four research sites to adapt to climate change?

Using qualitative coding software, the data from interviews was organized and analyzed to identify leverage points, synergistic projects, and partnerships. The adaptive capacity wheel (Gupta et al., 2010) was utilized to identify current institutional strengths facilitating potential adaptations and weaknesses constraining them. Moreover, GIS maps displaying the spatial distribution of climate change exposure and sensitivity in each city were created. By bringing together mixed methods and analytic frames, the assessment sought to provide decision-makers and stakeholders in participating cities with information and tools necessary to better adapt to climate change while also recognizing the current successes and strengths of each city.

What is GLAA-C?

The Great Lakes Adaptation Assessment for cities is an Integrated Assessment (IA) supported by Kresge Foundation and the Graham Environmental Sustainability Institute. The IA is being led by a member of University of Michigan (U-M) faculty research teams and regional partners with the aim to “strengthen the science and decision making necessary for more effective urban climate adaptation in the Great Lakes Region.”

The Project seeks to engage experts to:

- Work with cities to develop climate adaptation plans or strategies
- Integrate the collection of social and climate science data to further inform the field
- Create a tool that can be used by stakeholders to prepare for resiliency under different climate scenario
- Establish a council to create greater awareness of likely urban impacts of climate change

The Project website is available in the Integrated Assessment section of the Graham Institute website at www.graham.umich.edu/glaac
In May 2012, our research team sent one letter and two emails to Mayor Holly C. Brinda, asking Elyria to participate in our study. She responded back in the affirmative in June 2012. Between August and December 2012, we visited Elyria to carry out our interviews. We identified specific people to interview both through Elyria’s webpage (i.e. sectors and departments of interest) and through ‘snowballing’ from one key informant to another. We conducted 16 interviews, roughly sixty minutes each, with key decision-makers and stakeholders in Elyria to assess the overall levels of adaptive capacity determinants (see Table 1). We asked interviewees about their perceptions and concerns of climate change, current adaptation or sustainability initiatives within their departments and/or city at-large, current capacities and constraints to respond to projected impacts, and inter-institutional networks and support that could facilitate adequate response to projected impacts (see Appendix for interview questionnaire).

The recorded interviews were then transcribed and uploaded to NVivo 10 data management software. Utilizing a codebook we developed, we coded each interview for variables of interest, aligned with the determinants of adaptive capacity. We controlled for quality in coding by having each member of our research team read every interview, thereby guaranteeing that everyone was individually familiar with each city's capacities and constraints. Once the analysis was complete, we utilized the adaptive capacity wheel (Gupta et al., 2010) to identify current strengths facilitating potential adaptations and weaknesses constraining them.

Finally we created risk indices (vulnerability) maps for Elyria using geographic information system (GIS). In this study, GIS was used to augment the city interview analysis by delving into data to identify areas within Elyria where populations may be more vulnerable to anticipated climate change impacts and may be targets for program and policy intervention.

![Diagram of weighted calculation of potential risk](image)

**FIGURE 1: REPRESENTATION OF INPUTS INTO GIS WEIGHTED CALCULATION OF POTENTIAL RISK**
Data used for analysis included demographic information from the 2010 U.S. Census and 2006-2010 American Community Survey, 100-year flood plain data from FEMA, and a variety of city specific data including boundaries, roadways, rivers, and land use. The demographic data was downloaded according to block group and included percentage of the population below 2010 poverty level, percentage under 5 years of age, percentage over 65 years of age, and percentage minority. These demographics were of particular interest. Research has shown these groups may be most vulnerable to climate change impacts, particularly heat events (USGCRP, 2008). Block groups and neighborhood boundaries were overlaid to allow for visual reference. In addition to the equally weighted maps included in the appendix, maps with highest risk weighting for proximity to flood plain, proximity to green space, proximity to high vacancy areas, and population demographics are also available in the appendix. This data was combined in a weighted calculation to identify areas where the combination of these variables may increase their risk relative to the rest of the city. The weights of individual variables can be adjusted, depending on the primary concern of the city or department using the information.

We have also included a SWOT Analysis for Elyria to identify the strengths, weaknesses, opportunities and threats in the city’s efforts towards adaptation to climate change. By bringing together mixed methods and analytic frames, our IA seeks to provide decision-makers and stakeholders in Elyria with information and tools necessary to better adapt to climate change while also recognizing the current successes and strengths of Elyria.

**CLIMATE PROJECTIONS**

The Great Lakes watershed is home to 40 million people and contains 20% of the world’s freshwater (Graham, 2012). The Canadian Regional Climate Model projects changes in temperature probability distributions, showing increasing temperatures in the winter and summer, with variability around the mean remaining relatively constant (Pryor, 2013). Jones et al (1999) show that the Midwest region has also experienced reduced diurnal temperature range, that is, the minimum temperature at night has increased more than daytime maximum temperatures (Pryor, 2013). Downscaled global climate models predict that the frost-free season will increase two weeks by mid-century and more than four weeks by the end of the century (Pryor, 2013). The predicted warmer winter temperatures will likely lead to increased evaporation, warmer water temperatures, more variation in lake levels, increased likelihood of extreme precipitation events, and earlier onset of lake stratification (Hinderer, 2010). Projections also include less lake effect snow in winter and a significant increase in the days above 90°F in summer (Hinderer, 2010). Several studies (Meehl and Tebaldi, 2004, Tebaldi et al, 2006, Battisti and Naylor, 2009; cited in Pryor, 2013) project that there will likely be future increases in heat wave occurrence and intensity. Impacts on lake levels are uncertain, though most models predict a decrease of 1.5 to 8 feet by the end of the 21st century and some predicts a decrease of 1.5 to 3 feet by 2030 (Pryor, 2013; GLRA, 2000).
TABLE 2: CLIMATE PROJECTIONS AND THE IMPACT OF CLIMATE CHANGE ON GREAT LAKES CITIES. (Projections adopted from Pryor 2013; GLRA 2000; Bulkeley et al. nd; and Hinderer 2010).

