Climate Change Action Strategy Document

Resilient Buffalo Niagara

Strategies to Respond to Climate Change

Resilient Buffalo Niagara was prepared by Dr. Himanshu Grover, University at Buffalo School of Architecture and Planning

DECEMBER 2014

About this Strategy Document

Resilient Buffalo Niagara

Strategies to Respond to Climate Change

This strategy document provides a broad policy framework for responding to the existing and anticipated impacts of climatic change already underway across the Buffalo-Niagara region. Effective climate change response primarily requires increased environmental sensitivity in day-to-day planning and development decision-making.

The majority of climate change response strategies are rooted in ongoing local municipal planning initiatives such as land use planning, transportation planning, building codes, and hazard mitigation. As such this report highlights important considerations that local decision makers need to be sensitive to when implementing such local developmental planning actions.

A critical aspect of climate change response is limiting existing greenhouse gas emissions without compromising local economic growth and development. In light of this, the report recommends broad policy considerations to guide local decision making to limit greenhouse gas emissions without hindering economic prosperity.

With respect to direct local impacts from climate change, present models indicate marginal changes in normal temperature and precipitation patterns by mid-century. However, it is very likely that the resultant societal impacts will be heightened by existing vulnerabilities in the local physical infrastructure and social systems. Therefore, this report undertakes a regional assessment of such vulnerabilities, highlighting communities of relatively higher concern that need to undertake further detailed assessments at the local level.

In summary, this is a regional climate change response strategy document that provides a blueprint for advising local development actions to avoid further increases in community exposure to climate change risks, and rather enhance community resilience along with gains in local quality of life.

Recommended Citation: Grover, Himanshu, Margaret Smith, Yanjia Cao and Yi Yang. 2014. *Resilient Buffalo Niagara: Strategies to Respond to Climate Change*. University at Buffalo Regional Institute, State University of New York at Buffalo, School of Architecture and Planning.

This document was produced as part of One Region Forward, a regional initiative to promote more sustainable forms of development in Erie and Niagara counties. Research, analysis, and planning for this report were led by Dr. Himanshu Grover of the University at Buffalo, School of Architecture and Planning at the State University of New York. Funding was provided by the US Department of Housing and Urban Development through its Partnership for Sustainable Communities, an interagency collaboration also involving the US Department of Transportation and the Environmental Protection Agency.

AUTHORSHIP

Authors: Himanshu Grover, Margaret Smith, Yanjia Cao, Yi Yang

Principal Investigator: Robert G. Shibley, FAIA, AICP

ACKNOWLEDGEMENTS

Numerous individuals, organizations, and groups throughout the Buffalo-Niagara region have contributed generously with their ideas and time for this report.

Climate Change Action Working Group Members

Dr. Lynda Schneekloth, *UB Regional Institute (Team Facilitator)*
Sean Myers, *NBT Solutions LLC*
Terry Yonker, *Western New York Environmental Alliance*
Bill Nowak, *Buffalo Geothermal Heating and Cooling*
Padma Kasthurirangan, *Niagara Wind and Solar*
Lou Paonessa, *Niagara Power Project*
Bill Smith, *Buffalo Niagara Medical Campus*
Thomas Hersey, *Erie County Department of Environment and Planning*
Liz Santacrose, *Ecology & Environment*
Kelly Tyler, *New York State Energy Research and Development Authority*
Jim Simon, *University at Buffalo Office of Sustainability*
Aliesa Adelman, *Wendel Companies*

UB Regional Institute Research and Support Team: Bart Roberts, Bradshaw Hovey, Brian Conley, Brenda Stynes, Darren Cotton, Teresa Bosch de Celis, Matt Wattles, Laura Quebral, Kathryn Friedman, Paul Ray, Sharon Ana Entress, Emily Gibson (Graduate Assistant).

The work that provided the basis for this publication was supported by a U.S. Department of Housing and Urban Development (HUD) Sustainable Communities Regional Planning Grant. The author and publisher are solely responsible for the accuracy of the statements and interpretations contained in the publication. Such interpretations do not necessarily reflect the views of the Federal Government.

Table of Contents

Figures

Tables

EXECUTIVE SUMMARY

This Climate Change Response Strategy Plan, "Resilient Buffalo-Niagara", is one of the first initiatives in the nation to propose a comprehensive and integrated response to the challenge of climate change. Buffalo-Niagara region is located between two Great Lakes - Lake Erie and Lake Ontario. Historically, except for significant lake-effect snowfall, this region has not experienced any major natural hazards. However, this does not preclude it from the negative impacts of climate change. The detailed vulnerability assessment undertaken in this report reveals that as the world's climate continues to change, and weather patterns become more unpredictable, the future will not be as safe. This region too will face an increasing number of hazards and risks. In order to realize the vision of sustainable and equitable development in the region, local communities will need to consider existing and future vulnerabilities when formulating future development policies. This report, as part of the One Region Forward initiative for the region, will serve as a guide for local authorities in preparing for climate change.

This report undertakes a critical evaluation of local vulnerability to future impacts of climate change. This report utilizes downscaled data from climate change projections generated by the Community Climate System Models (CCSM). Changes in local temperature and precipitation are analyzed until the end of this century based on three-emission scenario of: low emissions, medium emissions, and high emissions. This analysis reveals that impacts under low emission scenario will be marginal, but will be significantly higher under medium and high emission scenarios. Under all scenarios, southern tier communities will be the first to experience significant changes in the local conditions. Climate change risks in this region will be exacerbated by existing vulnerabilities in the local infrastructure, and unsustainable development patterns.

This report also analyzes the patterns of social vulnerability in the region. This perspective highlights the differences in local adaptive capacities among the various communities in the region. Analysis of nine social vulnerability variables reveals that Cities of Buffalo, Lockport, Lackawanna, Tonawanda and Niagara Falls, Towns of Newfane, Somerset, Royalton, Cheektowaga, Brant, Collins, and Concord, and the villages of Springville and Sloan are of greatest concern. These communities will greater needs, but limited resources to implement an effective climate change response strategy.

Based on the vulnerability analysis, a number of strategic response options are presented in this report to minimize risk from future impacts of climate change. This report adopts a synergistic approach that seeks to bring together traditional adaptation, mitigation, and efficiency policies to enhance local resilience to climate change. The hallmark of the proposed climate change response strategy is the adoption of a balanced approach that emphasizes reduction of greenhouse gasses, efficiency and conservation of resources, and sustainable development policies that will enhance local resilience to climate change and result in an equitable and sustainable growth in the region. This report thus outlines an ambitious, yet achievable, vision of community resilience through local action.

1.

INTRODUCTION

There is now overwhelming evidence confirming that changing weather conditions, increasing frequency of extreme events, and growing losses from hydro-meteorological events are clearly attributed to climate-related stresses, combined with the socio-economic and structural vulnerabilities of human systems. Since 1900, the average temperature in the Northern Hemisphere has increased by 1oF, growing seasons have lengthened, and precipitation has increased significantly (Rogelj, Meinshausen, and Knutti 2012). During the same period, the number of hydro-meteorological events has also increased from less than 10 per year to more than 340 per year (Center for Research on Epidemiology of Disasters (CRED), 2007).

Historically, natural climatic variability has been the primary cause of extreme events, but the recent rise in weather related extreme events is most likely due to climatic changes caused by anthropogenic, or human-caused, emissions. This scientific consensus on the role of greenhouse gases in causing climate change is clearly expressed in most scientific international and national organizations, including the Intergovernmental Panel on Climate Change (IPCC) and the National Academy of Sciences (NAS) (Oreskes 2004). While the impacts of increasing greenhouse gases are starting to become evident in common weather measures of temperature and rainfall, the impacts of climate change on plants, animals, and ecosystems is still unclear. It is also uncertain if and how these species and systems will adapt to climate change.

However, it is widely feared that most of the ecosystem services that we depend on for our continued growth and prosperity are at existential risk from climate change. This certainty of changes coupled with uncertainty with respect to the exact nature, extent, and severity of risks lends urgency to the need to address climate change at the local and regional scales.

The Buffalo Niagara region is situated along two famous Great Lakes: Erie and Ontario. This geographical location creates unique climatic features that are highly sensitive to local and regional changes in weather and climate conditions. Historically, this region experiences extreme snowstorms during the late fall and winter months, due to cold air that sweeps across warmer lakes, picking up heat and moisture, and depositing large amounts of snow along the lee side of the lakes. This phenomena causes Buffalo to receive an average of 92 inches of snowfall per year (Kunkel, Westcott, and Kristovich 2002). While heavy lake-effect snowfall represents a potential natural hazard for local communities, it also plays an important role in winter recreational activities, agriculture, environmental health, and regional hydrology. Occurrence of these events is directly linked to temperature changes in the Northern Hemisphere, and local lake surface conditions (e.g., air temperature, lake-air temperature differences, wind speed, and wind direction). As regional climatic changes become more overt, the Buffalo Niagara region will undoubtedly experience changes in its existing patterns of lake-effect snowfall.

Other direct impacts of climate change will manifest themselves in the forms of increasing mean temperatures and rainfall. These changes are likely to be accompanied with an increasing number of days with extreme temperatures as well as localized flooding due to more intense rain events. Changes in the local climatic system will also lead to secondary impacts such as decreased agricultural productivity, shifts in the ecological distribution of forests and plants, changes in urban run-off, and increased seasonal variation in lake levels. The impacts of these changes will be further exacerbated by existing vulnerabilities and unsustainable development practices in local communities, such as urban expansion in low-lying areas, a lack of cohesive infrastructure management and redevelopment strategies, and income inequality, among other existing socio-economic challenges. As the impacts of climate change become more conspicuous there will be increased stress on urban infrastructural facilities such as energy generation and distribution, water supply, drainage, and wastewater management. Most notably, it is also expected that fresh water scarcities elsewhere may drive unprecedented changes in local economic and demographic patterns in this region.

These risks represent the most likely direct and indirect impacts of anticipated climatic changes based on the existing estimates of greenhouse gas emissions and the commonly accepted range of climate change model simulations. While recognizing the uncertainty in predicting the exact extent and nature of changes, this report adopts a synergistic planning framework to outline an informed climate change policy response for the region.

Extreme Lake-Effect Snowfall

In 2006, the lake-effect snowstorm in October dropped 24" of snow in the region over a 16-hour period. This off-season snow event crippled life across the region and resulted in losses worth millions of dollars. (Photograph courtesy NOAA)

A. What Does this Plan Provide?

This climate change response strategy document will serve as a guide to local municipalities in the Buffalo Niagara region to prepare for and respond to the local impacts of climate change. This plan focuses on building community resilience to minimize losses from climatic changes, while at the same time supporting the sustainable development of the region. It is expected that proactive planning for climate change will prove to be economical and beneficial for the region by significantly reducing future costs of redesigning, rebuilding, and retrofitting numerous types of infrastructure as a result of climate change impacts.

Since this plan is primarily meant to guide local municipal action, the analysis and results focus on sectors and services that are typically under local jurisdiction. Other sectors within the jurisdiction of state or federal agencies have not been addressed in thorough detail. For example, the impact of climate change on water levels and quality of marine resources in Lake Erie and Lake Ontario is expected to be quite significant, but the adaptation actions required to address these issues fall outside of the control of local communities. Therefore, these broader issues have not been addressed in detail in this plan. However, related issues of urban development and managing surface run-off in the local watershed, which are within the political control of local jurisdictions, have been addressed

B. Climate Change Response Planning Goals

The following goals serve as a guide for the research analysis and policy recommendations that follow in the subsequent sections. In addition to the analysis of the existing regional climate change and development challenges, these goals were also informed by discussions of the Climate Change Action Working Team organized as part of the regional sustainable development planning initiative, One Region Forward.

Goal 1

Provide appropriate guidance and information on related issues and challenges to ensure that local communities are better prepared in the face of changing climatic trends in the region.

Goal 2

Outline a balanced approach to addressing climate change through a combination of mitigation and adaptation measures.

Goal 3

Evolve a comprehensive methodology for climate change vulnerability assessment that can be implemented across the region.

Goal 4

Encourage strategies with tangible benefits across multiple sectors that will also contribute to local economic growth and wealth creation.

Goal 5

Identify actions that will support the continued sustainability of the Great Lakes and other natural resources in the region.

C. Resilient Buffalo Niagara Response Strategy

Traditionally climate change response policies have been classified into mitigation and adaptation responses. Mitigation refers to policies that aim to limit the severity of climatic changes by controlling greenhouse gas emissions and increasing the number of natural "sinks" that absorb emissions, such as forests. Adaptation on the other hand primarily aims at controlling the intensity of climate change impacts through a range of intervention policies to build resistance and resilience in vulnerable systems. Climate change research literature documents significant fundamental differences between the two approaches as well as potential conflicts between the two (Cohen et al. 1998, Christensen, Halsnæs, and Sathaye 1998). These differences relate to temporal scales, effective spatial scales, measures of cost-benefit analysis, and the appropriate actors for policy implementation.[1]

Despite the differences between these two policy options, they are also viewed as being complementary to each other (King 2004, Tol 2005, and Adger 2001a). Mitigation policies will help reduce the need for adaptive actions by reducing the threat of climate change. At the same time, adaptation policies will help reduce the residual impact of unavoidable climatic changes. Economically, mitigation policies are likely to be more cost effective as they focus on decreasing risks, and thereby reducing the need for adaptive actions. However, it is imperative that a meaningful climate change response strategy plan explore both kinds of policy options.

There is an intuitive appeal to creating synergies between the two policy responses, since that is likely to produce the most economical and efficient outcomes. At the same time it is important to recognize that climate change policy responses cannot happen in isolation. Rather, they need to be integrated with other environmental and developmental concerns. Climate

1 Refer to Fussel and Klein (2006) for a comprehensive analysis of differences between mitigation and adaptation policy options.

change policies that provide additional local benefits are likely to face lesser institutional resistance and gather broader public support. It is envisaged that the adoption of such a synergistic approach will enable policy makers to choose a balanced mix of policies based on specific local concerns and priorities.

Another critical aspect of climate change response strategy is the identification of opportunities to promote efficiency in existing systems. However, this aspect relating to modification in existing systems to promote efficiency has been largely ignored in most plans. For example, managing existing water demands in a community can lead to adaptation benefits by reducing the increased demand for water due to rising temperatures. It can also provide mitigation benefits by reducing the energy costs of the water supply system. At the same time, water demand management also promotes the overall sustainability of the community. However, such strategies are often addressed only in sustainability plans or individual sector plans, and do not receive adequate attention in climate change response strategies.

This strategy plan addresses the above issues by suggesting a mix of mitigation, adaptation, and conservation strategies as part of a broader climate change resilience policy response. The policies proposed in this plan are likely to provide synergistic benefits across a range of environmental and development priorities. The selection of such synergistic strategies is achieved by adopting a resilience-centered approach wherein the risks from climate change are seen as a cumulative outcome of anticipated impacts of changing climatic conditions and existing susceptibilities in local systems (e.g., socio-economic and physical infrastructure). The proposals are formulated to address these local vulnerabilities and build local resilience to climate change, while promoting regional sustainability.

This approach is particularly useful given the uncertainty associated with climate change impacts.[2] We believe that despite the lack of fine scale local climate change impact assessment data, an effective adaptive response strategy can be formulated through critical assessment of the existing vulnerabilities within the study area. An important aspect of such an approach is an assessment of inherent vulnerabilities[3]. It is expected that as a community addresses these vulnerabilities, it will become more resilient and will be able to cope with the increased risks as well as uncertainties from changing climatic conditions. Local programs and policies that reduce existing vulnerabilities will undoubtedly increase community resilience and consequently reduce overall exposure to the impending impacts of climate change.

This strategy document analyzes climate change vulnerability with respect to three dimensions: one external and two internal. The external dimension is represented by Buffalo Niagara's exposure to expected changes in the climatic systems. This is a scenario-based analysis that relies on outputs obtained from complex models that predict sub-regional impacts based on estimates of global greenhouse gas emissions.[4] These outcomes are discussed in terms of direct impacts on the local weather variables of temperature and precipitation, and secondary impacts of increased threats from natural environmental hazards as well as changes to natural ecosystems. The two internal dimensions include local greenhouse gas emissions contributions and local sensitivity to the anticipated impacts. Local emissions contributions are estimated across various local sectors and primarily rely on estimates developed as part of the 2013 Western New York Regional Sustainability Plan.[5] While there is no way to predict the direct marginal adaptation benefits of controlling local emissions, it does focus attention to the root cause of the problem. Non-tangible benefits of including mitigation as an important climate change response strategy include increased attention to climate change issues in local policy making. Another benefit is the provision of more policy options to enable policy makers to adopt a balanced climate change response strategy that is sensitive to both local environmental and developmental priorities. The sensitivity of a community is an a priori or inferable condition of a community that is determined by a variety of socio-economic and political factors (Blaikie et al. 1994, Adger 2001b).[6] This report utilizes commonly used indicators for assessing community sensitivity. It is anticipated that attention to these factors will result in beneficial outcomes not only in terms of an effective climate change response policy but also viable local sustainable development priorities.

D. Organization of the Report

The following chapter two analyzes the external threats (exposure) from anticipated changes in the climatic system. Geographical distribution of climate change risks is analyzed using Geographic Information Systems (GIS). In addition to the direct effects on temperature and precipitation, this report also analyzes the secondary impacts that are likely to be experienced in the region. Chapter three briefly summarizes the existing local greenhouse gas contributions. The underlying estimates were not conducted as part of this plan. Rather, they are based on the assessments undertaken as part of the 2013Western New York Regional Sustainability Plan. Chapter four presents a detailed analysis of local sensitivity to climate change across the various communities in Erie and Niagara counties. Using common indicators of social vulnerability, the variation between different communities in the region is analyzed and communities of higher concern are identified. The final chapter of this report discusses a range of response strategies recommended for minimizing the previously identified regional impacts of climate change.

2 Uncertainty in predicting the exact nature and extent of climate change is greater at the local level due to the limitations of climate change models in representing the complex interactions and mechanisms that impact local climatic conditions. For a detailed discussion on this topic see Heal and Kristrom (2002).

3 Vulnerability, according to the IPCC (2001), is an integrated measure of the expected magnitude of adverse effects to a system caused by a given level of certain external stressors. It is defined as: *"The degree to which a system is susceptible to, or 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 variation to which a system is exposed, its sensitivity, and its adaptive capacity."*

4 Discussed in further detail in Chapter 3. This is also referred to as physical vulnerability or place vulnerability in disaster research literature.

5 This plan was prepared under Phase I of the Cleaner, Greener Communities Program, sponsored by NYSERDA

6 This is referred to as "social vulnerability" in the disaster research literature (see Kasperson et al. 1988, Cutter, Boruff, and Shirley 2003).

Chapter References

Adger, W. N. 2001a. “Scales of governance and environmental justice for adaptation and mitigation of climate change.” Journal of International Development 13 (7):921-931.

Adger, W. N. 2001b. “Social Capital and Climate Change.” Tyndall Centre for Climate Change Research Working Paper 8:39–41.

Blaikie, P, T Cannon, I Davis, and B Wisner. 1994. At Risk: Natural Hazards, People’s Vulnerability and Disasters. London: Routledge.

Christensen, John M, Kirsten Halsnæs, and J Sathaye. 1998. Mitigation and adaptation cost assessment: Concepts, methods and appropriate use: Risø National Laboratory. UNEP Collaborating Centre on Energy and Environment.

Cohen, Stewart, David Demeritt, John Robinson, and Dale Rothman. 1998. “Climate change and sustainable development: towards dialogue.” Global Environmental Change 8 (4):341-371.

CRED. 2007. Country Profiles. Center for Research on Epidemiology of Disasters: EM-DAT Emergency Disasters Database.

Cutter, S. L., B. J. Boruff, and W. L. Shirley. 2003. “Social Vulnerability to Environmental Hazards*.” Social Science Quarterly 84 (2):242-261.