<table>
<thead>
<tr>
<th>Change in Climate</th>
<th>Possible Impact</th>
<th>Potential Urban planning related impacts</th>
<th>Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase in temperature</td>
<td>High heat wave occurrences and intensities</td>
<td>-Increased urban heat island effect -Health impacts on vulnerable population (increased heat mortality, heat stress, disease outbreaks etc.)</td>
<td>-Urban Forestry/ Tree Planting Program -Vulnerability assessment plan and mapping -Green building codes and design plans</td>
</tr>
<tr>
<td></td>
<td>Deteriorated air quality</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ground water depletion and water shortage</td>
<td>Water shortage -Food security access (high food prices)</td>
<td>-Emergency plan -Risk Prediction and mapping -Improvement of &quot;low regret&quot; infrastructure (water supply network, reservoir repair) -Incorporate urban gardening program in land use plan; -Capitalize on renewable energy</td>
</tr>
<tr>
<td></td>
<td>Damage to energy efficiency and transmission structure</td>
<td>Increase in energy prices and demand</td>
<td></td>
</tr>
<tr>
<td>Increase in Precipitation</td>
<td>Heavy rainfall</td>
<td>Flooding and erosion -Damaging Ecosystem services</td>
<td>-Restrictive land use plan -Infrastructure improvement; -Improved building codes -Erosion control plan -Disaster response plan/ emergency plan</td>
</tr>
<tr>
<td></td>
<td>Damage to food production and supply</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change in Lake levels (decrease from 1.5-3 feet or even 8 feet)</td>
<td>Drought</td>
<td>Effect on tourism, recreation and commercial navigation</td>
<td>-Drought management plan -Invasive species management plan</td>
</tr>
<tr>
<td></td>
<td>Habitat alteration and loss</td>
<td>-Biodiversity loss by shoreline habitat alteration</td>
<td>-Infrastructure improvement (drinking water supply system)</td>
</tr>
<tr>
<td></td>
<td>Economic losses</td>
<td>-Drinking water quality and availability -Increased infrastructure investment</td>
<td>-Increased water recycling and re-use -Insurance plan and economic burden-sharing programs</td>
</tr>
</tbody>
</table>

While the uncertainty in climate projections poses a distinct planning challenge to local and regional decision- and policy-makers, much can be done to anticipate action for successful climate adaptation (Lemos and Rood, 2010). Though it is difficult to definitively predict what climate impacts will affect Elyria, OH, policymakers and public officials can start by anticipate similar effects that the Great Lakes region will experience. We believe that the following methods and heuristics outlined in this report can empower policymakers to enable adaptive capacity that will contribute to a more resilient and vibrant Elyria.
Adaptive capacity refers to the ability of a system to respond to an outside perturbation. Often, there are three steps to adaptive capacity research: (1) identifying a set of factors or determinants of adaptive capacity, (2) conducting an evaluation of the relative adaptive capacity of countries or regions, and (3) finding areas with the greatest vulnerability or least adaptive capacity. This type of study assumes that policy- and decision-makers apply this information to improve response to the impacts of climate change (Smit & Wandel, 2006). Nelson et al. (2007) considered how adaptive capacity relates to efforts to respond to climate impacts and reduce system vulnerability. They outlined an approach in which adaptive capacity describes the preconditions for a system to adapt to outside disturbances through adaptive processes moving towards a level of system adaptedness, representing the normative goals set by managers and stakeholders. Here adaptive processes take two forms: system adjustments and system transformations. Adjustments are short-term and allow systems to cope with impacts and maintain the status quo. Transformations are long-term and involve transitioning the system to a new state better adapted to current or future conditions. Within this framework, a biophysical or social prompt must occur and an appropriate institutional structure must be in place to carry through this process.

<table>
<thead>
<tr>
<th>Determinant</th>
<th>Encompasses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human capital</td>
<td>Knowledge (scientific, “local”, technical, political), education levels, health, individual risk perception, labor</td>
</tr>
<tr>
<td>Information and technology</td>
<td>Communication networks, freedom of expression, technology transfer and data exchange, innovation capacity, early warning systems, technological relevance</td>
</tr>
<tr>
<td>Material resources and infrastructure</td>
<td>Transport, water infrastructure, buildings, sanitation, energy supply and management, environmental quality</td>
</tr>
<tr>
<td>Organization and social capital</td>
<td>State-civil society relations, local coping networks, social mobilization, density of institutional relationships</td>
</tr>
<tr>
<td>Political capital</td>
<td>Modes of governance, leadership legitimacy, participation, decentralization, decision and management capacity, sovereignty</td>
</tr>
<tr>
<td>Wealth and financial capital</td>
<td>Income and wealth distribution, economic marginalization, accessibility and availability of financial instruments (insurance, credit), fiscal incentives for risk management</td>
</tr>
<tr>
<td>Institutions and entitlements</td>
<td>Informal and formal rules for resource conservation, risk management, regional planning, participation, information dissemination, technological innovation, property rights and risk sharing mechanisms</td>
</tr>
</tbody>
</table>

TABLE 1: DETERMINANTS OF ADAPTIVE CAPACITY (EAKIN AND LEMOS, 2006)
Assessing adaptive capacity is difficult. Most scholars argue that adaptive capacity is a latent quality of a system and observable only when individuals call upon it to actually adapt to a stress (Engle, 2011). Because of this, researchers have identified determinants of adaptive capacity, which describe the assumed preconditions likely to increase the potential of any system to adapt to climate change. Broadly defined, these determinants include: social capital; human capital; financial capital; political capital; institutions and entitlements; and technology and communication (see Table 1). We believe this framework to be useful in assessing what capacities and constraints Elyria has in adapting to climate change.

ELYRIA, OH

[Photo: Ely Park, Elyria, OH (Source: Wikimedia Commons)]

Situated at the forks of the Black River, Elyria is the seat of Lorain County in northeast Ohio. Home to Cascade and Burr Oak Parks, Elyrians enjoy picnicking, biking, hiking and canoeing along the Black River. The Garford Manufacturing Company, located in Elyria, invented the first single-headlight car and created the first padded bicycle saddle. Herman Ely founded Elyria in 1817 in order to build water mills along the Black River. From the 1940s through the 1970s there was a period of tremendous growth, progress, and prosperity and the city population doubled to more than 50,000. During this time, Elyria was one of the fastest growing cities in Ohio. As of 2010, the population was approximately 54,500.