Füssel, H. M., and R. J. T. Klein. 2006. “Climate Change Vulnerability Assessments: An Evolution of Conceptual Thinking.” Climatic Change 75 (3):301-329.

Heal, Geoffrey, and Bengt Kriström. 2002. “Uncertainty and climate change.” Environmental and Resource Economics 22 (1):3-39.

IPCC. 2001. Climate Change 2001 - Impacts, Adaptation and Vulnerability, Working Group II Contribution to the Third Assessment Report of the Intergovernmental Panel on Climate Change. New York: Cambridge University Press.

Kasperson, R. E., O. Renn, P. Slovic, H. S. Brown, J. Emel, R. Goble, J. X. Kasperson, and S. Ratick. 1988. “The social amplification of risk: A conceptual framework.” Risk Analysis 8 (2):177-187.

King, David A. 2004. “Climate change science: adapt, mitigate, or ignore?” Science(Washington) 303 (5655):176-177.

Kunkel, Kenneth E, Nancy E Westcott, and David AR Kristovich. 2002. “Assessment of potential effects of climate change on heavy lake-effect snowstorms near Lake Erie.” Journal of Great Lakes Research 28 (4):521-536.

Oreskes, Naomi. 2004. “The scientific consensus on climate change.” Science 306 (5702):1686-1686.

Rogelj, Joeri, Malte Meinshausen, and Reto Knutti. 2012. “Global warming under old and new scenarios using IPCC climate sensitivity range estimates.” Nature Climate Change 2 (4):248-253.

Tol, Richard S. J. 2005. “Adaptation and mitigation: trade-offs in substance and methods.” Environmental Science & Policy 8 (6):572-578.

UN-ISDR. 2009. Risk and poverty in a changing climate: Invest today for a safer tomorrow. United Nations International Strategy for Natural Disaster Reduction Global Assessment Rep. on Disaster Risk Reduction.

2.

GREENHOUSE GAS EMISSIONS

An increased concentration of Greenhouse Gases (GHGs) in the atmosphere due to numerous human activities, including energy generation from fossil fuels, is the primary cause of climatic changes expected to occur in the coming decades. As such it is important to address this underlying cause of climate change in order to minimize future risks from resulting economic, social, and environmental impacts. If these GHG emissions are not controlled and reduced, the resulting costs to adapt to changing environmental conditions will be extremely high and will undoubtedly increase property losses and causalities.

With the understanding that the reduction of greenhouse gas emissions is an important climate change response strategy and necessary for effective adaptation, this section briefly discusses the existing GHG emissions in the Buffalo Niagara region. This report does not undertake a detailed inventory of local GHGs in the counties, but presents and analyzes the data included in the 2013 WNY Regional Sustainability Plan. This regional GHG inventory was undertaken as part of the Cleaner Greener Communities Program[1] supported by the New York State Energy Research and Development Authority (NYSERDA). The GHG inventory employed a Tier II analysis approach which utilizes local usage and other regional data to create the GHG emissions inventory for the year 2010. In the following sections, selected sectors that are of relevance to the climate change response strategy are discussed briefly.

A. Emissions from Electricity Consumption

Estimates of energy consumption in residential, commercial, and industrial sectors in this report are based on the data provided in the Tier II GHG Inventory Report of the WNY Regional Sustainability Plan, included in Appendix E. This inventory report did not provide sector level breakdowns of emissions from each county.[2] To estimate the sector-wise energy related emissions in each county, the total WNY regional emissions in 2010 for each sector were distributed to each county proportionally (using population for the residential sector, number of commercial employees on payrolls for the commercial sector, and number of industrial employees on payrolls for the industrial sector). Table 1 presents these estimates of GHG emissions from electricity consumption in each sector of the Buffalo Niagara region.

Sustainability Plan due to differences in the assessment methodology that are described in the above text.

As per these estimates, Erie County accounts for 71% of all energy consumption related GHG emissions in the WNY region. Erie County also has the largest share of residential population, commercial/business establishments, and industrial activity, making it the highest contributor of GHG emissions in all three sectors.

B. Residential Building Emissions from Stationary Combustion

In addition to electricity, residential buildings also consume energy from other fuels including natural gas, distillate, propane, and wood or biomass. GHG emissions from all of these sources are estimated as emissions from stationary sources in the 2013 WNY Sustainability Plan. The plan estimates

1 The WNY Regional Sustainability Plan was developed for Erie, Niagara, Chautauqua, Allegany, and Cattaraugus counties by the Regional Planning Consortium with a grant from NYSERDA under the Cleaner, Greener Communities program established by Governor Cuomo in 2011.

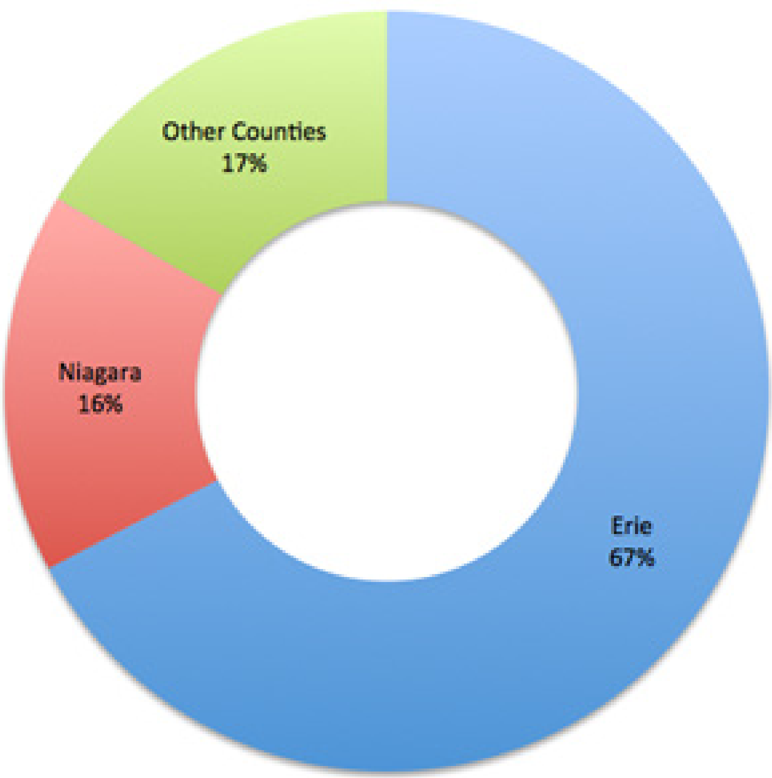
2 Only WNY regional emissions for each sector were provided in the WNY Regional Sustainability Plan

Table 1. Energy Consumption Related Emissions

Sectors	Emissions in Carbon Dioxide Equivalents (CO2e) (Metric Tons)		
	WNY Region*	Erie County	Niagara County
Residential	588,735	386,568	91,051
Commercial	603,564	392,814	85,733
Industrial	849,100	662,818	77,040
Total	2,04,1399	1,442,202**	253,825**

*Source: WNY Regional Sustainability Plan, 2013
**These totals are marginally different from the estimates in the WNY Sustainability Plan due to differences in the assessment methodology that are described in the above text.

Figure 1. Residential Building Emissions from Stationary Combustion



Source: WNY Regional Sustainability Plan, 2013.

that the total number of residential building emissions from stationary combustion in WNY for the year 2010 was 3,572,954 metric tons of CO2e. The respective emissions share (e share) of both Erie and Niagara counties is shown in Figure 1. Erie County had the highest share of these emissions in the Western New York Region at 67%.

C. Transportation

GHG emissions from energy consumption in the transportation sector are produced by a broad range of vehicles such as aircrafts, commercial marine vessels, trains and on-road vehicles. Among these the largest share of emissions is often from on-road vehicles. In WNY on-road vehicular GHG emissions were estimated to be 5,959,655 metric tons of CO2e for the year 2010. The respective share of emissions from on-road vehicles for each county is shown in Figure 2. Emissions from on-road vehicles in Erie County accounted for almost 65% of the WNY region's total on-road vehicular emissions.

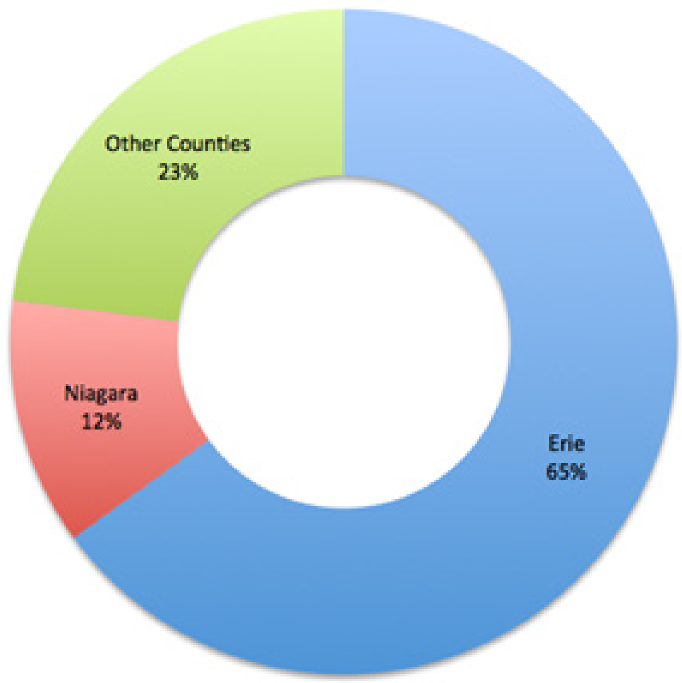
Figure 3 provides a comparison between the two counties and the region of annual vehicle miles traveled per household. It is evident that households in Erie County travel significantly more than those in Niagara County. These miles directly translate into more on-road vehicular emissions that not only contribute to increases in GHG concentrations but also greater incidences of air quality and public health issues.

D. Future Outlook

With Erie County likely to experience increasing investments in the coming years, its contribution to GHG emissions will increase further unless measures are taken to adopt more sustainable and efficient development policies. Despite the expected growth in population and residential development, residential energy and stationary source emissions can be controlled by supporting the adoption of better energy efficiency standards for new construction by all municipalities. For older residential buildings, policies that provide incentives for energy efficient retrofitting and weatherization will help to decrease existing residential emissions. Of particular concern are the high vehicular miles per household in Erie County. These directly contribute to climate change through vehicular GHG emissions. Additionally, increased vehicular miles will also require increased budgetary outlay for maintenance and improvement costs for roadways. In order to reduce these emissions municipalities will have to support increased use of public transportation, car-pooling, bicycling, and walking.

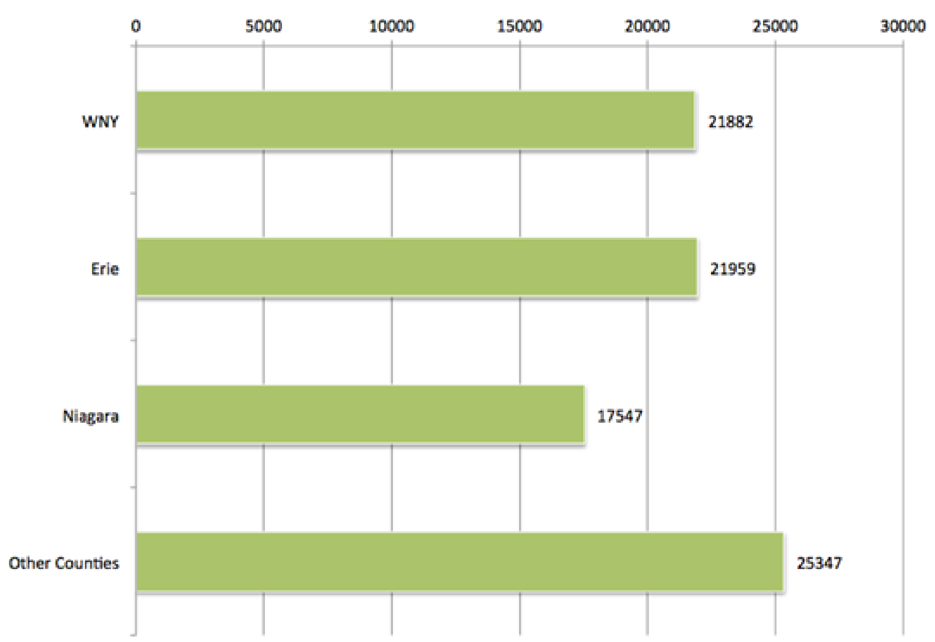
Based on the emissions data reviewed in this section, it is evident that in order to manage the region's growing risks from climate change it is important to decrease existing levels of GHG emissions from various sources. A balanced climate change response strategy will require policies to reduce existing GHG emissions while identifying actions to reduce local exposure to risks from climate change.

Figure 2. Emissions from On-Road Vehicles



Source: WNY Regional Sustainability Plan, 2013.

Figure 3. Annual Vehicle Miles Travelled Per Household (2010)



Source: WNY Regional Sustainability Plan, 2013.

3.

PHYSICAL VULNERABILITY TO CLIMATE CHANGE

The biophysical impacts of climate change will occur through various complex interactions in global ecosystems, and this will have significant but varied impacts on local ecosystem conditions. The primary climate-related drivers of impacts include warming trends, extreme weather conditions, and changes in local precipitation patterns. These changes will most likely exacerbate the existing risks from various hydro-meteorological hazards in local communities. A focus on physical vulnerability from climate change complements other elements of the report and provides a basis for physical adaptation strategies necessary to limit the risk of negative impacts of anticipated changes on local climatic conditions.

The intensity and exact magnitude of climate-related drivers of impacts can only be predicted with limited certainty owing to modeling complexity and data constraints in climate modeling. However, there is greater confidence in predicting the future likely trends of these drivers in various regions based on data collected in the last few decades. The degree of certainty for each of these predictions is based on the type, amount, quality, and consistency of their evidence (IPCC 2014). Some of the key risks identified with high confidence by the Fifth Assessment Report from the IPCC (2014) include:

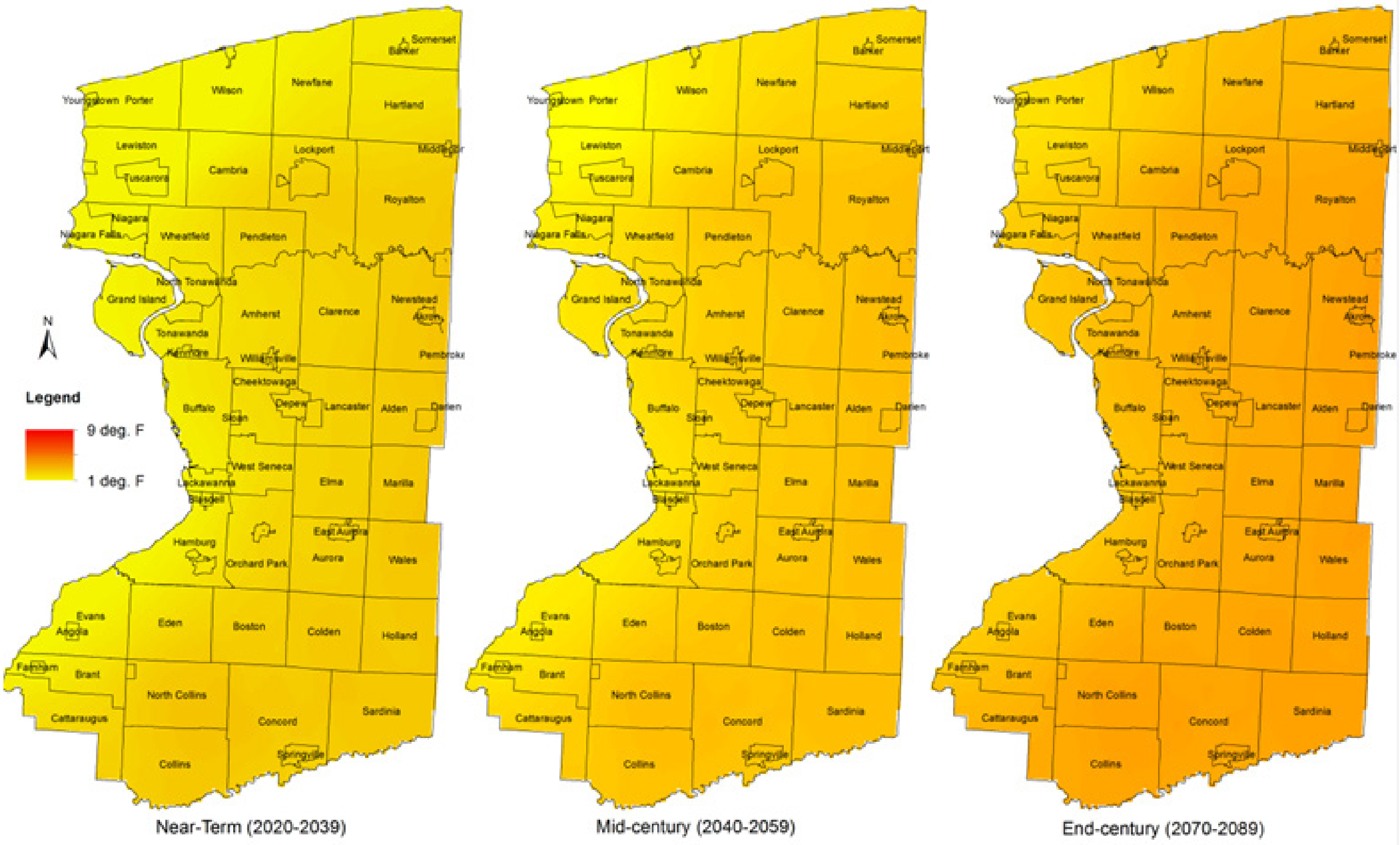
- Severe ill-health and disrupted livelihoods for urban populations due to inland flooding;
- Systemic breakdowns in infrastructure and critical networks;
- Decreased food-security and broken food systems; and,
- Loss of terrestrial ecosystems, biodiversity, and ecosystem biodiversity functions.

As per the recent U.S. National Climate Assessment (USGCRP 2014), changes in the climate-related drivers of impacts are already underway. This report utilizes two scenarios,[1] lower emissions (B1) and higher emissions (A2), to project future climatic changes across the country. Under the lower emissions scenario the projected warming in the Northeast region ranges from 3 degrees (deg.) Fahrenheit (F) to 6 deg. F by the 2010s. Under the high emissions scenario this warming is likely to range between 4.5 deg. F and 10 deg. F during the same period. Similarly, significant changes in precipitation patterns are also projected. Under a high emissions scenario, average winter precipitation over the region is expected to increase by about 5% to 20%. The frequency of heavy downpours is projected to continue to increase in the coming decades, along with the risk of droughts in the summer and fall seasons (Kunkel et al. 2013). Also, expected increases in temperature will lead to greater evaporation and earlier snowmelt (Kunkel et al. 2013).

Recent data collected from various stations across the country indicates that climate change is no longer a future possibility, but a present reality with clear evidence of changing climatic conditions. In most regions of the country summers are longer and hotter, with extended periods of heat that last longer than most living Americans have ever experienced. As per the national assessment, during the same period winters have generally become shorter and warmer. Data collected over the last few decades indicates that heat waves have also become more intense and widespread. Changes in precipitation have also been observed across the county. Rainfall now comes in heavier downpours, with longer dry spells in between. In addition, communities in traditionally colder regions are experiencing hotter, drier weather and earlier snow melt (Frumhoff et al. 2007).

1 Future climatic variables are projected using a set of coherent, internally consistent and plausible descriptions of a possible future state of the world identified as scenarios. A scenario is not a forecast but rather an alternative image of how the future may unfold. The B1 scenario future is characterized by a high level of environmental and social consciousness combined with a globally coherent approach to more sustainable development. Consequently greenhouse emissions in this scenario are estimated to be the lowest. The A2 scenario represents a differentiated world characterized by lower trade flows, relatively slow capital stock turnover, and slower technological change. Greenhouse emissions in this scenario are expected to be the highest.