Per-capita income and median household income are both below the average for the state. Percentage of the population below the poverty level is higher than the state average. Roughly seven percent of the population is younger than five years, and about fourteen percent of the population is sixty-five years or older. Manufacturing remains the largest portion of economic activities, followed by retail, wholesale, and accommodation and food service sales (Census, 2010). The closing of three major car plants in the 1970s and 1980s in the region led to high unemployment and economic stagnation in Elyria. Currently, the city is the world headquarters of companies like Ridge Tool, Invacare Corporation, EMC Corporation, Bendix Commercial Vehicle Systems and Diamond Products, but the service industry is replacing its dominant manufacturing base.

Despite these difficulties, Elyria has found creative ways to begin work on sustainability initiatives. It currently collaborates with the Northeast Ohio Sustainable Communities Consortium, the Lorain County
Storm Water Management District, and the Black River Remedial Action Plan. After a $70 million renovation, Elyria High School recently re-opened with new, green infrastructure. Educational institutions in the region are also implementing sustainability research and projects. Lorain County Community College and Oberlin College are equipped with solar panels, geothermal energy sources, green rooftop rain gardens, and have developed partnerships with more than ten other universities at the regional and national level that offer degree programs in sustainability, wind-turbines, and energy conservation.

Regarding potential impacts of climate change, in Elyria, many public officials were concerned about flooding, particularly as it relates to soil erosion in Cascade Park along the Black River. One official related: “Two large bodies of water and, when we get a heavy downpour, are meeting in Cascade Park, causing some definite hydraulic problems and erosion issues throughout the park.” Officials in Elyria also were concerned with ageing infrastructure and its ability to withstand climatic stressors. Elyria is unique among the four cities studied in the overall project in that officials partially address this concern by sharing with strong interregional networks. One interviewee related that they “work together with other communities on who’s got the right equipment, where we can borrow the equipment.” Furthermore, Elyria had concerns regarding the increase in vector-borne illnesses. One interviewee responded when asked about climate impacts: “The other concerns would be that during significant drought periods, that's when we see amplification of the West Nile virus, like this dry summer that we just had.”

PHOTO: CITY OF ELYRIA

ADAPTIVE CAPACITY WHEEL

To assess the adaptive capacity of Elyria, we have developed an analytical framework that builds upon and synthesizes institutional, and urban planning research methodology. We have applied the adaptive capacity wheel, a decision support tool created by Gupta et al., (2010) to assess adaptive capacity in Elyria. In doing so, we seek to answer the following question: In what ways do Elyria governance institutions constrain or facilitate adaptation to climate change? The adaptive capacity wheel lists twenty-two criteria within six dimensions (variety, learning capacity, room for autonomous change, leadership, resources, and fair
governance) (see table 3), which researchers rate using a five point scale ranging from ‘very negative’ (-2/dark red) to ‘very positive’ (+2/dark green) (see figure 2). In principle, these rankings should allow analysts, decision-makers, and stakeholders to increase their understanding of institutional adaptive capacity. The outputs of the adaptive capacity wheel are achieved through interpretation and judgment— rather than being objective, the wheel reflects the knowledge, experience, values, and beliefs of whoever is doing the evaluation (Gupta et al, 2010). In this study we base our evaluations of capacities (positively or negatively) both on what we observed in the cities and on what the existing literature suggests and/or shows is important.

![Adaptive Capacity Wheel](image)

**FIGURE 2: THE ADAPTIVE CAPACITY WHEEL (GUPTA ET AL, 2010)**

<table>
<thead>
<tr>
<th>Effect of Institutional Adaptive Capacity</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive effect</td>
<td>2</td>
</tr>
<tr>
<td>Slightly positive effect</td>
<td>1</td>
</tr>
<tr>
<td>Neutral or no effect</td>
<td>0</td>
</tr>
<tr>
<td>Slightly negative effect</td>
<td>-1</td>
</tr>
<tr>
<td>Negative effect</td>
<td>-2</td>
</tr>
<tr>
<td>Variety</td>
<td>Variety of problem frames—room for multiple frames of references, opinions, and problem definitions</td>
</tr>
<tr>
<td>---------------------------------------------</td>
<td>-----------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td>Multi.actor, multi-level, multi-sector—involved of different actors, levels, and sectors in the governance process</td>
</tr>
<tr>
<td></td>
<td>Diversity of solutions—availability of a wide range of different policy options to tackle a problem</td>
</tr>
<tr>
<td></td>
<td>Redundancy (duplication)—presence of over-lapping measures and back-up systems; not cost effective</td>
</tr>
<tr>
<td>Learning Capacity</td>
<td>Trust—presence of institutional patterns that promote mutual respect and trust</td>
</tr>
<tr>
<td></td>
<td>Learning—ability of institutional patterns to learn from past experiences and improve their routines</td>
</tr>
<tr>
<td></td>
<td>Discuss doubts—institutional openness towards uncertainties</td>
</tr>
<tr>
<td></td>
<td>Institutional memory—institutional provision of monitoring and evaluation processes of policy experiences</td>
</tr>
<tr>
<td>Room for Autonomous Change</td>
<td>Continuous access to information—accessibility of data within institutional memory and early warning systems to individuals</td>
</tr>
<tr>
<td></td>
<td>Act according to plan—increasing the ability of individuals to act by providing plans and scripts, especially in case of disasters</td>
</tr>
<tr>
<td></td>
<td>Capacity to improvise—increasing the capacity of individuals to self-organize and innovate; foster social capital</td>
</tr>
<tr>
<td>Leadership</td>
<td>Visionary—room for long-term visions and reformist leaders</td>
</tr>
<tr>
<td></td>
<td>Entrepreneurial—room for leaders that stimulate actions and undertakings; leadership by example</td>
</tr>
<tr>
<td></td>
<td>Collaborative—room for leaders who encourage collaboration between different actors; adaptive co-management</td>
</tr>
<tr>
<td>Resources</td>
<td>Authority—provision of accepted or legitimate forms of power; whether or not institutional rules are embedded in constitutional law</td>
</tr>
<tr>
<td></td>
<td>Human resources—availability of expertise, knowledge and human labor</td>
</tr>
<tr>
<td></td>
<td>Financial resources—availability of financial resources to support policy measures and financial incentives</td>
</tr>
</tbody>
</table>

TABLE 3: ADAPTIVE CAPACITY WHEEL CRITERIA (GUPTA ET AL, 2010)
Consistent with the determinants of adaptive capacity, as well as the adaptive capacity wheel framework, we have identified several capacities characterizing Elyria’s government. We have based this analysis mostly from our interviews with city officials. A majority of interviewees expressed some level of concern regarding climate change. Concerning environmental policy in general, in the city, a handful of departments has begun to incorporate sustainability into their general management practices. Mostly this is occurring within departments dealing with water, such as sewage treatment, and storm water management. Similarly, Elyria is updating some of its ordinances and codes improving sustainability that can potentially support future adaptation. For example, in 2012, the city revised its building codes to include wind turbine specifications; the zoning codes now allow for rain gardens, bioswales, parking islands with planted trees, and use of native plant species.