Figure 4. Projected Changes in Annual Mean Temperatures under Scenario B1 (Lowest Emissions)



Sources: NCAR GIS Program, 2012 and Hoar and Nychka, 2008.

A. Projected Impacts in Upstate New York

This region is characterized by changing weather patterns including seasonal cycles that result in extremely snowy winters, vibrant springs, pleasant summers, and colorful autumns. These weather changes are interspersed with dramatic year-to-year and day-to-day variability as a result of nor'easters, ice storms, and lake effect snow. While these variations are part of the regional climate, in recent decades there have been noticeable changes in the region's familiar climate. Winter temperatures and the number of hot weather days have been rising, while snow cover has been decreasing. Since 1970, the mean temperatures in the region have increased by 0.6 deg. F per decade, with a significantly higher increase of about 1.1 deg. F in winter temperatures between 1970 and 2000 (Rosenzweig et al. 2011). The same climate change assessment report for New York State documents a number of observed environmental changes that indicate changing climatic conditions:

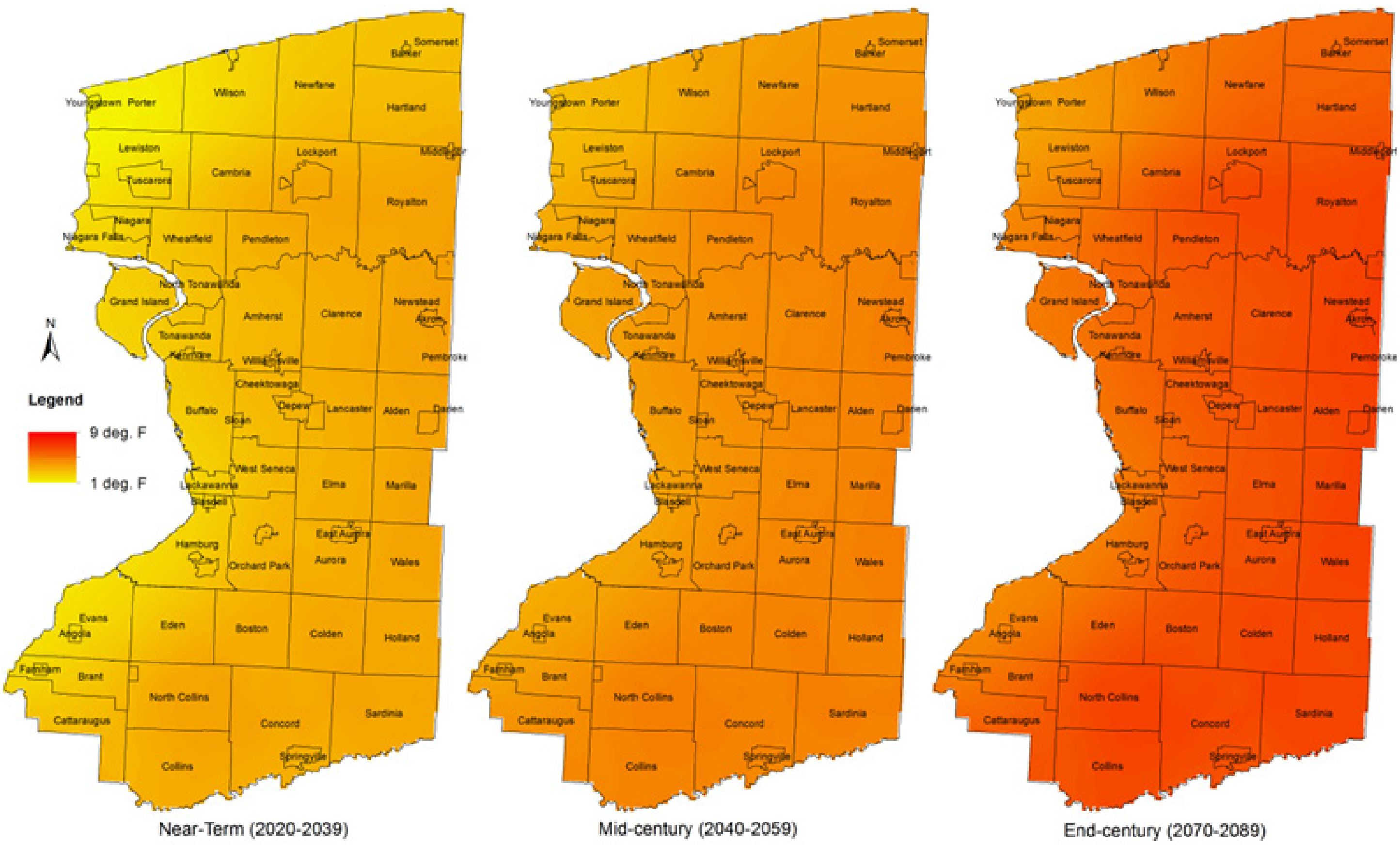
- More days with temperatures above the normal range
- A longer growing season
- Earlier first-leaf and first-bloom dates for plants
- More precipitation as rain and less as snow
- Reduced snowpack and increased snow density
- Earlier breakup of winter ice on lakes and rivers
- Earlier peak spring stream flow due to early spring snowmelt
- Rising lake-surface temperatures

A recent research report commissioned by NYSERDA (Horton et al. 2011) indicates that the Western New York and Great Lakes Plain region[2] is likely to experience a rising mean temperature that will be accompanied by more extreme heat events, precipitation storms, and seasonal droughts, as well as less intense cold events. This report utilizes three scenarios for projected future changes in climate-related drivers for the states (Rosenzweig et al. 2011). In addition to the A2 (lower emissions) and B1 (higher emissions) scenarios used by the U.S. National Assessment, the New York State Assessment also employs the A1B scenario.[3] Based on these scenarios temperatures are expected to rise by 1.5 to 3 deg. F by the 2020s, 3 to 5.5 deg. F by the 2050s, and 4 to 9 deg. F by the 2080s. The lower ends of the range represent the lower emissions scenario, and the higher ends signify the higher emissions scenario. However, it is highlighted that these are by no means the limits of change. Drastic reduction

2 This region consists of 5 counties: Niagara, Erie, Allegany, Cattaraugus, and Chautauqua.

3 The A1B scenario (medium emissions) is characterized by increases in the use of cleaner technologies and decreases in global population after 2050. Greenhouse gas emissions for this scenario are estimated to be between the levels estimated in the B1 and A2 scenarios.

Figure 5. Projected Changes in Annual Mean Temperatures under Scenario A1 (Medium Emissions)



Sources: NCAR GIS Program, 2012 and Hoar and Nychka, 2008.

in greenhouse gas emissions can result in lower changes, and continued increase in greenhouse gas emissions could result in increases beyond the higher ends. Climate change models project that annual precipitation will increase by up to 5 percent by the 2020s, up to 10 percent by the 2050s, and up to 15 percent by the 2080s. Much of this precipitation is expected in winter months, which is expected to increase by 5 to 15 percent by the 2050s.

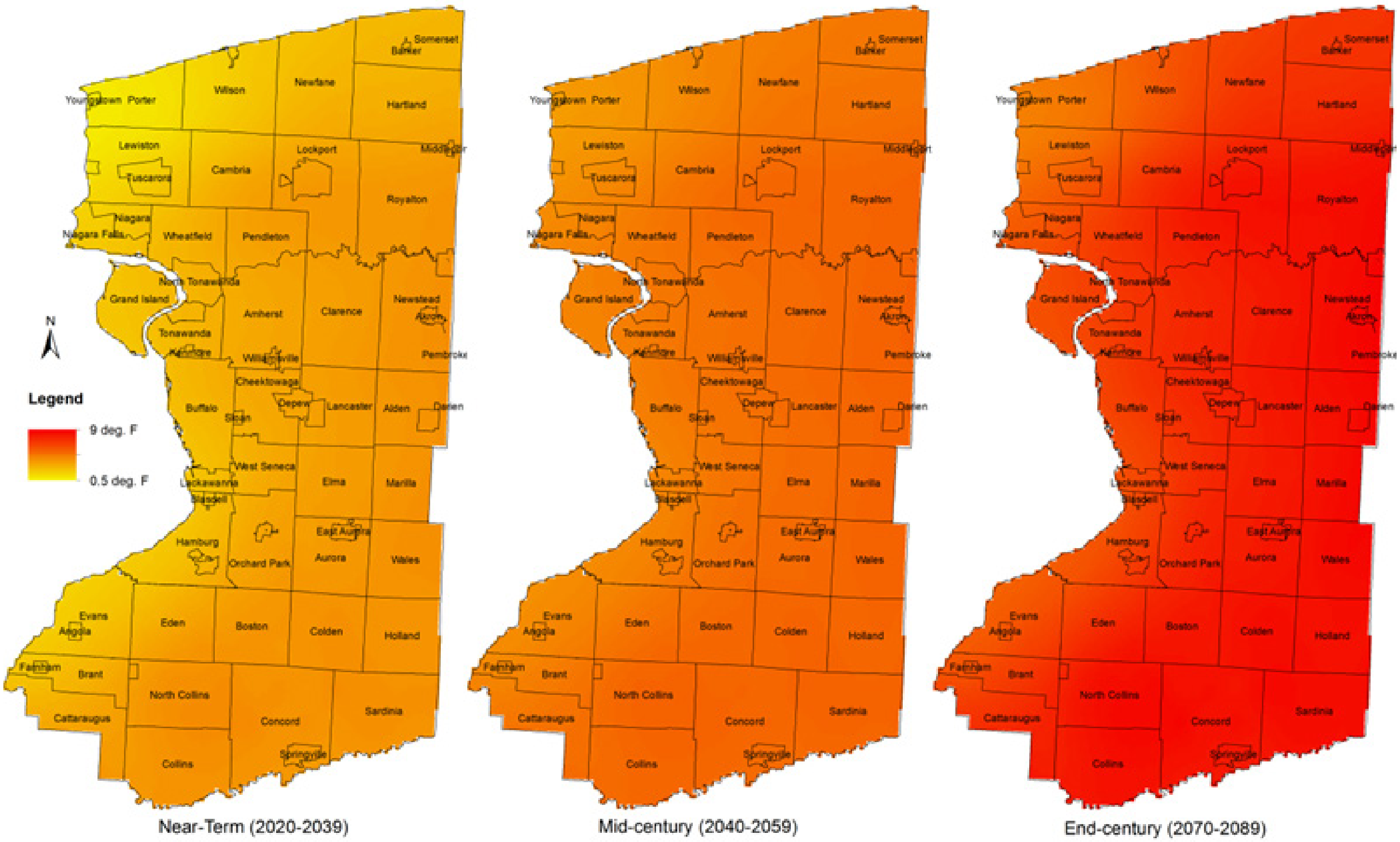
In the Western New York and Great Plains region, gradual changes in temperature, increased summer drought risk and changes in local rainfall patterns represent increasing risks to the local regional economy. Critical infrastructure systems will be exposed to increasing fluctuations in supply and demand that will result in increased stress that may cause critical system wide failure. Of special concern are older systems that are already in need of repair and maintenance. Climatic change will also result in widespread changes in species composition. Fragmentation of the landscape due to unsustainable urban expansion will further inhibit ecosystem adaptation by limiting dispersal and migratory patterns as the local climatic conditions change. Increased summer heat stress will negatively impact cool season crops and livestock. Agricultural production will suffer due to erratic weather patterns, increased weeds and pests, and fluctuations in water availability (e.g., water deficits during the summer and increased rainfall during the winter). Farmers will need to consider irrigation needs for high value crops to avoid increased crop failure. Increased stress on dairy due to higher heat is likely to result in decreased feed intake and milk production. More frequent heat waves will cause increased energy demand, resulting in stressed power supplies as well as peak demand loads. Coupled with decreased efficiency of power plants due to increased air and water temperatures, older infrastructure facilities are likely to face higher risks of failure. Demand for public health services and public health surveillance are also expected to increase as climatic changes become more overt. Vector-borne diseases, air-quality related ailments, and cardiovascular and respiratory related illnesses are expected to increase due to changing climate conditions.

B. Expected Climatic Changes in the Buffalo Niagara Region

The outputs from most of the global climate change prediction models are relatively coarse for applying to regional and local scales. The Community Climate System Model (CCSM) generates outputs at a spatial resolution of approximately 150 x 150 km. While this is useful for its intended purpose, it is more desirable to use greater detailed information at regional and local scales. In this report we use statistical downscaled[4] CCSM outputs developed by Tim Hoar and Doug

4 As such, a number of downscaling procedures have been developed. Downscaling is a generic term used for procedures to use information from large scales to make predictions at smaller, local scales.

Figure 6. Projected Changes in Annual Mean Temperatures under Scenario A2 (Highest Emissions)



Sources: NCAR GIS Program, 2012 and Hoar and Nychka, 2008.

Nychka at the Institute for Mathematics Applied to Geosciences (IMAGe), which is part of the National Center for Atmospheric Research (NCAR) (Hoar and Nychka 2008)[5]. Spatial resolution of downscaled CCSM3 projections of temperature and precipitation for the contiguous USA is 4.5 km. The dataset was downloaded for the selected region of interest and analyzed using ArcGIS software produced by the firm ESRI.

For the purpose of this report, three climate change scenarios[6] used by the New York State Integrated Assessment report were employed. The A2 scenario (highest emissions) is characterized by a very differentiated and heterogeneous world focused on regional oriented per capita economic growth. The A1 (medium emissions) scenario is characterized by rapid economic growth, the introduction of new and efficient technologies, and a global population that peaks in the mid-century but declines thereafter. The B1 scenario (lowest emissions) characterizes a world with a global population similar to the A1 scenario, but with greater reductions in material intensity and the introduction of cleaner and more efficient technologies.

1. Expected Temperature and Precipitation Changes

The CCSM model outputs are available for several temporal aggregations of each scenario. In this report we adopted the outputs for the anomaly deviations[7] for each scenario. The anomalies have been computed for a multi-year average of monthly, annual, and seasonal data with respect to the present day climate (1980-1999). The anomalies computed for the following time periods are presented in this report:

1. Near term climate anomalies show the differences between the climate of 2030 (represented by the climatological means of 2020-2039) and the present day climate.
2. Mid-century climate anomalies show the differences between the climate of 2050 (represented by the climatological means of 2040-2059) and the present day climate.
3. End of the century climate anomalies show the differences between the climate of 2080 (represented by the climatological means of 2070-2089) and the present day climate.

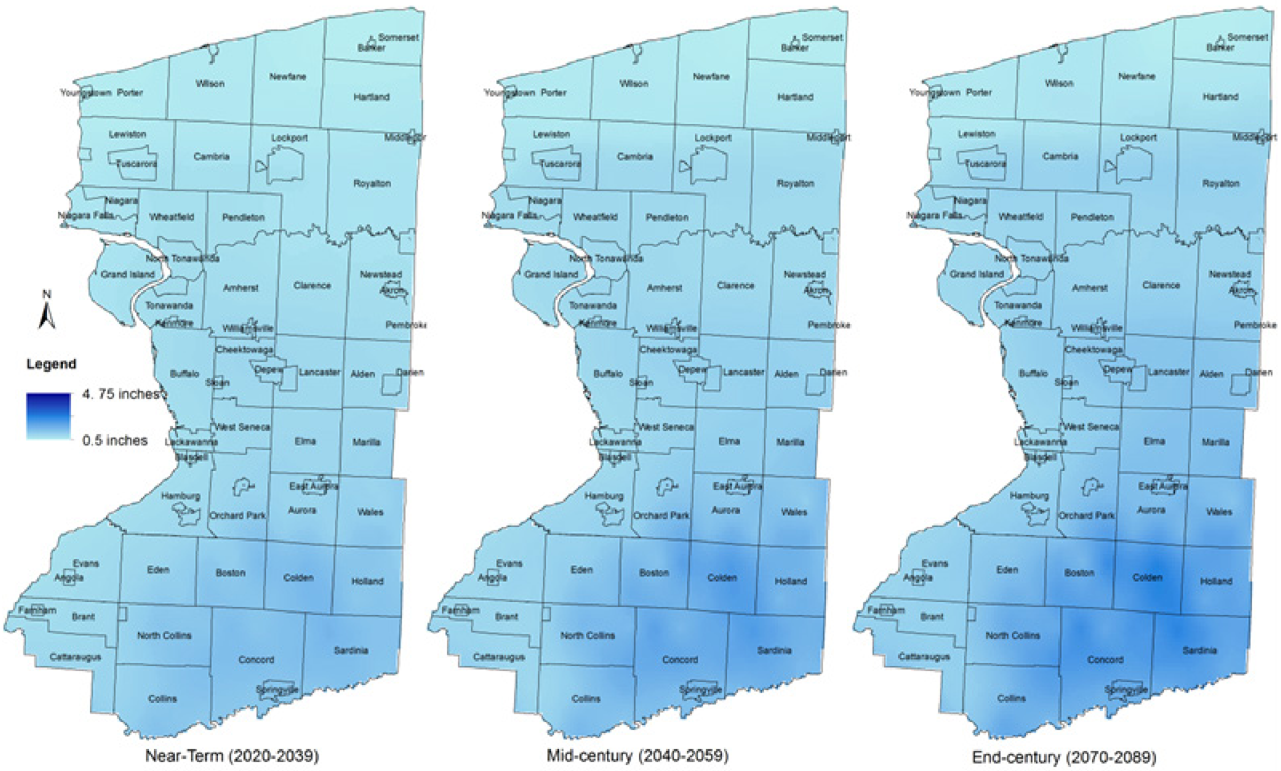
In the B1 scenario the climate change model projects an increase of 1 to 3 deg. F in the near-term, 1.5 to 5 deg. F by mid-century, and 2 to 6 deg. F by the end

5 This procedure involves three steps: 1) determining a simple linear model for every location in the prediction domain, 2) using the PRISM (Parameter-elevation Regressions on Independent Slopes Model) developed by Dr. Christopher Daly at Oregon State University (Daly, Taylor, and Gibson 1997) to provide an initial estimate at every prediction location from the CCSM data, and then 3) applying the linear model to the initial estimate to produce the final downscaled estimate.