An attribute benefitting Elyria’s adaptive capacity is the social and human capital the city government possesses. These capitals allow city employees to access resources and equipment that may enable adaptation, as well as call in favors when needed. One interviewee reflected this social capital within city departments, and referring to their ability to leverage resources, commented: “We usually just call each other up and ask for something.” We received similar comments from a variety of other departments. In these cases, departments rely on social capital to create informal networks with other departments to share resources. The operation of the city government seeks to encourage these networks, as department heads meet with each other on a routine basis. Furthermore, individuals have been able to build their own networks due to their long tenure within the city. Multiple interviewees have worked for the city for twenty or thirty years. During this time, they have been able to build relationships throughout the city, contributing to further build social capital within the city.

Many interviewees also stressed maintaining communication and relations with the broader community. One interviewee told us: “The first rule that I always follow is ‘have good community’. Have good lines of communication, not just having email or phone calls, but meet in person.” Good communication extends beyond day-to-day work and into day-to-day life for some individuals. For example, one city council member reported that he received phone calls at home and often spoke with constituents during his daily life, including waiting in line at the grocery store. Such informal interactions, which are difficult to measure, highlight the importance of social ties to accomplish city goals. More formal interactions, such as newspaper articles, special event participation, newsletters, and regular public-access television interviews by the mayor of Elyria, further increase public communication. Additionally, the city is starting to incorporate social media into its communication strategy. As one city employee in Elyria stated: “I’ve had two years—two summers—where I’ve had college interns coming in and they set us up for Facebook and Twitter and I’ve never—I don’t
Tweet—but we’re there.” Whether or not social media fulfills this promise remains to be seen. Another similar effort entails using text messaging to deliver fast warnings of dangerous conditions, such as severe weather and public health risks.

Active participation in regional networks promotes Elyria’s adaptive capacity as well. The city interacts with the Northeast Ohio Sustainability Communities Consortium (NEOSCC), the Northeastern Ohio Coordinating Agency (NOACA), regional Tree City meetings, the Oberlin Project, Lorain County Community College, and the Lorain County Growth Partnership. Also, interviewees repeatedly referred to the importance of regionalism and learning from nearby and similar communities. Many interviewees expressed their own dedication to and knowledge of the city. For example, in Elyria, one official with 25 years of experience attributes part of his current ability to accomplish tasks to his long tenure and deep knowledge of the city and its operations. The accumulated human capital and commitment from officials allow departments to overcome staffing shortages—at least to some extent. For example, another interviewee reported walking through the sewage treatment facility every Saturday and Sunday without compensation.

Elyria has also received a number of grants during the past few years. As a city official informed us: “I think our city as a whole has done an excellent [job] in obtaining grant money, which is outside money, whether it be federal grants or state grants…we got a $3.2 million grant for two years to employ about eighteen firefighters.” The city also received $535,000 through ARRA in 2009 to reduce energy consumption and has budgeted most of it to residential energy retrofits, including free programmable thermostats and a weatherization rebate program. A number of interviewees mentioned the Elyria Health Department as being particularly successful in bringing in grants. This ability to identify, apply for, and receive outside money is particularly beneficial in light of recent economic troubles.

Finally, individuals in the city expressed having some flexibility in allocating their budget towards unexpected expenses. One interviewee reported that: “if something happens you can say we’re not working overtime this year, switch that over here to buy a new pump.” Other interviewees expressed similar abilities to shift from expected outlays to surprises. Thus, departments have some flexibility in cutting back in some areas to fund their priorities.
Much like other Rust Belt cities, Elyria faces declining tax revenue, which limits its ability to sufficiently staff city departments and create new initiatives. The city government laid-off many employees after the start of the economic recession in 2008, while recent retirees have not been replaced. “The whole city government issue is undermanned; we went through some layoffs and stuff like that so, back in ’08, ’09 when the economy went down the tubes, so we’re battling that” stated one respondent. He went on to say “it does come down to staffing. We can program all day long but if we don’t have people to mow the grass, line the soccer fields, line the baseball fields, then we can’t offer those programs.” Many Elyria staff members have experienced additional burdens by absorbing the work left by the dearth of staffers. These staff members are so occupied in “putting out fires” and applying for grants in a time of declining funds that they have little time or human power to implement adaptation initiatives.

The city has not fully integrated adaptation and sustainability into city planning and governance processes. Some interviewees attributed this to a lack of complete understanding of the issues. For example, one interviewee described the difficulty he is having with teaching residents and politicians about the importance of urban trees, by stating “what they do with water run-off and things of that nature and how important they are with energy savings.” A similar thought was echoed by another city official: “They're [City Council] too focused on the bottom line right now as far as green buildings, and renewable energy ...they are more short-focused than long focused.” Further, the overall level of technical knowledge regarding likely effects of climate change was another constraining factor highlighted by many city officials in the interviews. Many interviewees expressed a desire for more easily accessible, credible, and salient information on likely climate impacts.