6 For a detailed discussion on scenarios refer to Nakicenovic and Swart (2000)

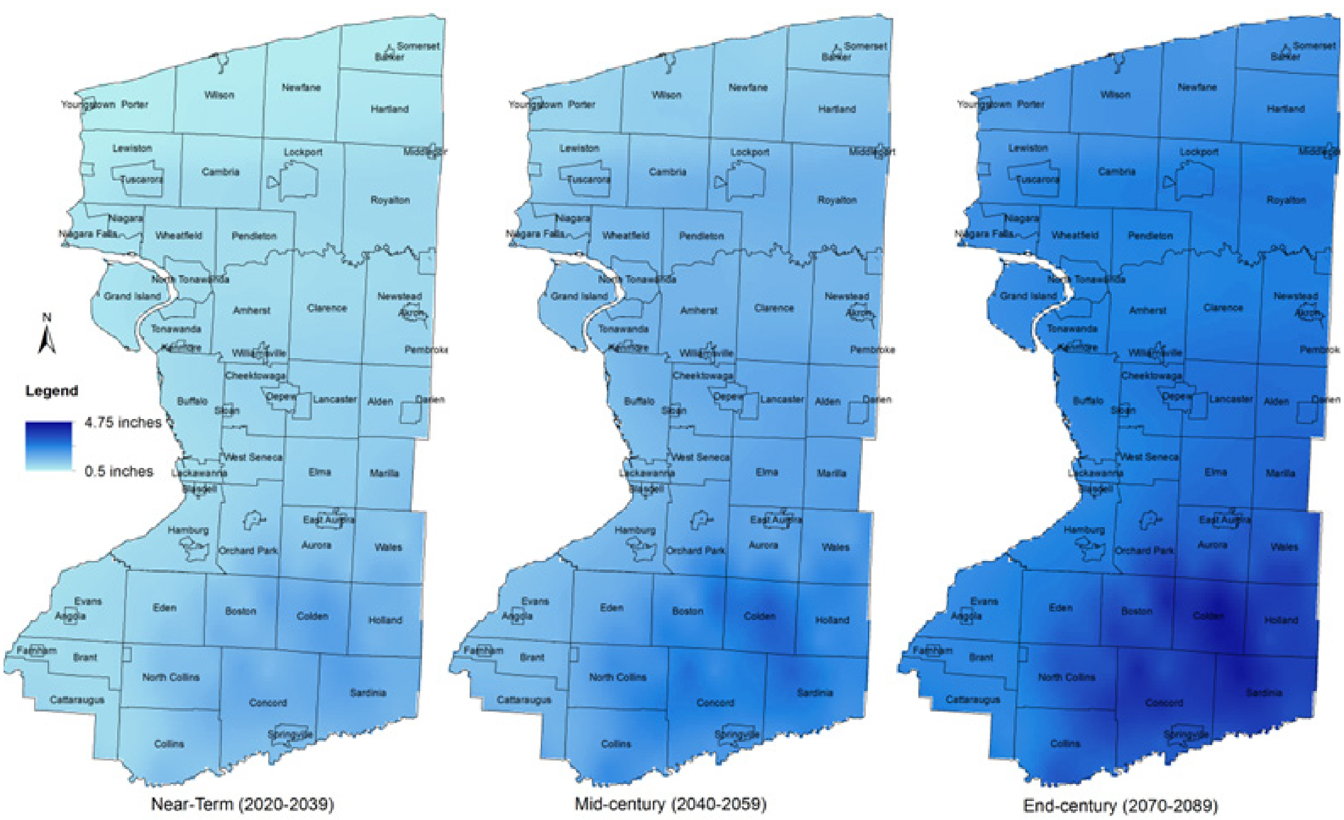
7 In climate science, an anomaly is a deviation of a meteorological variable from the normal (mean) value. Determining this anomaly is best accomplished by taking an average over multiple ensemble members, and then by averaging over multiple years within each ensemble average.

Figure 7. Projected Changes in Annual Mean Precipitation under Scenario B1 (Lowest Emissions)



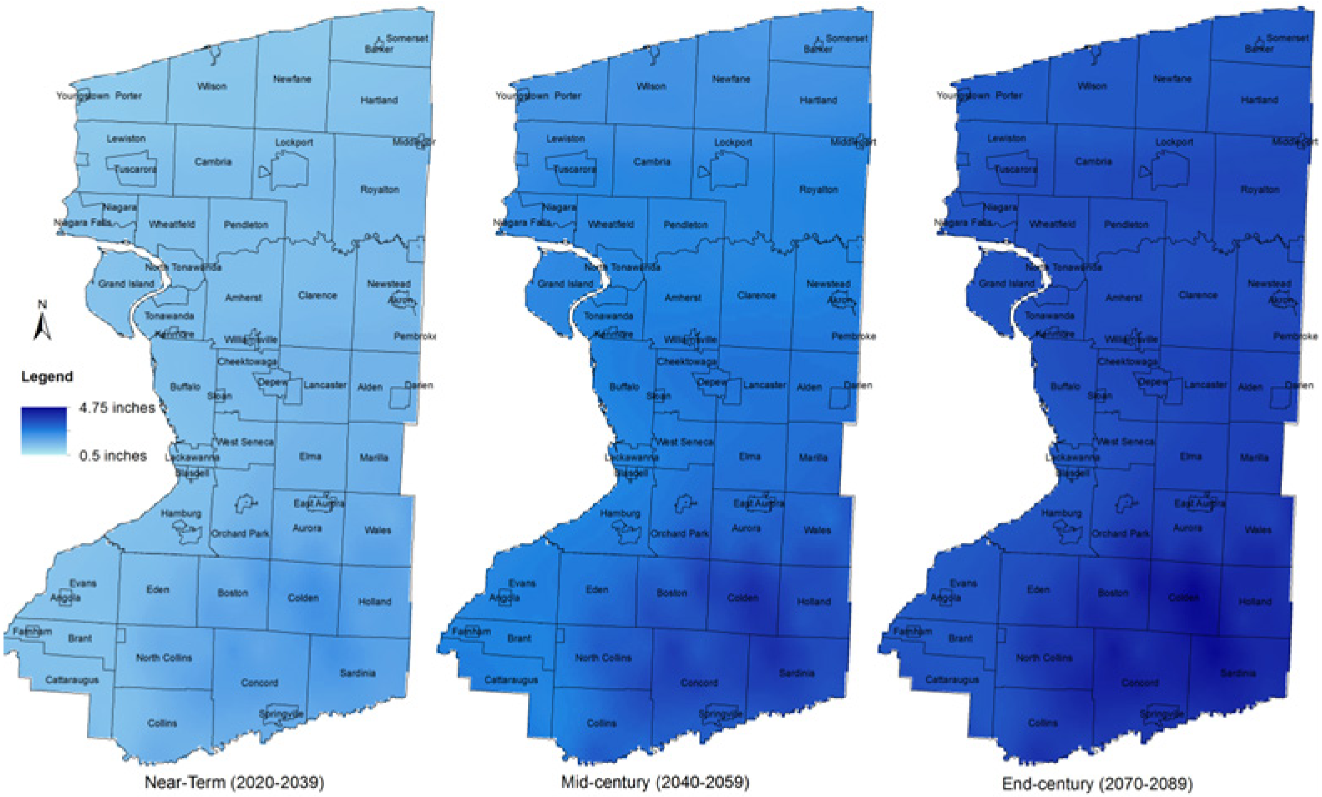
Sources: NCAR GIS Program, 2012 and Hoar and Nychka, 2008.

Figure 8. Projected Changes in Annual Mean Precipitation under Scenario B1 (Lowest Emissions)



Sources: NCAR GIS Program, 2012 and Hoar and Nychka, 2008.

Figure 9. Projected Changes in Annual Mean Precipitation under Scenario A2 (Highest Emissions))



Sources: NCAR GIS Program, 2012 and Hoar and Nychka, 2008.

of the century (see Figure 4). In the A1 scenario the models project an increase of 1 to 3.5 deg. F in the near-term, 2 to 6 deg. F by mid-century, and 2 to 7.5 deg. F by the end of the century. In the A2 scenario the model projects an increase of 1 to 4 deg. F in the near-term, 2 to 6 deg. F by mid-century, and 4 to 9 deg. F by the end of the century. While the exact increase in the temperature will vary across the region, it seems that communities farthest from the lakes in the east and southeast are likely to experience greater warming the most. The lakes will continue to have cooling influences on the communities along their shores. However, in the A2 scenario most communities in the region are likely to face significant warming by mid-century, which will increase further by the end of the century.

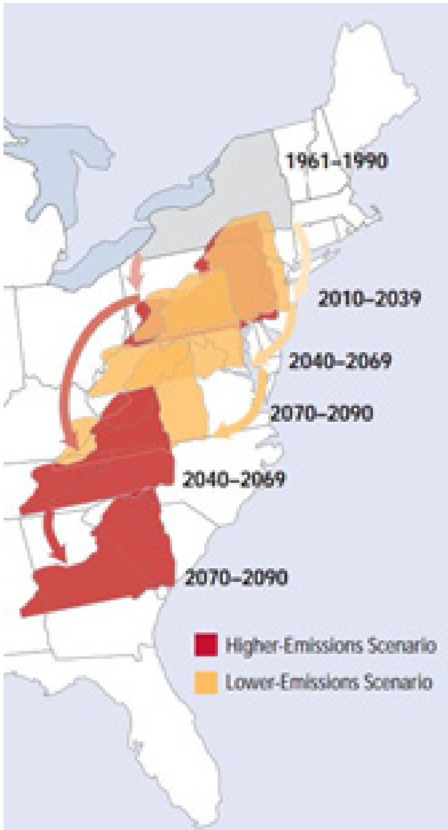
Precipitation patterns are also expected to change across the region by the end of the century. On average these changes are likely to be less drastic but may pose significant risks, as the increased precipitation is likely to be concentrated in the winter months. Also, an important concern with precipitation projections is the higher degree of uncertainty due to the complex interaction between local temperature changes, landscape patterns, and localized weather phenomenon. Therefore, the lower and upper ends of these projections are only to be taken as indicative of trends rather than absolute measures of change. In the B1 scenario the climate model projects increases in average annual precipitation ranging from 0.5 to 1.5 inches in the near-term, 0.5 to 2.5 inches by mid-century, and 0.5 to 3 inches by the end of the century. In the A1 scenario, the model projects changes from 0.5 to 2 inches in the near term, 0.5 to 3 inches by mid-century, and 1.5 to 4 inches by the end of the century. In the A2 scenario, the climate model projects increases in precipitation ranging from 0.5 to 2.0 inches in the near term, 1.5 to 3.5 inches by mid-century, and 2.5 to 4.75 inches by the end of the century. While the projected changes in precipitation from the medium and high emission models are most concerning, the southtowns will likely start to experience increases in precipitation even in the low emission scenario.

Across all scenarios, the southtowns will be the first to experience long term precipitation increases in the Buffalo Niagara region.

2. Heat Index and Extreme Heat

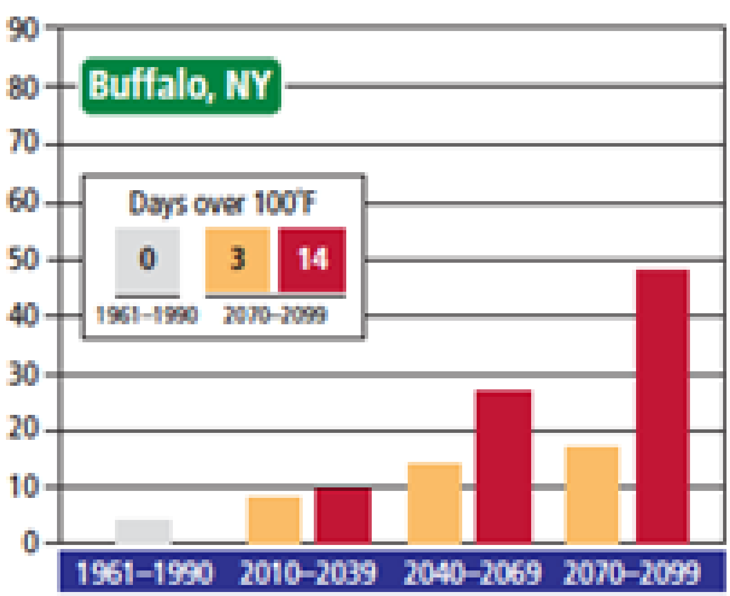
In addition to the increase in annual mean temperatures, the Buffalo Niagara region will also experience significant changes in its heat index. The heat index may be described as the feelings of hot and cold. For example, a sunny winter without wind feels warmer than a damp, windy spring day, while humid summer days can be stifling. For this reason the heat index is often adopted as a better measure of how the weather ‘feels’ rather than the actual temperature. Because the feelings of hot and cold are dependent on a number of local factors including the temperature, wind patterns, and humidity, it is difficult to model the heat index based on temperature and precipitation projections. Therefore the impact of climate change on the heat index is illustrated by comparing future summers in the region with

Figure 10. Expected changes in the Climate of Upstate New York.



Source: Frumhoff et al. 2007

Figure 11. Anticipated Heat Waves in Buffalo based on three climate models



Source: Frumhoff et al. 2007.

current summers in regions with the projected climatic conditions. Based on the existing conditions in Virginia (for the low emissions scenario), and Georgia (for the high emissions scenario), it is likely that the average summer heat index in Western New York will likely range from 72-98 deg. F.

While the changes in temperature and precipitation patterns are important, it is also useful to assess their likely impact on various natural and human activities that influence local communities. One way scientists have been able to envision overall future change is by projecting climate migrations of states and cities (Smith and Tirpak 1989). For this analysis, a city/state's current climate conditions are quantified and classified using historical data. Then scientists use global climate models to predict changes due to quantified levels of greenhouse gas concentrations in the atmosphere. Based on these outputs scientists can identify regions where the existing climate mimics the given city/state's conditions. Therefore, it would appear that the city/state's climate has 'migrated' due to climate change. This way, scientists can predict the most likely conditions to expect in a region/city given the projected changes in the future temperature and precipitation conditions. For example, late century summers in upstate New York are projected to resemble current summers in Georgia under the higher emissions scenario and those of Virginia under the lower emissions scenario.

In the coming decades, increasing humidity will likely make hot days feel hotter. Historically, heat waves with multiple consecutive days over 90oF are not very common in the region. In the past 45 years, the number of such days with the temperature exceeding 90oF in cities across the Northeast has roughly doubled. By the end of the century, heat waves could occur approximately three times each year under higher emissions scenarios. The WNY region, where no city has recorded any day over 100oF thus far, is likely to experience a growing number of such days in a changing climate (see Figure 10). This increase in extreme heat days will require increased allocation of public resources for preparation and improvements to the public health monitoring systems to avoid severe health impacts.

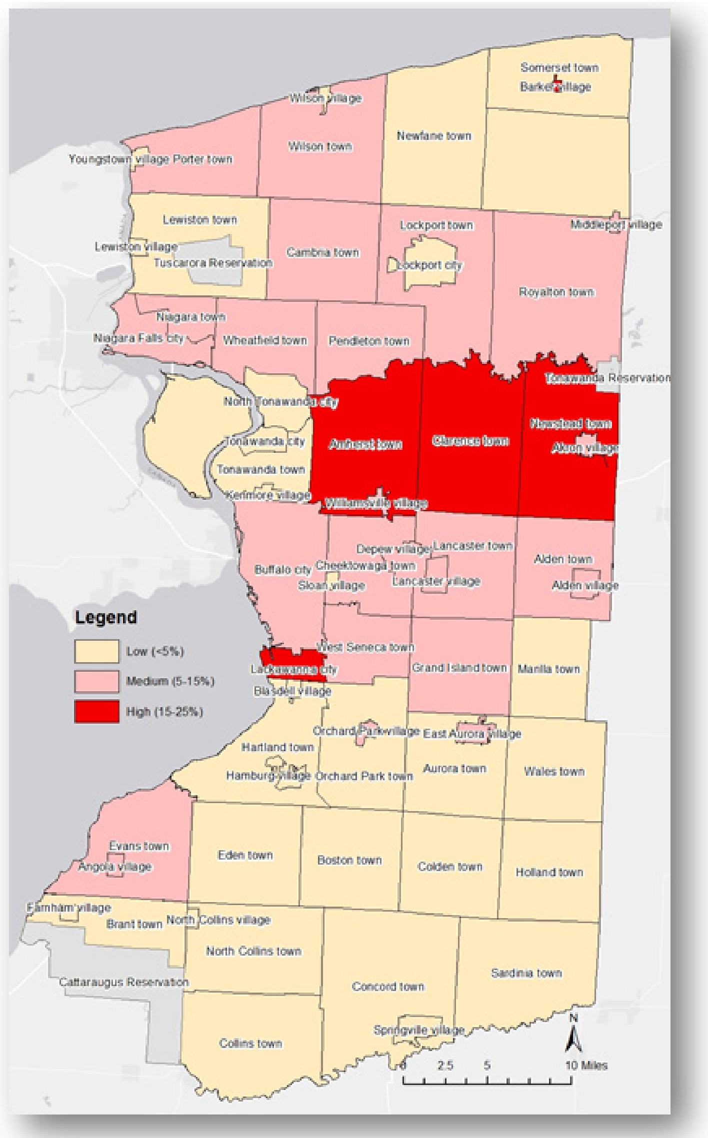
C. Vulnerability to Floods

With expected climatic changes, the amount of rain fall during a "100-year" storm is projected to increase, while the number of years between such storms ("return period") is projected to decrease (Milly et al. 2002). Thus, rainstorms will become both more severe and more frequent. This implies that areas presently delineated at 1% and 0.2% annual flood risk are likely to face more severe and frequent floods in the coming decades.

As per the New York State Standard Multi-Hazard Mitigation Plan (NYDHES 2014), while the Presidential Disaster Declaration in Buffalo Niagara for flood events between 1954 and 2013 has only been twelve (6 each in Erie and Niagara counties), more than 100 floods events have occurred in Erie County between 1960-2012. In Erie County, 4 dams are classified as high-hazard[8] and six are considered of intermediate-hazard[9] out of the total 184 dams in the county. In Niagara County, 3 dams are classified as high-hazard and 1 as intermediate-hazard out of a total of 30 in the county. Data from FEMA's Hazus Average Annualized Loss Viewer[10] ranks Erie County as the county with the second highest annualized losses, at $670,503,000. The 100-year flood event modeled in Hazus by the New York State Standard Multi-Hazard Mitigation Plan (NYDHES 2014) ranks Erie County at the top in the state with the highest building related economic losses at over $1 billion dollars. Multiple factors contribute to this figure, including the greatest number of tons of debris generated, shelters required, and damaged fire stations, police stations, and schools. Erie County also showed the highest estimated losses in the state for combined building-related and business-related loss categories.

Despite the above summarized flooding risks, both counties do not consider flood hazard as a high risk in the region (NYDHES 2014). This is particularly concerning for Erie County since it is likely to face increased risk of flooding. As per the New York State climate change risk assessment, the number of rainfall events exceeding one inch of rain are projected to increase significantly in all climate model future simulations (Rosenzweig et al. 2011). A detailed flooding risk assessment for the region will require watershed level scenario modeling using detailed terrain characteristics to identify specific areas likely to flood under different flooding events. Such detailed studies are expensive and time-consuming, and are beyond the scope of this report. However, existing flooding zones as delineated in the Flood Insurance Rate Maps (FIRMs) can be utilized to assess flooding risks to communities. Figure 12 summarizes the extent of 1% and 0.2% annual chance of flooding based on existing rainfall patterns in each of the municipalities in the Buffalo Niagara region. The Towns of Amherst, Clarence, and Newstead, as well as the City of Lackawanna, have a significant proportion of their jurisdiction in the 100yr floodplain. These communities will have to focus on enacting policies to control development in the identified floodplains within their communities. Table 2 summarizes the total value of residential property that has a 1% and 0.2% risk of annual flooding in each of the communities in the bi-county region. The total value of residential property at risk from a 1% chance of flooding is estimated to be more than $3 billion, while the total value

Figure 12. Estimated Percentage of Area at Risk from 1% Annual Chance of Flooding



Source: Estimated using 2010 FEMA Q3 Digital Floodplain data.

8 A high-hazard dam means a failure may result in serious and widespread damage, with loss of human life.

9 Intermediate hazard means a failure may result in moderate damage but loss of human life is not expected.

10 Viewer is accessible online http://fema.maps.arcgis.com. Uses Hazes-MH 2.1 model.

Table 2. Total Value of Residential Property at Risk from Flooding (Analysis based on GIS overlay of 2010 NYS Office of Real Property System (RPS) parcel center points with 2010 FEMA Q3 Digital Floodplains)

Municipality	Value of Residential Property at Risk from a 1% Annual Chance of Flooding	Value of Residential Property at Risk from a 0.5% Annual Chance of Flooding	Total Value of Residential Property at Risk
Village of Akron	$817,300.00	$2,959,400.00	$3,776,700.00
Village of Alden	$0.00	$883,250.00	$883,250.00
Village of Angola	$0.00	$2,594,140.00	$2,594,140.00
Village of Barker	$532,900.00	$1,462,280.00	$1,995,180.00
Village of Blasdell	$0.00	$752,800.00	$752,800.00
Cattaraugus Reservation	$0.00	$253,500.00	$253,500.00
Village of Depew	$6,157,600.00	$23,918,500.00	$30,076,100.00
Village of East Aurora	$0.00	$12,156,800.00	$12,156,800.00
Village of Farnham	$0.00	$0.00	$0.00
Village of Hamburg	$154,000.00	$4,374,900.00	$4,528,900.00
Village of Kenmore	$0.00	$0.00	$0.00
Village of Lancaster	$2,351,600.00	$9,465,600.00	$11,817,200.00
Village of Lewiston	$0.00	$0.00	$0.00
Village of Middleport	$1,909,015.00	$4,912,600.00	$6,821,615.00
Village of North Collins	$0.00	$0.00	$0.00
Village of Orchard Park	$1,408,544.00	$5,928,176.00	$7,336,720.00
Village of Sloan	$0.00	$0.00	$0.00
Village of Springville	$850,750.00	$3,510,750.00	$4,361,500.00
Tonawanda Reservation	$0.00	$0.00	$0.00
Tuscarora Reservation	$0.00	$0.00	$0.00
Village of Williamsville	$26,873,200.00	$20,476,200.00	$47,349,400.00
Village of Wilson	$0.00	$286,100.00	$286,100.00
Village of Youngstown	$0.00	$0.00	$0.00
Town of Alden	$411,800.00	$40,585,340.00	$40,997,140.00
Town of Amherst	$2,049,637,141.00	$2,108,305,467.00	$4,157,942,608.00
Town of Aurora	$193,900.00	$3,247,300.00	$3,441,200.00
Town of Boston	$1,458,900.00	$4,899,500.00	$6,358,400.00
Town of Brant	$0.00	$825,216.00	$825,216.00
City of Buffalo	$331,841,288.00	$297,028,258.00	$628,869,546.00
Town of Cheektowaga	$118,394,414.00	$64,169,250.00	$182,563,664.00
Town of Clarence	$50,590,912.00	$245,305,900.00	$295,896,812.00
Town of Colden	$211,400.00	$1,526,300.00	$1,737,700.00
Town of Collins	$1,848,400.00	$2,827,400.00	$4,675,800.00
Town of Concord	$134,800.00	$3,045,230.00	$3,180,030.00
Town of Eden	$0.00	$2,778,700.00	$2,778,700.00

of residential property at risk from a 0.2% chance of flooding is estimated to be $3.6 billion. The Towns of Amherst, Clarence, Wheatfield, and Cheektowaga, as well as the City of Buffalo, are the top five communities with the highest total value of residential property at risk from flooding, due to 1% and 0.2% annual chances of flooding. Undoubtedly, these communities will have to implement policies that will minimize their present and future risks from increased flooding.

1. Ice Jam Floods

In addition to the flooding caused directly by overflow of drainage channels due to increased precipitation, a number of communities in the Buffalo Niagara region are also at risk from ice jam flooding (NYDHES 2014). FEMA floodplain maps do not identify the locations of areas at risk from this hazard because the formation of ice jams depends largely on localized weather and the physical characteristics of the channels. While it is difficult to identify particular areas that are generally prone to ice jam flooding because the hazard can be localized, ice jam flooding is most prevalent in locations of flat terrain, with extended periods of below-freezing temperatures. Areas at higher risk also have channel slopes that naturally decrease, in culverts, and have shallows where channels may freeze solid. Ice jam related floods can occur during: 1) fall freeze-up from the formation of frazil ice, 2) midwinter periods when stream channels freeze solid, forming anchor ice, and 3) spring breakup when rising water levels from snowmelt or rainfall break existing ice cover into large floating masses that lodge against bridges or other infrastructure (NYDHES 2014).

Ice jam flooding is more dangerous than open water flooding, as water levels change rapidly, and can cause additional physical damage by the impact of ice on buildings and structures. Flood elevations for ice jam flooding are usually higher than predicted for free-flow conditions. That is, flooding will likely occur beyond the FEMA delineated flood plain boundary even during a 100yr flood. Flooding caused by ice jams is similar to flash flooding. Ice jam formation causes a rapid rise of water at the jam and extends upstream. The failure or release of the jam can also cause sudden flooding downstream.

D. Other Local Risks from Climate Change

While the direct risks of climate change in terms of changes in temperature and precipitation patterns are serious, it is equally (if not more) important to recognize that this net change in annual mean measures coupled with changes in the global climatic system will result in numerous secondary negative impacts on local environments and development sectors. These indirect impacts of climate change are often more severe and can have significant negative effects on the local economy if not addressed adequately in local planning and development policies. Such impacts that are relevant to the region are discussed in the following sub-sections.

1. Surface Runoff and Erosion Rates

Increased precipitation in the region will result in increased surface run-off from developed areas, as well as result in faster saturation of soils. Saturated soils will not be able to absorb the waters from intense events, causing increased surface run-off after intense rainstorms. Increased paved surfaces will exacerbate the impacts, and will result in increased property damage. As dislodged sediments and topsoil become suspended in the runoff water, it will impact soil fertility, quality of stream water, and floodplain ecology in the drainage basin. As runoff waters flow over various surfaces, chemicals, pollutants, sediments, and nutrients will be transported and deposited into regional streams and rivers, which may degrade water quality and enhance algae blooms. Such events will place an increased burden on emergency services, cleanup and rebuilding. Older municipal storm water infrastructure is likely to be overwhelmed during such situations, and will result in increased combined sewer overflows. As future climatic changes happen, communities will have to spend an increased proportion of their budget on the frequent dredging of open drains and upgrade of water-related infrastructure facilities to limit possible damages from increased surface runoff and erosion.

2. Increased Stream Flow

With the expected changes in regional weather patterns, the total stream flow is expected to increase by up to 9% across all emissions scenarios (Kunkel et al. 2013). This average increase in annual stream flow will affect the vast network of streams and channels that deliver a major proportion of fresh water to the Great Lakes. Maximum seasonal runoff is expected to occur in the winter and spring and average runoff will increase by 20 to 60%. The climate models predict that winter and spring will experience an increase in the number of days with high flows, autumn will experience more low-flow days, and summer will experience a varied response depending on local variation in annual rainfall.

Municipality	Value of Residential Property at Risk from a 1% Annual Chance of Flooding	Value of Residential Property at Risk from a 0.5% Annual Chance of Flooding	Total Value of Residential Property at Risk
Town of Grand Island	$0.00	$1,836,195.00	$1,836,195.00
Town of Evans	$2,450,077.00	$51,574,744.00	$54,024,821.00
Town of Hartland	$19,437,500.00	$58,180,100.00	$77,617,600.00
Town of Holland	$399,900.00	$2,890,000.00	$3,289,900.00
City of Lackawanna	$71,883,644.00	$90,659,324.00	$162,542,968.00
Town of Lancaster	$23,532,210.00	$137,518,304.00	$161,050,514.00
Town of Marilla	$441,700.00	$4,054,700.00	$4,496,400.00
Town of Newstead	$286,500.00	$26,077,754.00	$26,364,254.00
Town of North Collins	$0.00	$0.00	$0.00
Town of Orchard Park	$3,377,300.00	$21,075,561.00	$24,452,861.00
Town of Sardinia	$0.00	$12,778,062.00	$12,778,062.00
City of Tonawanda	$36,304,500.00	$5,630,300.00	$41,934,800.00
Town of Tonawanda	$62,541,700.00	$7,318,010.00	$69,859,710.00
Town of Wales	$593,000.00	$2,393,530.00	$2,986,530.00
Town of West Seneca	$8,920,200.00	$53,053,277.00	$61,973,477.00
Town of Cambria	$0.00	$9,780,400.00	$9,780,400.00
Town of Lewiston	$2,400,400.00	$4,494,400.00	$6,894,800.00
City of Lockport	$496,400.00	$8,505,300.00	$9,001,700.00
Town of Lockport	$5,523,900.00	$16,413,000.00	$21,936,900.00
Town of Newfane	$2,508,000.00	$8,429,800.00	$10,937,800.00
Town of Niagara	$23,090,300.00	$15,226,660.00	$38,316,960.00
City of Niagara Falls	$31,092,764.00	$94,617,850.00	$125,710,614.00
City of North Tonawanda	$2,426,300.00	$4,545,300.00	$6,971,600.00
Town of Pendleton	$13,406,700.00	$19,150,700.00	$32,557,400.00
Town of Porter	$3,257,900.00	$10,444,650.00	$13,702,550.00
Town of Royalton	$0.00	$11,273,200.00	$11,273,200.00
Town of Somerset	$296,300.00	$1,448,800.00	$1,745,100.00
Town of Wheatfield	$152,009,435.00	$71,641,275.00	$223,650,710.00
Town of Wilson	$4,956,000.00	$14,538,900.00	$19,494,900.00
Total	**$3,067,410,494.00**	**$3,634,028,953.00**	**$6,701,439,447.00**

3. Drinking Water

There will be significant changes in water demands and supplies for human consumption, agriculture, forests and changing vegetation patterns, in light of higher temperatures and differences in the carbon-dioxide concentrations in the air. The towns and cities in Erie and Niagara counties have been traditionally drawing the majority of their water supplies from the surface-water systems that are readily available in the region.

This is directly related to the capacity of water resources that is available at any point in time. Given the historical stability of fresh water availability in the region, the water supply reservoirs in various communities in the region are less equipped to handle the extended periods that might arise out of below-average annual precipitation. Most of the region's public water systems are currently adequately equipped to deal with the existing needs of the communities in the region, however the older systems are likely to face extreme stress as future demands start to outstrip existing infrastructure capacity.

There is an increasing need for a detailed evaluation of the adequacy of the surface water systems and a thorough analysis of regional dependence on the groundwater system that has experienced higher use in recent years. This increases the importance of the bedrock aquifers in the region, especially in the rural areas. The projected snowpack decline in the winter months will cause a further decline in the subsurface water table, and further stress the drinking water system. Even though the region lies next to one of the largest sources of freshwater in the world, changing environmental conditions are likely to make local communities vulnerable to drought conditions in the future.

4. Waste Water

The wastewater collection systems in the cities of Buffalo, Niagara, Tonawanda, and Lackawanna are subjected to constant overflows since untreated sewage and storm water are released into one unified system. Rainwater runoff flows directly into the system following heavy rains. This additional flow into the systems pushes the capacity of the sewer and the sewage treatment facility beyond the maximum limit, resulting in untreated discharge at the outfall locations. This situation is likely to further worsen with increases in the intensity and timing of storms as a result of climatic changes. Communities with older systems are likely to face the worst impacts, such as localized sewage contamination conditions in addition to an overburdened wastewater system that was already struggling.

Furthermore, even newer communities are likely to face increased system maintenance costs. Communities at higher risk of flooding will experience faster and longer saturation levels of soils that can lead to the settlement of wastewater collection mains. These communities will have to invest in continuous monitoring and maintenance programs for their waste water systems.

5. Agriculture

Based on the annual agricultural receipts generated in the Western New York region, Erie and Niagara counties had cash receipts over $150 million in 2010. Agricultural productivity is highly dependent on complex regional patterns of local environmental conditions and global carbon dioxide concentrations. Warmer temperatures will increase the length of the growing season mainly due to earlier dates for the last spring frost and later dates for the first fall freeze. It has been estimated that across the Northern Hemisphere, growing seasons have advanced by one to 1.5 days per decade during the past 50 years. Also, more carbon dioxide availability in the atmosphere may stimulate the growth rates of plants but nutrients such as nitrogen and soil moisture may become limiting factors. While the changing climatic conditions are likely to contribute to increased productivity in the short term, the overall impacts are projected to be significantly negative in the long term.

Most climate scenarios suggest that farmers in the region are likely to face problems of increased weeds and pest-related damages. Warmer winters and warmer, drier summers could increase growth rates and wintertime survival of known agricultural pests. For example, the gypsy moth, a generalist defoliator, may experience increased survival rates during warmer winters, increasing population sizes.

In some areas, an increase in temperature may make some invasive species more aggressive, causing current invasive species to expand their geographic spread and population size. Furthermore, new invasive species can be opportunistic, thriving where landscapes have been altered or disturbed. Climate change will place stress on many native plants and animals, providing a window within which invasive species may establish themselves across the region.

Without adequate adaptation measures, milk production, a major component of WNY agriculture, is likely to decline by 5 to 20 percent in most emissions scenarios (Rosenzweig et al. 2011). Rainfall events of higher intensity and longer duration are likely to result in lower summertime soil moisture levels. This will affect agricultural production as well as surface runoff generation throughout the year.

6. Shifts in Ecological Landscapes

With changing climatic conditions, many native plants and animals will find local conditions outside of their normal preferred range. As air temperatures rise and local weather conditions change, plants and animals are likely to move northward from their historic ranges. However, it is feared that this rate of change may exceed most species' natural rates of migration, and this may prevent the ability of some animals and plants to migrate. The challenge will be further compounded in the Buffalo Niagara region because of more pronounced habitat fragmentation, and the natural barrier of the Great Lakes. Climate change may therefore cause some species to die off in their current areas. Without active management, some species may not relocate to more tolerant thermal regimes.

Furthermore, this region will experience major shifts in plant hardiness zones, a metric based on the average annual minimum temperature in which a plant species can be cultivated. In 2006 the Arbor Day Foundation changed its U.S. hardiness zone map to reflect changes in climate. A large portion of New York was changed from Zone 5 to the warmer Zone 6. This includes much of WNY, although pockets of Zone 5 are still present. Changing climatic conditions may result in further changes to hardiness zones in the coming decades. These new plant hardiness zones may be unsuitable for regionally important species and might result in species migration. Such conditions are likely to promote the establishment of novel plants that will alter the region's ecology and biology.

Significant shifts in phenology are also likely to occur by the end of this century, specifically in the higher emissions scenario. Phenology refers to the general timing of natural events. The timing of tree budding and butterfly migrations are well known indicators of phenology. Vegetation phenology is highly sensitive to climate change and also controls the feedback of vegetation into the climate system by influencing the seasonality of albedo, surface roughness length, and canopy conductance, as well as fluxes in water, energy, CO2 and biogenic volatile organic compounds. As the rhythms of nature respond to the changing climate, there will be unforeseen consequences to existing trophic structures. For example, if the timings of insect emergence and migratory bird patterns no longer overlap, the region could experience an increase in pests due to the absence of top-down predator control on insect populations. Many of these changes will be unanticipated until it is too late. Therefore agricultural management systems will have to be prepared for the unforeseen consequences of changing climatic conditions.

7. Reduced Air Quality

Climate change models indicate that summer weather patterns could arrive earlier and last longer in this region. These periods of more intense and extended heat, coupled with more electricity generation for air conditioning will most likely result in an increase in ground level ozone by 10 to 25%. Several research studies (e.g., Jacob and Winner 2009, Carvalho et al. 2014) indicate that the temperature increases and other predicted changes in the local climatic conditions are likely to:

- Accelerate ozone forming chemical reactions in the lower atmosphere
- Increase the frequency and duration of air stagnation, which will enhance pollution accumulation
- Increase emissions of volatile organic compounds

The EPA's eight-hour ozone standard is projected to exceed by more than 50 percent in the lower-emission scenario, and by 300 percent under the higher-emission scenario by the end of the century (Rosenzweig et al. 2011). While local air quality is determined by a number of factors such as local meteorological conditions, local transportation and industrial emissions, and wind patterns blowing in or blowing away pollutants, there will be a significant deterioration in regional air quality, resulting in increased incidences of respiratory illness and disease.

8. Winter Storms and Ice Storms

This region's proximity to the Great Lakes makes it vulnerable to the snowstorms arising from the lake effect phenomenon. Increased severity of this particular hazard will be high due to climate change effects (Kunkel et al. 2013, Kunkel, Westcott, and Kristovich 2002). As per the NYS Multi-Hazard Mitigation Plan, between 1995 and 2001 winter storms have been particularly severe in Erie County with the impacts of lake effect storms resulting in blizzards, ice storms and synoptic winter storms which have brought high winds and cold temperatures to the region, making this a critical issue (NYDHES 2014). While there is no scientific data available to analyze the exact effect of changing climatic conditions on lake effect snowstorms, it is quite likely that the communities may experience increasingly erratic extreme events due to the lake effect in the coming decades.

9. Effect on Great Lakes

It is difficult to accurately predict the impact that climate change will have on lake levels because water level is a complex balance between riverine input and output, precipitation and evaporation, wind, humidity, and extraction rates. All of these variables will respond to climate change; lake level is the integrated consequence of these variables interacting with and counteracting against each other. Some models have predicted large drops in lake levels (up to 1.4 m) due to increased evaporation rates as temperatures rise, while others have displayed slight increases in lake levels (up to 0.35 m) because of increased precipitation patterns (Kling et al. 2003). Under a low emissions future, lake levels could change within a range from -0.87 to +0.31 m and under a high emissions future, changes in lake levels could range from -1.81 to +0.88 m by the year 2100 (Mortsch and Quinn 1996). It is very likely that lake levels will be in flux for centuries to millennia as the many facets of climate change and human responses play out.

If the water levels do decrease as projected, it will have unprecedented impacts on the regional economy. The total amount of water available to generate power through hydroelectric dams for the region will be reduced. Lower lake water levels will also reduce existing wetlands, and at the same time, new habitats that were formerly submerged may open up as water levels drop. An important factor of the changing water levels in the Great Lakes will be the reduced availability of fresh water for future population growth and economic activities. The Great Lakes serve as important natural reservoirs of freshwater for the region. It is anticipated that water demand will be 20 to 50% higher in the future as population and economic requirements grow (Hartmann 1990). If water levels decline as a result of climate change, the total volume of freshwater available will decline as well which could impact existing water infrastructure for municipalities.

A more drastic but plausible scenario is increased political conflicts in the region due to a general decline in the availability of freshwater resources across North America. Given that a number of communities across the country are starting to face extended periods of drought, and have to import water from other watersheds, it is likely that the freshwater in the Great Lakes may become a contentious geopolitical issue. While we are still far away from such a situation, increasing impacts of climate change can certainly lead to such an event.

10. Water Chemistry

There is a lack of sufficient scientific knowledge on the potential consequences of the enhanced diffusion of carbon dioxide into the Great Lakes. Ocean acidification, or drops in pH levels, is observed when carbon dioxide reacts with naturally occurring carbonate and bicarbonate ions in water. However, the chemistry of the Great Lakes is very different from that of the open ocean, making it harder to assess and predict changes in water chemistry due to climate change (Fritz et al. 1991). Further, the Great Lakes integrate more variables than the open ocean, such as nutrient loading from agriculture and urban runoff, adding spatial and temporal complexity to predicting changes in water chemistry.

Based on the unique geological location and basin characteristics of the catchment areas it is clear that the changes in water chemistry of the Great Lakes will not follow trends in either the open ocean or in smaller lakes and streams. However, it is expected that deposition of acidic nitrogen and sulfur from the atmosphere or through agricultural and urban runoff is likely to increase acidification by 10 to 50% or more, over acidification rates expected from fossil fuel emissions alone (Magnuson et al. 1997, Williamson et al. 2009). Given the uncertainties associated with predicting water chemistry in the lakes, there is an increasing need to study and improve our understanding of the Great Lakes' biogeochemical cycles in order to predict how increased fossil fuel emissions may affect their water chemistry. However, based on existing scientific understanding it is very likely that the future lake conditions will be very different from the present and will worsen as the rate of global climate change increases over the next century.

11. Recreation and Tourism

Recreation and tourism activities in Upstate New York are predominantly outdoor-oriented. Anglers on the lakes and smaller inland lakes in the region are likely to be impacted by range shifts, loss of habitats, and changes in their preferred catch (Rosenzweig et al. 2011). Specifically in Lake Erie, the duration of summer stratification is likely to increase, adding to the risk of oxygen depletion and formation of deep-water dead zones for fish and other organisms. Lower water levels in the lake coupled with warmer water temperatures are also likely to accelerate the accumulation of mercury and other contaminants in the aquatic food chain.