Ecosystems around the city are in a degraded state, which has led to erosion issues, increased maintenance costs, and some health concerns. The EPA has designated the Black River one of the forty-three Great Lakes Areas of Concern, due to past industrial contamination. The Black River also flows through Cascade Park, which the city prides as an area of recreation and the birthplace of the city. In recent years, severe rain events have led to erosion along the banks of the Black River in Cascade Park. Yet despite these constraints, we believe Elyria has the ability to implement adaptation projects and policies that can improve the well-being and future vitality of the city and its residents.
Elyria’s greatest capacity is its ability to pool resources, work together, and be flexible. The city government has collaborated with a variety of nearby organizations to achieve its sustainability goals, which tend to center around renewable energy and storm water management. Decision-makers within the city repeatedly stressed their commitment to regionalism and learning from nearby communities. The city’s participation in multiple regional planning consortiums reflects this commitment. Additionally, efforts by the city to work with Lorain County, nearby communities, and local institutes of higher education to develop renewable energy and ‘green’ technology industries attests to the government’s willingness to collaborate vertically and horizontally to achieve its sustainability and development goals. Though collaboration centered explicitly on adaptation is lacking, institutions with which the city is working, such as Oberlin College and Lorain Community College, are considering climate adaptation. Thus, considering the city has some concerns regarding climate change, these collaborations entail opportunities to gain knowledge on adaptation.

PHOTO: THE MORNING JOURNAL

In addition, social capital present within the government connects departments together. Many individuals working for the city have lived most of their lives in Elyria and have been employed by the government for decades. They know each other, their city, and many of the residents. Because of this, Elyria has built positive trust and collaborative leadership, and incorporates stakeholder input from multiple levels. This social capital will likely aid the dissemination of climate information throughout the city government as individuals learn more about potential impacts and strategies to ameliorate them. On the other hand, communication networks in Elyria are often informal and built on years of interaction, which may make accessing these valuable streams of knowledge and experience difficult for new employees.

As with each of the cities we studied, there is significant lack of resources within Elyria. Lack of financial capital in particular limits many initiatives. Without a steady, sustainable level of revenue, it is difficult for the city to plan for the medium-term—let alone the long-term—time horizon that successful climate adaptation requires. The various interviewees that described staffing constraints further demonstrate the difficulty the current financial conditions place on short-term operations and planning. These budgetary constraints also likely decrease the city’s visionary leadership. The main focus of city government is managing short- and medium-term concerns and priorities. There is little space for systemic, far-reaching thinking regarding the future of the city.
FIGURE 3: ELYRIA ADAPTIVE CAPACITY WHEEL
ELYRIA RISK ANALYSIS

Note: These maps should serve as a tool or starting point for the city. They do not indicate definite patterns, and they are not predictions.

FIGURE 4: RISK INDEX OF POTENTIAL CLIMATE VULNERABILITY IN ELYRIA, OH

The map included is a risk index for Elyria, OH, showing a composite of distance to green spaces and distances from FEMA flood plains, overlaid with demographics supported by the literature to be most vulnerable to the impacts of climate change in US cities. We have aggregated each separate risk analysis for the flood risk, green spaces and demographics layer, to show one composite map where areas highlighted red are those areas that deserve priority by policymakers regarding climate adaptation.

As can be seen in the equally weighted map (subsequent maps of different weights included in the Appendix), the southwest section of Elyria is considered to be at very high risk due to proximity to the floodplain, lack of local green spaces, and presence of vulnerable populations. The same can be said of the southeast corner of Elyria, though at a smaller geographic scale. The most insulated sections to the projected impacts of climate change are block groups located within the center and northern section of the city. Consideration of the potential distribution of impacts from climate change when implementing adaptation and sustainability policy can ensure that the most effective, economic and equitable actions are taken.
SWOT Analysis is a common method used to identify strengths, weaknesses, opportunities and threats to any project, business venture, or institution. For the purposes of this report, we have created a SWOT analysis for the city of Elyria as a whole, as it pertains to climate adaptation, informed by our interviews in 2012. Strengths are internal characteristics of the institution that put it in an advantageous position for adaptation. Weaknesses are those internal characteristics that place the institution at a relative disadvantageous position for adaptation. Opportunities are external elements that the institution can exploit for its advantage towards adaptation. Threats are external elements that can provide obstacles to the institution in its efforts toward adaptation. This SWOT Analysis is only meant to start a conversation about the elements therein. The following graphic is not an attempt at creating a comprehensive representation of all strengths, weaknesses, opportunities and threats of the entire city, nor is the information presented in this table guaranteed to occur or enable adaptive capacity.

### CITY OF ELYRIA, OH

<table>
<thead>
<tr>
<th>STRENGTHS</th>
<th>WEAKNESSES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social capital and informal relationships among city officials allows for resource and information sharing, as well as collaboration</td>
<td>Shortage in number of staffers among institutions</td>
</tr>
<tr>
<td>Consistent communication and informal relationships with the public</td>
<td>Overburdening of current staff members</td>
</tr>
<tr>
<td>Membership of regional sustainability networks</td>
<td>Little integration of sustainability and adaptation in city governance</td>
</tr>
<tr>
<td>Resourceful staff members that obtain grants and maximize opportunities</td>
<td>Limited awareness of climate change, adaptation, or sustainability among staffers</td>
</tr>
<tr>
<td>Relative flexibility to allocate funding within departments</td>
<td>Inconsistent or a lack of access to climate information for use in planning</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>OPPORTUNITIES</th>
<th>THREATS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regional leaders in sustainability willing to share best practices and collaborate, collaboration with universities (U of M, Oberlin College, Lorain Community College)</td>
<td>Projected increase in precipitation will increase soil erosion in Cascade Park</td>
</tr>
<tr>
<td>Renewable energy projects in Northern Ohio likely to create new green jobs in Elyria</td>
<td>Reduction in federal grants</td>
</tr>
<tr>
<td>Industrial infrastructure of Elyria attractive to national green industry</td>
<td>Invasive species to threaten biodiversity of local flora and fauna</td>
</tr>
<tr>
<td>Sustainable storm water management on regional brownfields, i.e. rain gardens, green roofs, etc. can be emulated in Elyria</td>
<td>Political silos at interstate and interregional levels prevent collaborative solutions</td>
</tr>
</tbody>
</table>
CITY COMPARISONS

In this section, we provide a comparative analysis of adaptive capacity to climate change through the display of adaptive capacity wheels for Avon Lake city, one of our research sites (Avon Lake, Dayton, Elyria, Toledo, OH) involved in our project study. We believe this comparison serves as a starting point for conversations about the extension of regional adaptation networks, as Avon Lake is more similar in size and demographic composition to Elyria. Below, we have also included a table comparing Elyria’s census data to Avon Lake.