Winter tourism activities in region are likely to be negatively impacted by early snowmelt and shorter winter seasons. All climate change scenarios consistently projected a trend toward shorter snowmobile seasons throughout the region with most models predicting a loss of more than 50% of the snowmobiling season under the lower to medium emission scenarios (Scott, Dawson, and Jones 2008). At the same time it is also likely that the summer recreation season will expand as temperatures warm up, but extreme heat, heavy rains, and possible increases in disease vectors may impact outdoor recreation and tourism activities.

12. In-migration from the Coasts and Mid-West

While the changes in temperature and precipitation will have lasting impacts on the region, other pressures related to human activities can further exacerbate negative consequences for communities in this region. These factors include continued population decline in major cities along the Great Lakes, decreased incomes, increased cost of living, and exacerbated racial segregation. This is especially true for older cities. Ecological resilience of local ecosystems is being further compromised with unchecked urban sprawl and vacation home building that is altering the countryside. Aging infrastructure and persistent poverty in some of the oldest cities, shoreline erosion, air and water pollution, and changing economics in traditional primary industries such as fishing, farming, and timber harvesting, will potentially worsen the effects of climate change and undermine local capacity to adapt to changing climatic conditions in the region.

At the same time, other communities across the nation and the world will also be facing similar challenges due to anticipated changes in climatic systems. These impacts elsewhere are also likely to significantly impact communities in WNY. A number of studies have identified the Great Lakes region as one of the most desirable areas for climate induced migration. For example, New York contributes to a significant number of new immigrants to coastal communities in Florida. When these communities are threatened by the increasing frequency of hurricanes and sea level rises, these immigrants are likely to return back to the safer regions of their home state. The cumulative impact of fresh water availability, low cost of living, and milder winters is likely to pull a number of these migrants to the region. Increasing immigration to this region from the coastal regions along the east coast can also be expected for the same reasons. Given this scenario, communities in this region will likely face unprecedented pressures for growth and development over the coming decades. Proactive planning can help guide this new growth and development in a manner that will promote environmental sustainability and ensure a higher quality of life in this region.

Chapter References

Carvalho, Anabela, Helena Martins, Myriam Lopes, and Ana Isabel Miranda. 2014. "Climate Change and Air Quality." Global Environmental Change:435-445.

Daly, Christopher, GH Taylor, and WP Gibson. 1997. "The PRISM approach to mapping precipitation and temperature." Proceedings, 10th Conference on Applied Climatology, American Meteorology Society.

Fritz, SC, Stephen Juggins, RW Battarbee, and DR Engstrom. 1991. "Reconstruction of past changes in salinity and climate using a diatom-based transfer function." Nature 352 (6337):706-708.

Frumhoff, Peter C, James J McCarthy, Jerry M Melillo, Susanne C Moser, and Donald J Wuebbles. 2007. "Confronting climate change in the US Northeast." Union of Concerned Scientists. Cambridge, MA.

Hartmann, Holly C. 1990. "Climate change impacts on Laurentian Great Lakes levels." Climatic Change 17 (1):49-67.

Hoar, T, and D Nychka. 2008. "Statistical downscaling of the Community Climate System Model (CCSM) monthly temperature and precipitation projections." White Paper. Boulder.

Horton, Radley, Daniel Bader, Lee Tryhorn, Art DeGaetano, and Cynthia Rosenzweig. 2011. "Climate Risks." In Responding to Climate Change in New York State: The ClimAID Integrated Assessment for Effective Climate Change Adaptation in New York State, edited by C. Rosenzweig, W. Solecki, A. DeGaetano, M. O'Grady, S. Hassol and P. Grabhorn, 2-649. Albany, New York: New York State Energy Research and Development Authority (NYSERDA).

IPCC. 2014. "Summary for Policymakers." In Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, edited by C. B. Field, V. R. Barros, D. J. Dokken, K. J. Mach, M. D. Mastrandrea, T. E. Bilir, M. Chatterjee, K. L. Ebi, Y. O. Estrada, R. C. Genova, B. Girma, E. S. Kissel, A. N. Levy, S. MacCracken, P. R. Mastrandrea and L. L. White, 1-32. Cambridge, United Kingdom, and New York, NY, USA: Cambridge University Press.

Jacob, Daniel J, and Darrell A Winner. 2009. "Effect of climate change on air quality." Atmospheric Environment 43 (1):51-63.

Kling, G, Katharine Hayhoe, L Johnson, J Magnuson, Stephen Polasky, S Robinson, B Shuter, M Wander, D Wuebbles, and D Zak. 2003. "Confronting climate change in the Great Lakes region." Union of Concerned Scientists, Ecological Society of America.

Kunkel, KE, LE Stevens, SE Stevens, L Sun, E Janssen, D Weubbles, CE Konrad, CM Fuhrmann, BD Keim, and MC Kruk. 2013. "Regional climate trends and scenarios for the US National Climate Assessment. Part 2: Climate of the southeast United States." NOAA Technical Report, NESDIS:142-2.

Kunkel, Kenneth E, Nancy E Westcott, and David AR Kristovich. 2002. "Assessment of potential effects of climate change on heavy lake-effect snowstorms near Lake Erie." Journal of Great Lakes Research 28 (4):521-536.

Magnuson, JJ, KE Webster, RA Assel, CJ Bowser, PJ Dillon, JG Eaton, HE Evans, EJ Fee, RI Hall, and LR Mortsch. 1997. "Potential effects of climate changes on aquatic systems: Laurentian Great Lakes and Precambrian Shield Region." Hydrological processes 11 (8):825-871.

Milly, PCD, RTi Wetherald, KA Dunne, and TL Delworth. 2002. "Increasing risk of great floods in a changing climate." Nature 415 (6871):514-517.

Mortsch, Linda D, and Frank H Quinn. 1996. "Climate change scenarios for Great Lakes Basin ecosystem studies." Limnology and oceanography 41:903-911.

Nakicenovic, Nebojsa, and Robert Swart. 2000. "Special report on emissions scenarios." Special Report on Emissions Scenarios, Edited by Nebojsa Nakicenovic and Robert Swart, pp. 612. ISBN 0521804930. Cambridge, UK: Cambridge University Press, July 2000. 1.

NYDHES. 2014. 2014 State Hazard Mitigation Plan. Albany, New York: New York State Division of Homeland Security and Emergency Services.

Rosenzweig, C., W. Solecki, A. DeGaetano, M. O'Grady, S. Hassol, and P. Grabhorn, eds. 2011. Responding to Climate Change in New York State: The ClimAID Integrated Assessment for Effective Climate Change Adaptation in New York State. Vol. 1244. Albany, New York: New York State Energy Research and Development Authority (NYSERDA).

Scott, Daniel, Jackie Dawson, and Brenda Jones. 2008. "Climate change vulnerability of the US Northeast winter recreation–tourism sector." Mitigation and Adaptation Strategies for Global Change 13 (5-6):577-596.

USGCRP. 2014. National Climate Assesment. Washington, DC: U.S. Global Change Research Program.

Williamson, Craig E, Jasmine E Saros, Warwick F Vincent, and John P Smol. 2009. "Lakes and reservoirs as sentinels, integrators, and regulators of climate change." Limnology and Oceanography 54 (6):2273.

4.

SOCIAL VULNERABILITY ASSESSMENT

Consequences of global climate change are expected to vary by geographic location, degree of association with climate-sensitive environments, and unique socio-economic characteristics of human populations and particular communities. This section focuses on understanding the socio-economic characteristics of the communities in the bi-county region that influence their capacity to prepare for, respond to, and recover from climate-related effects. These socio-economic characteristics, often collectively designated as the social vulnerability of a place (Cutter et al. 2008), are commonly used in the field of disaster research[1] as an overarching lens to analyze the disproportionate impacts of extreme natural events on certain groups.

Emphasis on this aspect of vulnerability is important because it highlights the need for communities to adapt proactively despite the uncertainty of the extent and intensity of future climatic changes. Scholars who are skeptical about the significance of future climatic changes argue that proactive actions are not critical because adaptation can occur as and when it becomes necessary. For example, Beckerman (1995) argues that precautionary action is not critical as "we would all have plenty of time to change into lighter shirts" (p100) and that "future generations will not have to go to all of the trouble of moving to the sunbelt" (p91). This line of reasoning focuses only on those sections of population who have resources to migrate or lighter shirts to change into, and ignores a significant proportion of the population that faces disruptions of their livelihoods, quality of life and living conditions as result of their insecure socio-economic conditions that will be exacerbated through future climatic changes.

The utility of a social vulnerability based approach has been validated through a number of studies[2] that discuss the critical role of pre-existing socio-economic conditions on the disproportionate impacts of natural disasters (Flanagan et al. 2011, Phillips et al. 2010). Consequently, social dimensions of vulnerability are now considered an important part of an effective climate change response strategy. For example, the climate change response strategy for New York State also emphasizes the need for focusing on such vulnerable groups as they will require increased assistance to successfully adapt to changing climatic conditions (Rosenzweig et al. 2011).

This aspect of vulnerability to climate change is based on measures of relative poverty, deprivation, education, health, access to resources, and other individual and household level characteristics that undermine an individual's ability to withstand changes in economic and environmental conditions. It is of relevance to understand that these measures of socio-economic vulnerability are not absolute but relative indicators. There is no specific measurement level below which an individual may be considered highly vulnerable. However, individuals with relatively lower income, education, and other similar characteristics (refer to Table 4.1 for a detailed list of variables employed in this analysis) in comparison to others in the community are likely to be more vulnerable. Therefore,

1 The natural hazards literature defines social vulnerability in several ways. Wisner et al. (2004, 11) defines vulnerability broadly in relation to natural hazards as "the characteristics of a person or group and their situation that influence their capacity to anticipate, cope with, resist and recover from the impact of a natural hazard (an extreme natural event or process)." Cutter and Finch (2008) define social vulnerability as a measure of both the sensitivity of a population to natural hazards and its ability to respond to and recover from the impacts of hazards. The United Nations Development Programme (2000) defined it as "...the degree to which societies or socioeconomic groups are affected by stresses and hazards, whether brought about by external forces or intrinsic factors—internal and external—that negatively impact the social cohesion of a country" (Gall 2007).

2 Hundreds of such studies exist on disaster experiences in the US that were produced just in the last two decades.

by investing in the development of human and social capital, communities can enhance their ability to respond to climate change impacts through effective coping strategies and responses, whereas a lack of such capital can leave individuals isolated and at greater risk of exposure to anticipated climate change impacts such as extreme heat waves and floods.

In this discussion on social vulnerability it is pertinent to highlight the dominant role of race. The research literature on social vulnerability identifies race as a consistent and important factor in influencing risk and disaster impact outcomes (Morrow 1999, Williams, Neighbors, and Jackson 2003, Cutter 2006, Bolin 2007). African Americans, who make up 13 percent of the U.S. population, on average are responsible for nearly 20 percent less emissions of greenhouse gases than are non-Hispanic Whites per capita (Hoerner and Robinson 2008). Yet, like other marginalized populations who are less responsible for the causes of climate change, African Americans are more vulnerable to its effects on health, housing, economic well-being, and culture in their own communities. They are also more vulnerable to higher energy bills, unemployment, and recessions caused by global energy price shocks (Brody et al. 2008). Among all racial groups, African Americans (almost 12% of the population of this region) are most likely to be disproportionately affected by climate change based on the following factors identified in earlier research (Hoerner and Robinson 2008):

- Public health: Climate change will increase heat waves and the potential for increased heat-related deaths. Currently, the incidence of African American heat-related deaths is 150 to 200 percent higher than those of non-Hispanic Whites. Climate change will also increase air pollution and the potential for increased respiratory health problems, including asthma. African Americans have a 36 percent higher rate of incidents of asthma than Whites, indicating increased risk from future climatic changes.
- Energy: Climate change will increase energy rates and fluctuations in oil prices. Currently, African Americans spend 30 percent more of their income on energy compared to Whites and thus are more vulnerable to these price shifts
- Food security: Climate change will cause an increase in food costs and a decrease in food availability. The potential impacts of climate change include more frequent and intense extreme weather events, which could damage crops and affect crop yields. Climate mitigation strategies, such as biofuel crops, could also affect crop yields. Currently, African Americans are among the most undernourished racial groups, and they spend a larger proportion of their household income on food procurement. Anticipated climatic changes will only exacerbate their situation.
- Economy and jobs: Climate change will increase health problems and the associated need for health insurance. Currently, 20 percent of African Americans lack health insurance, about twice the rate of Whites. Climate change will affect jobs and income, which for an African American household averages 57 percent less than the average income of Whites.

Table 3. Selected Indicators of Social Vulnerability

	Variable	Effect on Social Vulnerability
1	High percentage of the population over 65 years	Increase
2	High median dollar value of owner-occupied housing	Decrease
3	High percentage of the population that is African American	Increase
4	High percentage of the civilian labor force that is unemployed	Increase
5	High percentage of the population living in poverty	Increase
6	High percentage of the population that is 25 years or older with no high school diploma	Increase
7	High percentage of female-headed households, no spouse present	Increase
8	High percentage of households receiving social security income	Increase
9	High percentage of population employed in primary extractive industries (e.g., agriculture, forestry, mining, and fishing and hunting)	Increase

Sources: Cannon 1994, Morrow 1999, Smith 2013, Fothergill and Peek 2004

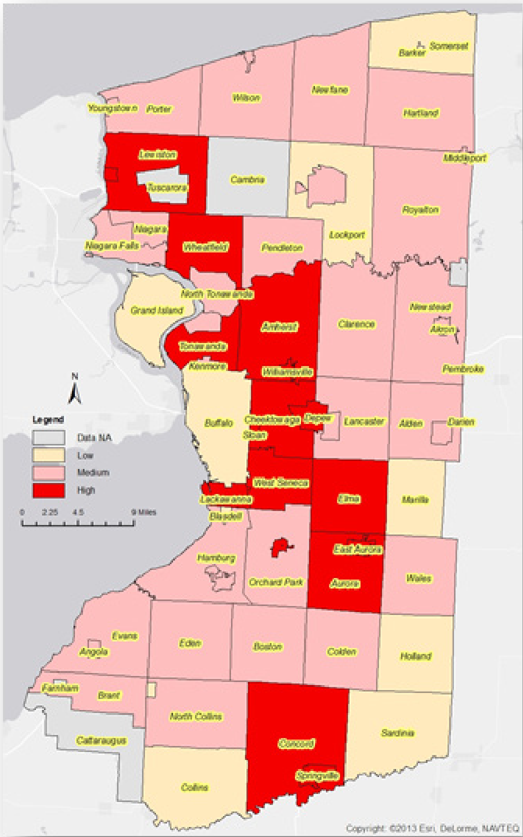
A. Methodology Adopted for this Study

The use of Geographic Information Systems (GIS) software for mapping and community data analysis allows us to identify municipalities within the Buffalo Niagara region that have a higher proportion of vulnerable populations, and therefore need more resources to build their local capacities for climate change adaptation. The focus here is to provide guidance for the investment of resources and efforts based on the relative vulnerability of each municipality within this region. These vulnerable communities have a greater proportion of people whose socio-economic conditions and limited access to resources place them at disproportionately higher risk from the expected prolonged and severe impacts of climatic changes.

Hazards research literature identifies a number of indicators for measuring and understanding vulnerability, including levels of income, unemployment, pension contributions, child illiteracy, livelihood resilience, self-protection, societal protection, social capital, class or income group, gender, ethnicity, type of state, and civil society (Cannon 1994, Morrow 1999, Smith 2013, Fothergill and Peek 2004). For the purpose of this study, nine indicators from the hazards research literature were selected, based on the relevance and availability of data. These indicators, along with their expected effect on social vulnerability, are listed in Table 3

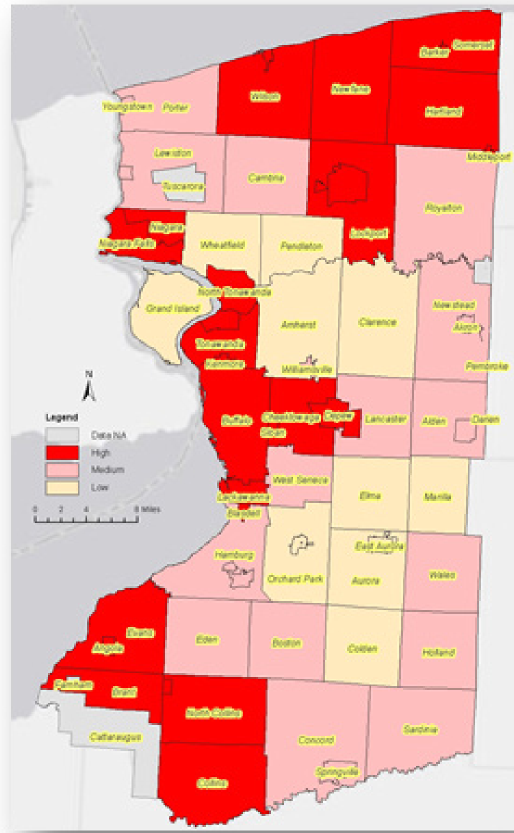
Each of the variables included in this analysis influence social vulnerability in different ways. In general, higher socioeconomic status variables decrease social vulnerability (Cutter, Boruff, and Shirley 2003). The opposite holds true for variables indicative of poverty and lower socioeconomic status, including the percentages of the population living in poverty, with low education or that is unemployed. These variables tend to increase the social vulnerability of a

Figure 14. Social Vulnerability Indicator – Population Above 65 yrs.



Source: US Census Bureau, ACS, 5-Year Estimates (2007-2011), 2012.

Figure 13. Social Vulnerability Indicator - Median Home Values



Source: US Census Bureau, ACS, 5-Year Estimates (2007-2011), 2012.

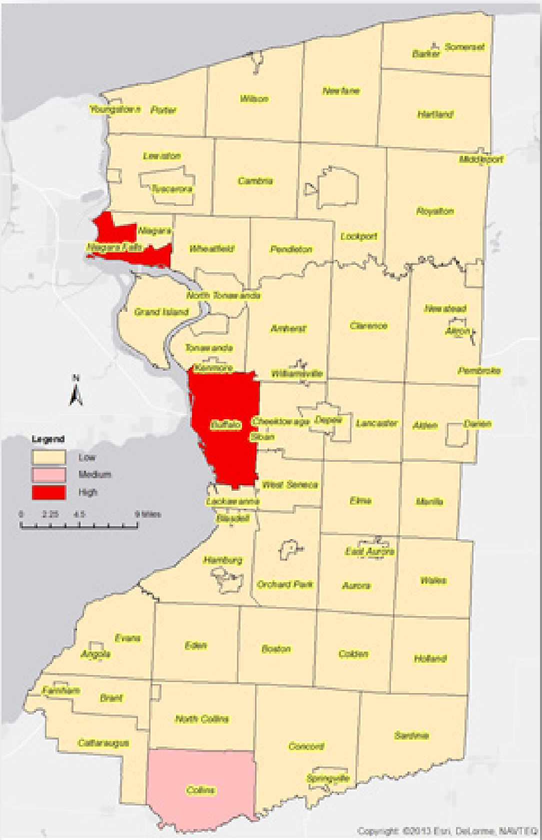
community. Households receiving social security income also increase social vulnerability because these households may have lower incomes overall, as well as represent a greater dependence on social infrastructure. This suggests that these groups will require greater support for adapting to the challenges of climate change (Simpson and Human 2008). Demographic and family structure variables, such as gender, race and family structure, also shape social vulnerability in different ways (Andrew, Mitnitski, and Rockwood 2008, Peek 2008). Greater populations of elderly individuals increase social vulnerability because these people are more dependent on others and are more likely to be the most impacted by extreme events such as heat waves. Research finds that the effect of race and gender on social vulnerability operates through complex socioeconomic linkages. Cutter and colleagues (2003) note that non-White populations experience language and cultural barriers to communicating about disasters and accessing recovery resources. Larger families and single parent households also increase social vulnerability because they have added demands in terms of work and family responsibilities, and may have fewer resources with which to support them. Finally, industry specific occupations also influence social vulnerability because some industries are associated with lower pay and education, which have their own independent effects on social vulnerability. Moreover, extractive industries that utilize natural resources are likely to be impacted the most by climatic changes and will likely take longer to recover in the case of an extreme weather event.

Data for the selected indicators of social vulnerability was collected from the 2007-2011 (5-Year Estimates) of the American Community Survey (ACS). The ACS data was used because the 2010 decennial U.S. Census no longer provides data on most of these commonly used variables that are necessary for a comprehensive social vulnerability analysis. Additionally, the 5-year estimates of the ACS are the most representative samples, as they draw from the greatest amount of data compared to the 1-Year and 3-Year ACS estimates. This raw data for the county subdivisions, as well as the places and remainders of those subdivisions for Erie and Niagara counties, was downloaded from the website Social Explorer. This approach included the cities, towns and villages in each county. We cross-referenced this dataset with local government websites to ensure that all communities within Erie and Niagara Counties were included in our dataset.

B. Spatial Distribution of Social Vulnerability Indicators

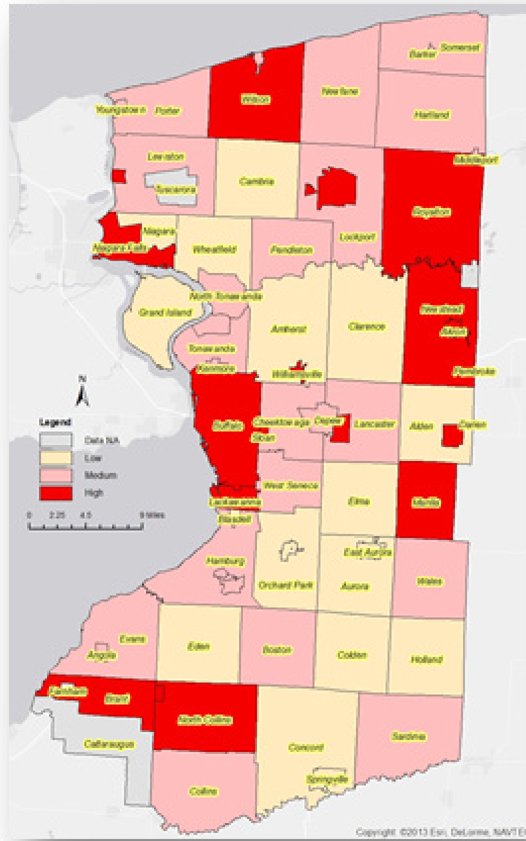
Each of the selected social vulnerability indicators was mapped to the respective communities in the region and analyzed using ESRI ArcGIS software.

Figure 15. Social Vulnerability Indicator – African Americans



Source: US Census Bureau, ACS, 5-Year Estimates (2007-2011), 2012.

Figure 16. Social Vulnerability Indicator - Unemployment



Source: US Census Bureau, ACS, 5-Year Estimates (2007-2011), 2012.

The data analysis reveals that the municipalities of Lewiston, Wheatfield, Amherst, Tonawanda, Williamsville, Cheektowaga, Depew, Sloan, Lackawanna, West Seneca, Elma, East Aurora, Aurora, Concord, and Springville have a relatively higher proportion of the population that is above 65 yrs. of age (Figure 13). The elderly tend to be more vulnerable to a number of anticipated impacts of climate change such as changes in temperature and the incidence of disasters such as floods, due to decreased mobility. Therefore, these communities will need to invest in the upgrading of local community health infrastructure facilities and develop plans to address future public health issues with a special focus on the health issues of the elderly.

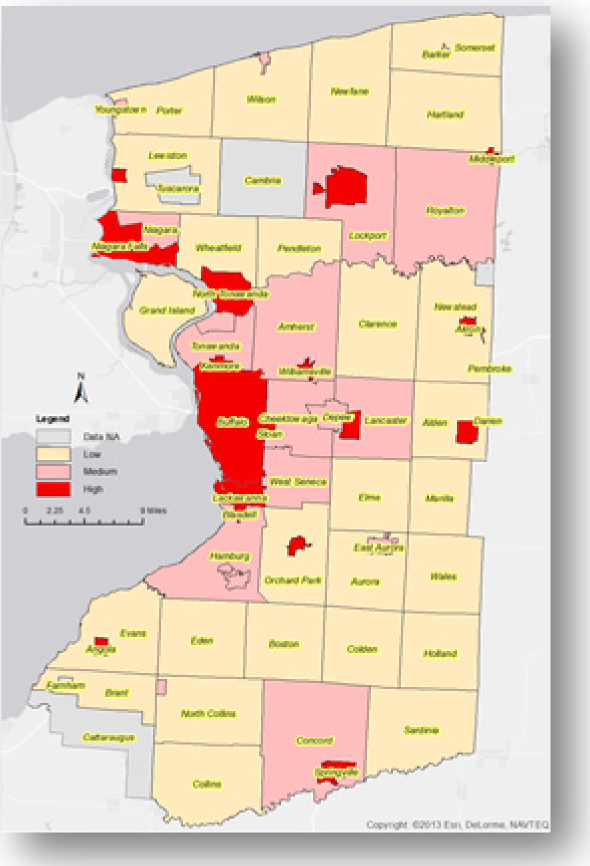
With respect to median home values, the municipalities of Wilson, Newfane, Barker, Somerset, Hartland, Lockport, Niagara Falls, North Tonawanda, Kenmore, Buffalo, Cheektowaga, Depew, Sloan, Lackawanna, Evans, Angola, Brant, North Collins, and Collins are identified as communities of high concern (Figure 14). These communities have relatively lower median home values, which is often indicative of lower quality housing. Owners of such properties are unlikely to have sufficient resources to invest in weatherization or other upgrades that may be necessary due to changing weather conditions. Therefore, such communities will have to dedicate resources for supporting weatherization and building upgrade programs.

With respect to racial composition, and specifically the percentage of African-Americans in communities, jurisdictions with relatively higher levels of vulnerability include the cities of Buffalo and Niagara Falls (Figure 15). All of the other communities have a comparatively very low percentage of African-Americans, except for Collins that has a relatively moderate percentage of African Americans. These communities will have to evaluate future adaptation actions in the context of their impact on non-white groups. Climate change policy response actions will have to be sensitive to the socio-economic needs of all stakeholders in the community and provide additional support required by residents in their communities to help adapt to changing climatic conditions.

Communities with higher rates of unemployment are also likely to face increased challenges in appropriating resources for climate change response policies. Residents in these communities will also require additional support to help them adapt to changing climatic conditions. Such communities with relatively higher rates of unemployment in the Buffalo Niagara region are Wilson, Niagara Falls, Royalton, Newstead, Akron, Buffalo, Sloan, Lancaster, Darien, Marilla, Brant, and North Collins (Figure 16).

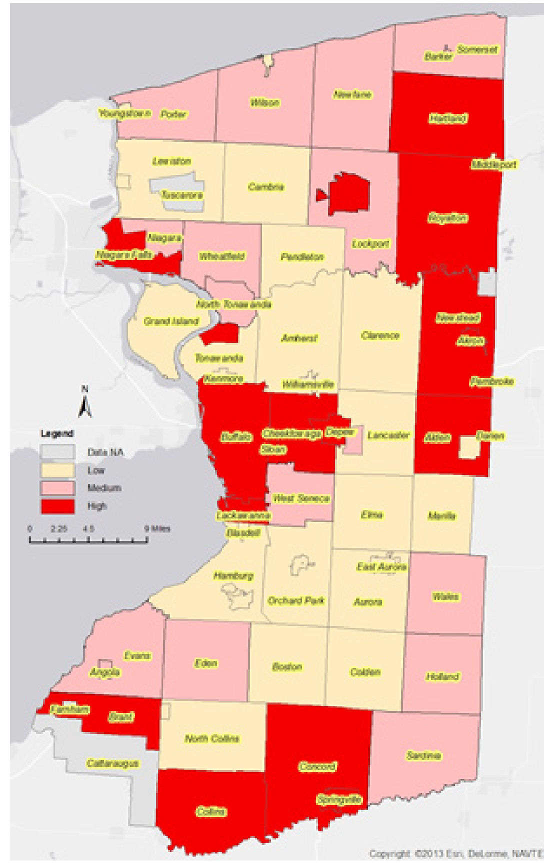
With respect to poverty, among the various communities in the region, Buffalo has the highest percentage of

Figure 17. Social Vulnerability Indicator - Poverty



Source: US Census Bureau, ACS, 5-Year Estimates (2007-2011), 2012.

Figure 18. Social Vulnerability Indicator- Education



Source: US Census Bureau, ACS, 5-Year Estimates (2007-2011), 2012.

population living below the poverty line. The City of Lockport, Niagara Falls, Cheektowaga, Alden, Lackawanna, and Collins also have significant percentages of their populations living below the poverty line. These communities are thus relatively more vulnerable than other communities in the region, since they will require additional resources to ensure that their residents below the poverty line are not exposed to increased public health hazards and other impacts from climate change (Figure 17). These communities are also very likely to face obstacles in generating local resources for implementing climate change response actions.

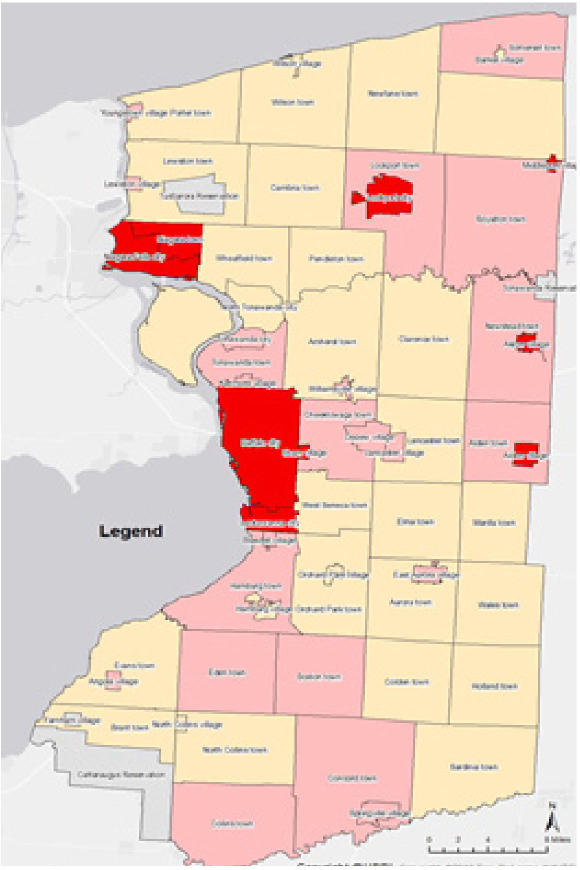
With respect to education, Hartland, Royalton, Lockport, Niagara Falls, Newstead, Akron, Tonawanda, Alden, Buffalo, Sloan, Cheektowaga, Lackawanna, Brant, Collins, Concord, and Springville have a relatively lower percentage of high school graduates in the region (Figure 18). Therefore these communities are likely to be more vulnerable to climate change impacts and will require assistance in adapting to climate change.

With respect to the number of single parent female-headed households, the Village of Youngstown, City of Lockport, Town of Niagara, City of Niagara Falls, Village of Akron, City of Buffalo, City of Lackawanna, and Village of Alden have been identified as relatively more vulnerable communities (Figure 19). Such households are likely to face relatively greater challenges in generating and utilizing resources to undertake climate change adaptive actions at the individual and household scales. Consequently, local governments in these communities will have to consider the needs of such groups while allocating public resources for climate change response actions in their jurisdictions.

A number of communities in the region also have a significant proportion of households receiving social security income. Except for Native American reservations, the Town of Cambria, Town of Lancaster, Town of Marilia, Village of Barker, Village of Akron, Village of Kenmore, Grand Island, Village of Orchard Park, Town of Boston, Town of Colden, Town of Holland, and Town of North Collins, all other communities are identified as relatively more vulnerable due to higher percentages of households that receive social security (Figure 20). These communities will be challenged to generate local resources for implementing climate change response strategies, and will have to explore options for attracting state and federal funding to support adaptation actions.

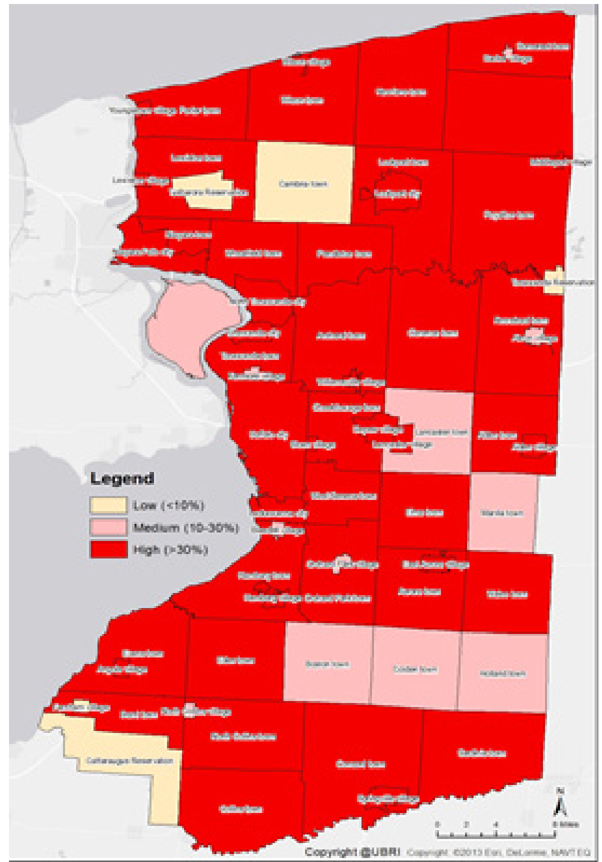
With respect to the employment sector, the Towns of Somerset, Cambria, Wales, Sardinia, and Collins have been identified as relatively more vulnerable because a significant proportion of the residential population is dependent on the primary extractive industries that are likely to be severely impacted by impending climatic changes (Figure 21).

Figure 19. Social Vulnerability Indicator- Single Parent female-headed Households



Source: US Census Bureau, ACS, 5-Year Estimates (2007-2011), 2012.

Figure 20. Social Vulnerability Indicator - Households with Social Security Income



Source: US Census Bureau, ACS, 5-Year Estimates (2007-2011), 2012.

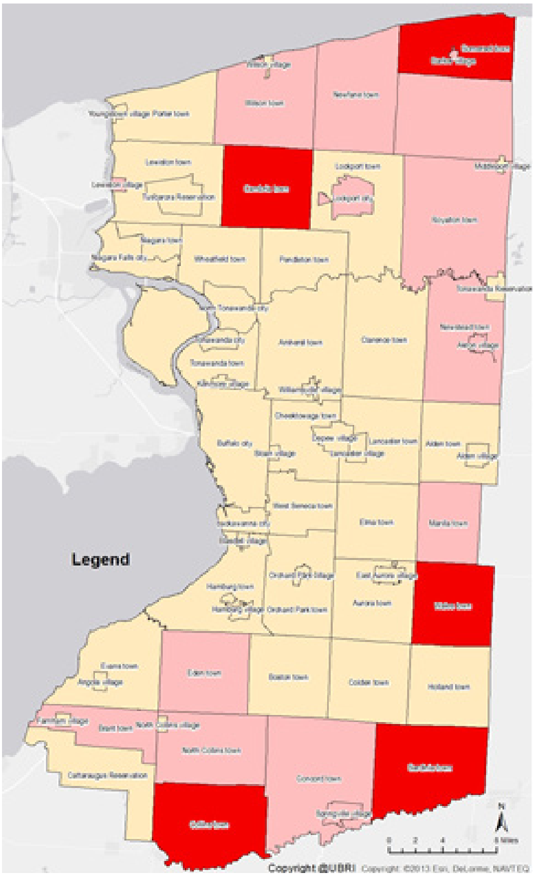
These communities will have to plan proactively for future changes in local ecosystems and specifically the natural resources that drive local employment. It is expected that most changes to the natural ecosystem will be irreversible; therefore, these communities will have to explore ways of transitioning the existing workforce employed in at-risk sectors into other employment sectors.

C. Overall Social Vulnerability Index

Based on the 9 indicators of social vulnerability identified in this study, a cumulative relative index of social vulnerability was developed for each of the communities in the Buffalo Niagara region. The methodology adopted for the creation of this index is similar to that proposed by Cutter et al. (2003). The index is created by synthesizing socioeconomic variables through the statistical process of principal components analysis (PCA). PCA involves a mathematical procedure that transforms a number of possibly correlated variables into a smaller number of uncorrelated variables called principal components. The first principal component accounts for as much of the variability in the data as possible, and each succeeding component accounts for as much of the remaining variability as possible (Dunteman 1989). The Social Vulnerability Index presented in Figure 22 is the primary component extracted from the nine social vulnerability variables selected for this analysis. This analysis of social vulnerability variables reveals that the Town of Newfane, Town of Somerset, City of Lockport, Town of Royalton, Town of Niagara, City of Niagara Falls, City of Tonawanda, City of Buffalo, Village of Sloan, Town of Cheektowaga, City of Lackawanna, Village of Angola, Town of Brant, Town of Concord, Town of Collins, and Village of Springville are relatively more vulnerable and likely to require additional resources for effectively adapting to climate change. Most notably the southern communities are likely to experience the most changes in local weather conditions. A number of communities with medium social vulnerability may eventually face greater impacts if the climate changes as per the medium and high emissions scenarios occurred. A higher social vulnerability index also indicates increased need for resources for undertaking climate change response actions in comparison to other communities in the region. These communities will also face the greatest challenge in identifying local resources for implementing effective climate change response actions.

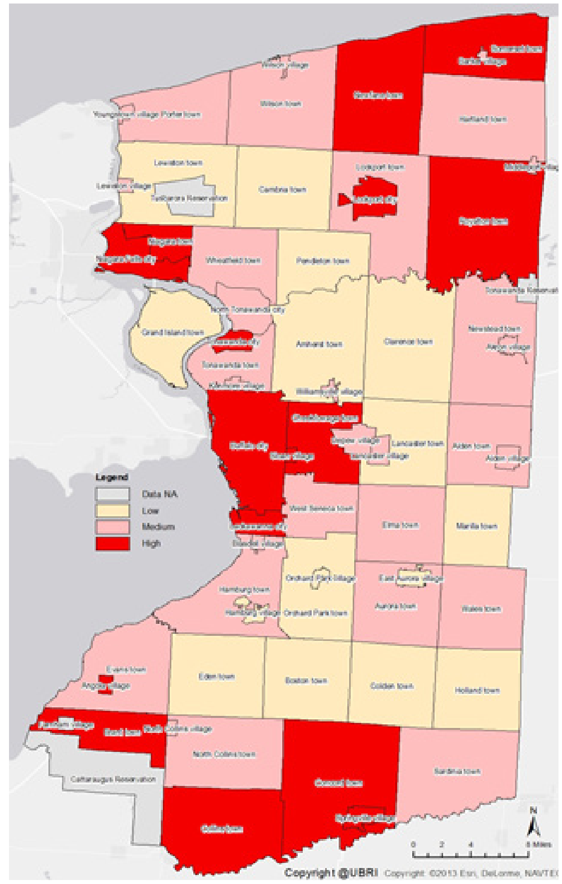
Like disasters (Fothergill and Peek 2004), the effects of climate change and climate policy will exacerbate social inequities in the community. If decision makers take no action to address them, these inequities will result

Figure 21. Social Vulnerability Indicator - Primary Extractive Sectors Employment



Source: US Census Bureau, ACS, 5-Year Estimates (2007-2011), 2012.