<table>
<thead>
<tr>
<th></th>
<th>Elyria</th>
<th>Avon Lake</th>
<th>State of Ohio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population</td>
<td>54,533</td>
<td>22,581</td>
<td>11,536,504</td>
</tr>
<tr>
<td>Population under 5 years</td>
<td>6.9%</td>
<td>5.7%</td>
<td>6.2%</td>
</tr>
<tr>
<td>Population 65 years and over</td>
<td>14.3%</td>
<td>14.5%</td>
<td>14.1%</td>
</tr>
<tr>
<td>Median household income</td>
<td>$ 42,383</td>
<td>$ 81,635</td>
<td>$ 48,071</td>
</tr>
<tr>
<td>Persons below poverty line</td>
<td>16.5%</td>
<td>4.5%</td>
<td>14.8%</td>
</tr>
<tr>
<td>Racial make-up</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>78.1%</td>
<td>95.7%</td>
<td>82.7%</td>
</tr>
<tr>
<td>Black</td>
<td>15.5%</td>
<td>1.1%</td>
<td>12.2%</td>
</tr>
<tr>
<td>Other</td>
<td>6%</td>
<td>3.8%</td>
<td>5%</td>
</tr>
</tbody>
</table>

**TABLE 4: 2010 CENSUS DATA**

Avon Lake is a small town on the shore of Lake Erie, just outside of Cleveland. Part of Lorain County, Avon Lake did not officially become a city until 1961. The city is home to an estimated 22,602 people, with per-capita income, median household income, home ownership rate, and median value of owner occupied units all higher than the state’s average. The percentage of people living below the poverty level in Avon Lake is lower than the average for Ohio (U.S. Census, 2010).

Avon Lake’s economy has historically been tied to manufacturing (mainly sawmills and shipyards) with industry continuing to play a large role today. Industrial companies such as Lubrizol, Ford, and PolyOne Corporation have facilities located in the area. Other economic activities include merchant wholesaler sales, retail, accommodation and food service (U.S. Census, 2010).

The city has 220 acres of parkland, including a MetroPark, along with beaches and a boat launch for tourism and recreation. Current environmental programs include P.I.P.E. (storm sewer public involvement and public education program), the Renewable Energy Task Force, the Sustainability Master Plan, updating the storm water and sewer system to comply with EPA regulations, and Avon Lake’s municipal utilities’ work. Though Avon Lake, OH was the city in which the fewest interviewees expressed concerns about climate change, a few
interviewed officials worry about the impact of extreme events. In particular, officials relayed doubts about the capacity of current sewer and drainage systems.

The city has made efforts to establish partnerships and networks across sectors and departments that would generate may result in a higher social capital for the region. These communication networks are largely informal, through face-to-face interactions, social media, the Community Channel, etc. However, very few interviewees reported participating on more than one external network or partnership, apart from the Services Department and the Economic Development. A lack of formalized communication networks between departments and with the public may constrain the overall adaptive capacity of the city.

Further, interviewees in Avon Lake expressed a willingness to implement new policies if they believed them necessary. For example, efforts to develop renewable energy demonstrate officials’ commitment to innovate. However, what is lacking in Avon Lake is visionary leadership—especially in connection to sustainability or adaptation. Some officials in the city were skeptical of climate change. This perception that climate change does not exist constrains adaptive capacity by decreasing the ability to make connections between city planning, climate change adaptation, mitigation, and sustainability. It also places the city in a more reactive position, as they may respond to climate events or consequences as they happen, rather than being able to anticipate impacts and plan ahead based on projected climate trends.

Compared to Elyria, Avon Lake possesses a steady financial base. Interviewees perceive financial capital to be low, however our research team does not feel that current financial capital in Avon Lake to be constraining adaptation. City departments are not severely understaffed and the city does not face severe resource constraints like other cities in the region. The human capital displayed through some prominent projects and programs like P.I.P.E (Public Information/Public Education) add to the adaptive capacity of the city. The program activities educate the community about storm water management and works towards achieving compliance with EPA directives. These outreach activities center on a mascot who educates about storm water management on the Avon Lake TV channel, city website, and occasionally, in-person. As part of their outreach strategy, the P.I.P.E. program also hosts a photo contest.

Given our analysis of adaptive capacity, our research believes that Avon Lake currently possesses less adaptive capacity than Elyria, though this is difficult to definitively measure. The major constraints in Avon Lake pertain to leadership, ability to learn and respond to impacts, as well as providing a variety of problem frames and solutions. Avon Lake and Elyria would do well to further integrate their adaptation plans in order to improve their adaptive capacity, perhaps contributing to an increase of the adaptive capacity of the region.
POLICY RECOMMENDATIONS

Currently, Elyria is facing economic, social and institutional challenges. Climate change may further overburden the city with future impacts. City officials would be wise to adopt an anticipatory risk-based approach to climate change. Planning for climate change must be part of a risk-management process in every city department. Based on the identified climate impacts in Elyria, combined with key findings from the adaptive capacity wheel and SWOT analysis, we are providing an inchoate recommendations list for local decision makers and planners, to serve as a starting point for conversations about the implementation of adaptation initiatives within institutional policies.

Invasive Species, Water pollution and Flood Events

- Adopt strategic wetland restoration and a low-impact development (LID) approach to land and storm water management
- Promote landscape connectivity to facilitate species adaptation and conservation
- Improve communication of climate risks and resources to vulnerable populations
- Develop robust disaster management plans to resume critical services during emergencies
- Design and implement impact insurance, early warning, emergency back-up and evacuation schemes

Lack of Integration of Sustainability and Adaptation in Planning and Governance

- Form a sustainability/adaptation focused leadership team consisting of city government officials and interdisciplinary experts to initiate and coordinate adaptation processes for the city
- Incorporate collaborative and communicative planning approaches to shift towards a dynamic, multi-stakeholder engagement to promote consensus-based decision making on climate initiatives
- Focus on research and development on current adaptation and mitigation issues by building partnerships with research institutes and organizations studying climate change
Strengthening Institutional Response to Climate Impacts

- Build and expand on ongoing coordination at the local, and regional level by involving multiple layers of government, public and private partnerships and community representatives
- Adopt a holistic and integrated approach in policy formation with a flexible adaptation pathways approach that would accommodate climate change risk in local government operations
- Monitor and evaluate adaptation initiatives at the departmental level

Lack of Access to Climate Data

- Share knowledge and best practices with nearby cities to achieve outcomes towards regional adaptation
- Facilitate scientist-stakeholder information sharing through continuous engagement and consensus building
- Enhance interaction among city officials and departments by linking stand-alone and isolated departmental projects and programs to larger sustainability activities of the region

Aging Infrastructure and Constraints in Service Provisions

- Review city codes and redesign existing infrastructure to respond to projected climate impacts
- Focus on “no regret” strategies with socially beneficial outcomes
- Implement “soft strategies” that are institutional and financial tools for addressing climate impacts
- Develop robust disaster management plans to resume critical services during emergencies

CONCLUSION

Elyria must adapt to climate change. The Great Lakes region is likely to experience multiple negative impacts due to a changing climate. Most relevant impacts include increased temperature, severe heat events, flooding, freeze-thaw events, and invasive species as well as decreases in lake levels and ice cover. Decision-makers in every city expressed concerns regarding these likely impacts.

The city of Elyria possesses unique capacities enabling and constraints inhibiting adaptations designed to attenuate projected impacts. Leaders in Elyria demonstrated an ability to champion causes and act as policy entrepreneurs. However, efforts by leaders to adapt to climate change are highly uneven throughout the city. Though public officials often expressed concern surrounding the potential impacts of climate change, they also described lacking access to sufficient information regarding climate change and the financial and human resources needed to implement solutions.

A long economic decline since the late 1970s, combined with the acute effects of the recent economic recession, has greatly reduced the financial base with which Elyria operates. Nearly all interviewees had a story to tell regarding the myriad effects the economic downturn has had on their job. Because of financial constraints, available funds are spent on core city priorities. Additionally, though city staff constantly demonstrated high competence and dedication within their jobs, city departments tend to be understaffed. Expanding the scope of government within this climate is difficult, to say the least.

Further, public officials do not have sufficient access to scientific information, nor the capacity to use it, necessary for robust adaptation planning. Scientific knowledge is often inaccessible and perceived as not
usable. Further, city decision-makers do not have the technical training to fully digest, weigh, and compare relevant information. We utilized the adaptive capacity wheel to analyze how these constraints and capacities combine to shape the overall adaptive capacity of each city. We have also provided a SWOT Analysis for the use of city officials to begin a dialogue about adaptation planning.

Decision-makers in Elyria are concerned about the potential that climate change will worsen erosion and invasive species, as well as lead to increased heat events. Well-connected individuals, possessing relatively high social capital, populate the city government. Because of this, the city is able to share resources and knowledge. Further, city employees and officials reported being well connected to the broader city community—often interacting with citizens both as part of their job and in their everyday life. However, decision-makers have not deeply considered the effect climate change might have on city functions. Climate change will likely challenge the city’s efforts to reduce erosion in Cascade Park and increase urban forestry as well as negatively affect city infrastructure, such as the sewage treatment plant and roads.

Elyria faces unique challenges. Nevertheless, the city has the capacity to ameliorate these impacts, so long as it begins to systematically plan for adaptation. Important for this will be taking advantage of partnerships with organizations that can bridge the gap between scientific information and practical governance needs. Organizations such as universities and research units in the region (University of Michigan, Lorain Community College, Oberlin College) can provide salient and credible information to local decision-makers. If leaders are able to capitalize on these resources, assimilate this information into core departmental and city goals in order to create long-term and flexible plans, and implement the type of policies we recommended, Elyria will become more resilient to climate change.
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INTERVIEW QUESTIONS FOR QUALITATIVE RESEARCH

Priorities

- What are the priorities for your office/department?
- What are the priorities for the city?

Opportunities and Constraints for Development and Program Implementation

- What are some sustainability-related programs adopted/initiated by the city? Can you give us some examples?
- Now talking more specifically about mitigation…
- What incentives exist at the city level to curb or decrease emissions?
- Does the city have plans to promote energy efficiency or energy conservation?
- Can you tell me more about plans and goals related to renewable energy sources?
- How are decisions about energy use and production made at the municipal level?
- Is climate adaptation or mitigation included in these plans?
- We’re interested in knowing more about funding/financing of initiatives and programs, can you tell us more about that process?
- Is the city facing budget problems at this time? Where does much of your revenue come from? Do you have flexible sources of revenues?
- What about funding for environmental and/or sustainability initiatives?
- How easy is it for your department to innovate? How do you think you are innovative in this area? Can you give us an example of an innovative effort you are proud of?
- Do you collaborate with others on any climate related efforts? How? Can you give us an example?
- Do the collaborations work?

Potential Impacts of Concern

- In terms of both climate and weather impacts, what concerns you most?
- Has the city experienced any extreme weather events in the past 10 years?
- 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? Was there anything you felt went particularly well? That you felt unprepared for? That surprised you?
- Do you have any formal emergency response plans in place at the city level? Department-level?

Use of Climate Science

- What kind of information do you use? Where do you get your climate information?
- Is the information you receive useful?
- How would you prefer to get climate information (format/method)?

Consideration of Human Health

- What public health programs are currently offered?
- Is the city taking preventative measures to prepare for future climate change induced human health issues (i.e., increased heat wave frequency, intensity, and duration impairing health)?
Ecosystems and the Built Environment

- Are there specific environmental concerns about potential impacts of climate change?
- What is the city policy for land-use planning (zoning, etc.)?
- In your opinion, will changes to the water levels in the Great Lakes affect your city?
- (If yes) How so?

Consideration of Infrastructure

- How does the city plan, coordinate, and implement infrastructure maintenance and repairs (drinking water, storm water, roads, bridges, electric, etc.)?
- Has preparing for or adapting to climate change influenced this process of updating infrastructure?
- In Ann Arbor, we have had a very hot summer…Have you had any power outages similar to ours? Do you have means to prevent it? What grid are you on?

Public Involvement

- How do you keep the community involved in what you are doing?
- Do you have a targeted audience for these communications?

Barriers and Challenges to Adaptation

- What are main opportunities for you to address climate issues? What are the main constraints that make it difficult?
- What additional mitigation projects might the city undertake if there were no constraining factors?

GLOSSARY OF TERMS

The following list contains definitions from GLAA-C, based on definitions from the IPCC AR4, USGCRP 2012, Ontario Expert Panel on Climate Change Adaptation (2009), whenever possible. Other references include NOAA, and US EPA as noted.

Climate Change

Climate change refers to a change in the state of the climate that can be identified (i.e. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use. (IPCC Fourth Assessment Report)

Adaptation

Initiatives and measures to reduce the vulnerability of natural and human systems against actual or expected climate change effects. Various types of adaptation exist, i.e. anticipatory and reactive, private and public, and autonomous and planned. Examples are raising river or coastal dikes, the substitution of more temperature shock-resistant plants for sensitive ones, etc. (IPCC Fourth Assessment Report)

Adjustment in natural or human systems to a new or changing environment that exploits beneficial opportunities and moderates negative impacts. (USGCRP, 2012)
Adaptive Capacity

The whole of capabilities, resources and institutions of a country or region to implement effective adaptation measures. (IPCC Fourth Assessment Report)

The ability of a system to adjust to climate change (including climate variability and extremes) in order to moderate potential damages, to take advantage of opportunities, or to cope with the consequences. (Ontario Expert Panel on Climate Change Adaptation, 2009)

Capacity building

In the context of climate change, capacity building is developing technical skills and institutional capabilities in developing countries and economies in transition to enable their participation in all aspects of adaptation to, mitigation of, and research on climate change, and in the implementation of the Kyoto Mechanisms, etc. (IPCC Fourth Assessment Report)

Coping Range/Capacity

The capacity of systems to accommodate variations in climatic conditions. (IPCC Fourth Assessment Report)

Effects

Changes in the physical characteristics of climate that are driven by forcings. These usually describe indicators from a management or status perspective.

Extreme weather event

An event that is rare at a particular place and time of year. Definitions of “rare” vary, but an extreme weather event would normally be as rare as or rarer than the 10th or 90th percentile of the observed probability density of weather events. (USGCRP, 2012)

Impacts

Changes in the engineered or natural environment that affect human or ecosystem behavior and can be altered or avoided by direct action. They are often the result of climate effects coupled with existing conditions in built or natural the environment. For example, severe storms and paved surfaces can lead to channeled storm water and flooding. This, in turn, can lead to further cascading impacts, such as water supply contamination and property damage. Reducing the amount of paved surface, or changing storm water management practices can avoid this particular impact. Climate impacts are generally problems that can be solved through action.

Indicators

Observations that are unambiguously affected by natural or anthropogenic climate change. Precipitation, temperature, sea level rise, extreme weather, snow cover, snowfall, and glacial melt are some examples. NOAA limits this definition to observable physical changes. Ecological and environmental changes are often included in a broader definition of indicators used by many organizations.

Integrated Assessment

A method of bringing together knowledge of ecosystems, people, and policy in order to find solutions for particularly challenging or “wicked” problems. Assessments summarize scientific knowledge to build
consensus and guide decision making around a particular resource management, environmental or sustainability issue. (Vaccaro, 2009).

**Mitigation**

Technological change and substitution that reduce resource inputs and emissions per unit of output. Although several social, economic and technological policies would produce an emission reduction, with respect to climate change, mitigation means implementing policies to reduce GHG emissions and enhance sinks. (IPCC Fourth Assessment Report)

An anthropogenic intervention to reduce the anthropogenic forcing of the climate system; it includes strategies to reduce greenhouse gas sources and emissions and enhancing greenhouse gas sinks. (Ontario Expert Panel on Climate Change Adaptation, 2009)

**Climate Prediction**

A climate prediction or climate forecast is the result of an attempt to produce an estimate of the actual evolution of the climate – including weather variations – in the future, for example, at seasonal, interannual, or long-term timescales. (USGCRP, 2012)

**Climate Projection**

A projection of the response of the climate system to emission or concentration scenarios of greenhouse gases or aerosols, or radiative forcing scenarios, often based upon simulations by climate models. Climate projections are distinguished from climate predictions in order to emphasize that climate projections depend upon the emission/concentration/radiative forcing scenarios used, which are based on assumptions concerning, for example, future socioeconomic and technological developments that may or may not be realized and are therefore subject to substantial uncertainty. (USGCRP, 2012)

**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. (Ontario Expert Panel on Climate Change Adaptation, 2009)

**Uncertainty**

An expression of the degree to which a value is unknown (e.g. the future state of the climate system). Uncertainty can result from lack of information or from disagreement about what is known or even knowable. It may have many types of sources, from quantifiable errors in the data to ambiguously defined concepts or terminology, or uncertain projections of human behavior. Uncertainty can therefore be represented by quantitative measures (i.e. a range of values calculated by various models) or by qualitative statements (i.e. reflecting the judgment of a team of experts). (IPCC Fourth Assessment Report)

**Urban Heat Island**

The elevated temperatures in developed areas compared to more rural surroundings. (US EPA)

**Vulnerability**

The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate and global change, including climate variability and extremes, as well as climate change in conjunction with other stressors. (USGCRP, 2012)
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. (Ontario Expert Panel on Climate Change Adaptation, 2009)

**Exposure**

The severity and frequency that a system experiences a given type of event.

**Sensitivity**

The susceptibility of a system is to a particular type of impact.

**Risk**

The probability of an event occurring multiplied by the severity of the consequence.
WEIGHTED ELYRIA RISK INDICES

Potential Climate Change Risks for Elyria, OH: Weighted Demographics

Index based on distance to green space, distance from FEMA flood plain, and demographic variables (% under 5, % over 55, below 2010 poverty line, and % minority).

Risk Index
- High
- Low

Block Groups

Potential Climate Change Risks for Elyria, OH: Weighted Distance to Flood Hazards

Index based on distance to green space, distance from FEMA flood plain, and demographic variables (% under 5, % over 55, below 2010 poverty line, and % minority).

Potential Climate Change Risks for Elyria, OH: Weighted Distance to Green Spaces

Index based on distance to green space, distance from FEMA flood plain, and demographic variables (% under 5, % over 55, below 2010 poverty line, and % minority).

Risk Index
- Value
  - High
  - Low

Block Groups