Figure 22. Overall Social Vulnerability Index



Source: US Census Bureau, ACS, 5-Year Estimates (2007-2011), 2012.

in disproportionate suffering on the vulnerable sections of the community. Understanding the distribution, relationships and dimensions of socially vulnerable populations in the region will facilitate the formulation of policies to reduce vulnerability among these populations and consequently strengthen the overall adaptive capacity of the region. However, climate change decision-making processes that do not consider climate vulnerability, equity, and justice will certainly fail to adequately provide services, information, education, and other types of support to key population segments of the region, and result in increased losses as a result of impending climatic changes.

Chapter References

Andrew, Melissa K, Arnold B Mitnitski, and Kenneth Rockwood. 2008. "Social vulnerability, frailty and mortality in elderly people." PLoS One 3 (5):e2232.

Beckerman, Wilfred. 1995. Small is stupid: Blowing the whistle on the greens: Duckworth London.

Bolin, Bob. 2007. "Race, class, ethnicity, and disaster vulnerability." In Handbook of disaster research, 113-129. Springer.

Brody, Samuel D, Sammy Zahran, Arnold Vedlitz, and Himanshu Grover. 2008. "Examining the relationship between physical vulnerability and public perceptions of global climate change in the United States." Environment and behavior 40 (1):72-95.

Cannon, Terry. 1994. "Vulnerability analysis and the explanation of 'natural'disasters." Disasters, development and environment:13-30.

Cutter, S. L., B. J. Boruff, and W. L. Shirley. 2003. "Social Vulnerability to Environmental Hazards*." Social Science Quarterly 84 (2):242-261.

Cutter, S.L., L. Barnes, M. Berry, C. Burton, E. Evans, E. Tate, and J. Webb. 2008. "A place-based model for understanding community resilience to natural disasters." Global Environmental Change 18 (4):598-606.

Cutter, S.L., and C. Finch. 2008. "Temporal and spatial changes in social vulnerability to natural hazards." Proceedings of the National Academy of Sciences 105 (7):2301-2306.

Cutter, Susan. 2006. "The geography of social vulnerability: Race, class, and catastrophe." Understanding Katrina: Perspectives from the social sciences:120-122.

Flanagan, Barry E, Edward W Gregory, Elaine J Hallisey, Janet L Heitgerd, and Brian Lewis. 2011. "A social vulnerability index for disaster management." Journal of Homeland Security and Emergency Management 8 (1).

Fothergill, Alice, and Lori A Peek. 2004. "Poverty and disasters in the United States: A review of recent sociological findings." Natural hazards 32 (1):89-110.

Gall, Melanie. 2007. Indices of social vulnerability to natural hazards: a comparative evaluation: ProQuest.

Hoerner, J Andrew, and Nia Robinson. 2008. "A climate of change: African Americans, global warming, and a just climate policy for the US." Environmental Justice and Climate Change Initiative 1:1-59.

Morrow, Betty Hearn. 1999. "Identifying and mapping community vulnerability." Disasters 23 (1):1-18.

Peek, Lori. 2008. "Children and disasters: Understanding vulnerability, developing capacities, and promoting resilience-an introduction." Children Youth and Environments 18 (1):1-29.

Phillips, Brenda, Deborah SK Thomas, Alice Fothergill, and Lynn Blinn-Pike. 2010. Social vulnerability to disasters: CRC Press Boca Raton, FL.

Rosenzweig, C., W. Solecki, A. DeGaetano, M. O'Grady, S. Hassol, and P. Grabhorn, eds. 2011. Responding to Climate Change in New York State: The ClimAID Integrated Assessment for Effective Climate Change Adaptation in New York State. Vol. 1244. Albany, New York: New York State Energy Research and Development Authority (NYSERDA).

Simpson, David M, and R Josh Human. 2008. "Large-scale vulnerability assessments for natural hazards." Natural hazards 47 (2):143-155.

Smith, Keith. 2013. Environmental hazards: assessing risk and reducing disaster: Routledge.

Williams, David R, Harold W Neighbors, and James S Jackson. 2003. "Racial/ethnic discrimination and health: findings from community studies." American Journal of Public Health 93 (2):200-208.

Wisner, Benjamin. 2004. At risk: natural hazards, people's vulnerability and disasters: Psychology Press.

5.

SYNERGISTIC CLIMATE CHANGE RESPONSE STRATEGIES

This section outlines a synergistic response strategy to the challenge of climate change. Proposed policies bring together adaptation, mitigation, and efficiency benefits to enhance local resilience to climate change (Figure 23). Adaptation actions are rooted in disaster risk management approaches, with the primary focus on reducing existing and future exposure to local climate change risks. Also included are policies to enhance social, institutional, governmental, and technical capacities to facilitate future actions as the local impacts of climate change become more overt. Mitigation actions focus on risk reduction by limiting local greenhouse gas emissions. While a certain degree of climatic changes is ensured as a result of past greenhouse gas emissions, further changes can be avoided by limiting future emissions. Finally, efficiency actions are recommended to enhance the benefits of both the mitigation and adaptation policies. Proposed adjustments to existing development and growth-oriented policies will result in ensuring that future development in the region is climate change sensitive, environmentally sustainable, and provides a higher quality of life to local residents.

A. Proposed Climate Change Response Strategies

The climate change response strategies listed in this section are organized at three spatial scales: regional/community scale, neighborhood scale, and building scale. Policies at the community scale will serve the whole community/region and are likely to provide the most opportunities for creating cost-effective solutions embedded within other sustainable development strategies. Neighborhood strategies are focused on distinct groups of buildings. These activities will be implemented in public spaces and provide direct quality of life and sustainability benefits to local residents. Building scale activities include recommendations that can be implemented on individual buildings. These polices will focus on design and built form modifications to enhance adaptation, mitigation, and efficiency benefits. Each of the recommendations is accompanied with an identification of a potential agency/actor for implementation, suggested implementation time frame, and suggested measures and indicators of success.

Regional/Community Scale Response Strategies

CRS - 1 Find ways to collaborate and coordinate land use and planning decisions across jurisdictions as well as incorporate climate change considerations into decision-making.

A coordinated land use management strategy is imperative for a balanced climate change response. A climate change sensitive land use management program can direct development away from at risk areas and support smart growth development that will decrease resource waste and promote efficiency. At the same time, smart growth strategies will also contribute to reduced vehicular trips by promoting efficient links between residential and work areas. Reduced vehicular trips will provide direct mitigation benefits. However, presently most development in the region is largely decided by local governments that rarely concern themselves with the external impacts of local development. It is therefore recommended that local governments explore the possibility of coordinating their local development decisions, in order to promote smart growth and more effectively respond to the future challenges of climate change. This coordination could be facilitated by the One Region Forward network, the WNY Regional Economic Development Council's Smart Growth Coordinating Council, or the Greater Buffalo Niagara Regional Transportation Council.

Potential Agency/actor: One Region Forward Network, WNY Regional Economic Development Council's Smart Growth Coordinating Council, Greater Buffalo Niagara Regional Transportation Council (GBNRTC), local communities, and advocacy groups

Suggested Implementation time-frame: Near- to long-term (1-10 yrs.)

Measures of Success: Coordinated regional development

Suggested Indicators:

1. Decreased urban sprawl
2. Communities that are less vulnerable to the impacts of climate change

Figure 23. Synergistic Climate Change Response Strategy

CRS - 2 Discourage outward expansion of urban areas and preserve large, contiguous areas of open and agricultural space.

In recent decades this region has seen increasing outward urban expansion into open areas and agricultural lands. This kind of development is extremely resource intensive and unsustainable. It results in increased energy consumption and decreased availability of agricultural land for food production. This form of growth also increases community vulnerability to the negative impacts of climate change. It is therefore recommended that future land use and development plans for local communities discourage outward expansion and instead promote infill development within the existing urbanized areas. An important tool available to communities is the adoption of an adequate public facilities ordinance (AFPO). Using this tool, local governments can coordinate the timing of new development based on the provision of infrastructure facilities such as water supply and sewage systems. Local governments can also use AFPO to employ concurrency requirements, through measures such as delaying new development projects if existing services such as water, wastewater, roads, schools, fire stations or police stations cannot support the new development.

Potential Agency/Actor: Local communities

Suggested Implementation Time-frame: Near- to long-term (1-10 yrs.)

Measures of Success: Preservation of open space and controlled expansion of urbanized areas.

Suggested Indicators:

1. Adoption of an adequate public facilities ordinance

CRS - 3 Promote alternative transportation infrastructure

It is recommended that local communities consider the development of effective and efficient alternative transportation systems to decrease the increasing dependence on private vehicles for work and recreational trips. A number of public transportation projects that may be considered include: (a) Extension of the NFTA-metro system; (b) Integrated bike and pedestrian paths connecting residential neighborhoods with schools and recreational areas; (c) Increased access along the Niagara River Greenway with improved bike paths and railways; and (d) Expansion of existing infrastructure for the charging of electric vehicles across the region. It is recommended that communities highlighted as being highly vulnerable in the preceding social vulnerability analysis be considered as high priority areas for such projects. While a number of these projects will provide direct benefits of reduced greenhouse gas emissions, they will also help households (and especially vulnerable households) to adapt to the increasing costs of fossil fuels in the coming years. Additional health and quality of life benefits will help families in all communities to become more resilient to the negative impacts of future climatic changes.

Potential Agency/Actor: GBNRTC, local communities, and advocacy groups

Suggested Implementation Time-frame: Near- to long-term (1-10 yrs.)

Measures of Success: Increased low emission transportation options

Suggested Indicators:

1. Increase in the length of the metro system
2. Increase in the length of bike lanes and trailways
3. Increase in the number of charging stations for electric vehicles

CRS - 4 Implement enhanced flood protection measures in the region.

Flooding is an important concern in most communities in the region. It is expected that the changing climate will result in increased rainfall events, making it a more urgent concern in most of the communities with significant areas within the 100 yr. and the 500yr floodplains. The most effective way to minimize future losses from increased instances and intensities of floods is to reduce exposure by locating and designing development away from low-lying areas. In order to frame an effective flood risk management strategy for the region the following specific tasks are recommended:

CRS -4.1 Update of existing floodplain maps.

Given the changes in the local landscape and the increasing instances of extreme rainfall events it is recommended that the communities in the Buffalo-Niagara region coordinate with FEMA for Letter of Map Revisions (LOMR) to update the existing Flood Insurance Rate Maps (FIRMs).

CRS -4.2 Preserve the 500yr floodplain delineated areas as open or green spaces.

Traditionally 500 yr. floodplain boundaries have been considered relatively safe for most developmental uses. However, increasing risks of extreme weather events due to climate change necessitate a more cautious approach. It is recommended that a regional greenway system be developed on the existing 500yr floodplain boundaries. This will not only keep future development away from at risk areas but also provide added health, ecological and leisure benefits by enhancing local quality of life.

CRS -4.3 Adopt stronger floodplain management ordinances in all communities

Local flood management policies are an important and effective tool for mitigating flood losses. They also help to minimize redevelopment costs to taxpayers in case of damages due to floods. Presently, both Niagara and Erie counties have all-hazard mitigation plans that address flooding among other natural hazards. However, only a small number of communities in the region have adopted any kind of floodplain management ordinance. It is recommended that other communities also undertake flood mitigation planning. These ordinances should include provisions for the acquisition of repeated flood loss properties, preservation of 100 yr. floodplains as open or green areas, controlled growth (preferably open/green area preservation) in the 500 yr. floodplain, and adequate freeboard (clearance from the highest anticipated flood levels) provision for properties in the delineated floodplain.

Potential Agency/Actor: Local communities and advocacy groups

Suggested Implementation Time-frame: Near- to long-term (1-10 yrs.)

Measures of Success: Decreased exposure to flood risk

Suggested Indicators:

1. Update of flood maps
2. Number of communities with enhanced floodplain management ordinances
3. Cumulative value of property within the 100 yr. and 500 yr. floodplain

CRS - 5 Establishment of storm water utility districts (SUDs)

While most communities are struggling with increasing costs to replace or repair aging infrastructure facilities there is limited scope for the reallocation of general budget funds towards these activities. Therefore, it is proposed that communities consider establishing storm water utility districts (SUDs). SUDs are alternative, independent organizations that can support local and regional authorities. They work in tandem with various jurisdictions to support the basic functions of financing, operating and maintaining storm water and drainage activities. SUDs can be extremely beneficial in addressing multiple related concerns that include: creating a sustainable revenue source for storm water programs, assuring regulatory compliance, addressing regional flooding concerns, and addressing regional water quality issues. SUDs can provide major advantages over funds generated through property tax revenues in terms of greater equity and better opportunity for incorporating incentives for the implementation of on-site storm water management (Doll, Lindsey, and Albani 1998, Brisman 2001).

Potential Agency/Actor: Local communities

Suggested Implementation Time-frame: Near- to long-term (1-10 yrs.)

Measures of Success: Better storm water management infrastructure

Suggested Indicators:

1. Establishment of SUDs

CRS - 6 Conduct community scale water resource management studies

Water has been long considered an abundant resource in this region. However, with anticipated changes in lake levels and increasing demands from other regions for freshwater, it is very likely that this sense of water security may disappear within the coming years. With most communities largely dependent on the lakes for their drinking water supply, it is important to undertake a regional water resource management plan that will evaluate the existing and future reliability of raw water sources with respect to growing water demands in the region. In addition, the study should also focus on: (a) assessing and analyzing water infrastructure, (b) formulating a water loss control program, and (c) creating a demand management strategy. With climate change likely to affect the fresh water quantity and quality of the Great Lakes, a proactive management strategy will help communities prepare for future situations of water stress. Early adoption of a water loss control program and demand strategies will enable households to effectively adapt to decreasing fresh water availability as well as possible increases in the cost of water services.

Potential Agency/Actor: Local communities

Suggested Implementation time-frame: Near- to long-term (1-10 yrs.)

Measures of Success: Sustainable water supply infrastructure

Suggested Indicators:

1. Number of communities with updated water resource management plans

CRS - 7 Implement combined sewer overflow abatement programs in communities with CSO facilities

Combined sewer overflow is a major environmental challenge in four cities in the region: Buffalo, Lockport, North Tonawanda, and Niagara Falls. This problem is likely to worsen with increased intensity of rainfall as a result of changing climatic conditions. It is therefore recommended that CSO abatement programs be undertaken in each of these communities. The City of Buffalo has taken the lead by incorporating green infrastructure as an important strategy in its long term control plan that was recently approved by the EPA. It is recommended that other communities follow Buffalo's example and consider adopting a similar approach to CSO abatement. A number of financial and funding mechanisms are available to communities to undertake such projects. CSO abatement projects are also eligible for low interest rate financing through the New York State Revolving Fund (SRF) for Water Pollution Control.

Potential Agency/Actor: Local communities

Suggested Implementation Time-frame: Near- to short-term (1-6 yrs.)

Measures of Success: Better quality water at discharge locations

Suggested Indicators:

1. Decreased instances of CSO in each community

Buffalo Sewer Authority's Plan to Reduce Sewage and Water Pollution in Niagara River through Green Infrastructure

The U.S. Environmental Protection Agency and the New York State Department of Environmental Conservation have recently approved the Buffalo Sewer Authority's plan to reduce the amount of sewage and storm water run-off that flows from the City of Buffalo's combined sewer system. Under the approved plan, the Buffalo Sewer Authority will implement a series of projects that will improve water quality in the Niagara River and its tributaries, including projects that use green infrastructure to soak up and store storm water that would otherwise increase overflows of raw sewage into local waterways. The Buffalo Sewer Authority has already invested over $50 million in completed and ongoing construction projects under its approved Long Term Control Plan, including:

- A $2.8 million pilot project to determine green infrastructure effectiveness related to rain garden/infiltration basins, pervious pavement and house downspout disconnections
- $1.2 million for green street projects along Carlton Street and Fillmore Avenue to collect flows from these areas and to turn vacant land into green space
- $7.5 million for demonstration projects to determine how to maximize wastewater and storm water storage with real time control technology
- $18 million to construct the Hamburg Drain Floatable Control Facility to control entry of large floating debris into the Niagara River
- $8 million for a storage project at Smith Street to reduce raw sewage overflows into the Niagara River

In addition to these projects, $93 million will be spent on green infrastructure for between 1,315 and 1,620 acres of impervious surface throughout Buffalo. Projects will include vacant property demolitions, vacant lot modifications to allow for infiltration, pervious pavements, rain gardens, downspout disconnections and rain barrels.

Source: EPA News Release (2014). "EPA Approves Buffalo Sewer Authority's Plan to Reduce Sewage and Water Pollution in Niagara River". Accessed 5/12/2014

CRS - 8 Community scale climate change sensitivity analysis

The ultimate impact of climate change on a community will depend on local sensitivity to climatic impacts and levels of proactive preparedness. Therefore it is recommended that all communities in the region undertake self-assessments to identify sectors and areas that are sensitive to anticipated changes in local climatic conditions. A self-assessment tool included in Appendix I will enable communities to identify local risks and estimate their present levels of preparedness. This detailed analysis will also help identify specific weaknesses in the existing physical infrastructure facilities such as roads, water supply, and energy distribution systems that are likely to exacerbate the local impacts of changing climatic conditions. Based on this sensitivity analysis, specific policy actions can then be formulated to address important sectors or areas of concern. The community will be best served by repeating this analysis every five years to ensure that any significant changes in local sensitivity to climate change are addressed in a timely manner.

Potential Agency/Actor: Local communities and administrations of counties

Suggested Implementation Time-frame: Near- to long-term (1-10 yrs.)

Measures of Success: Decrease in sensitivity to climate change and increase in preparedness.

Suggested Indicators:

1. Likelihood of impact to critical infrastructure facilities due to flooding events
2. Number of local plans and programs that incorporate climate change considerations

CRS - 9 Incorporate Climate Change considerations in local planning

Most local governments (e.g., counties and municipalities) in the region exercise their local planning power to create local comprehensive development plans. These plans outline the future development paths for communities based on local priorities as envisioned by communities. At present, none of the local plans in Buffalo-Niagara address climate change as an important issue in the region. However, both counties have all-hazard mitigation plans that do address local climate change risks. Only a few communities (e.g., the Town of Amherst, Town of Tonawanda, and City of Niagara Falls) have local hazard mitigation plans. These too do not address local climate change risks. It is therefore recommended that updates to local plans both at the county level and at the local level incorporate climate change considerations. Climate change sensitivity analysis recommended earlier will help communities identify local impacts and undertake appropriate response actions.

Potential Agency/Actor: Local communities and county administrations

Suggested Implementation Time-frame: Near- to long-term (1-10 yrs.)

Measures of Success: Increased preparedness.

Suggested Indicators:

1. Number of local plans that incorporate climate change considerations

The Cost of Lighting Skies

Wasted outdoor lighting that shines directly upward is estimated at 17,400 gigawatt-hours a year as per the International Dark-Sky Association. At an average of $.10 per kilowatt-hour the cost of that wasted energy is $1.74 billion a year. In terms of our carbon footprint, the impacts are significant and avoidable: 11,998,000 metric tons of carbon dioxide equivalent.

Source: http://www.darksky.org

CRS - 10 Communities should consider the adoption of dark sky legislation

Dark sky legislation is primarily designed to reduce light pollution and energy usage. The advantages of reducing light pollution include an increased number of stars visible at night, reduced effects of unnatural lighting on the environment, and reduced greenhouse gas emissions by decreased energy usage. Communities can identify dark sky overlay zones within their communities wherein this policy can be implemented and enforced.

Potential Agency/Actor: Local communities

Suggested Implementation Time-frame: Near term (1-3 yrs.)

Measures of Success: Decrease in night time light pollution

Suggested Indicators:

1. Percentage of area covered by dark sky overlay zones

CRS - 11 Work with utility companies to promote energy conservation and remove disincentives associated with reduced consumption.

While it is evident that energy conservation is a smart climate change response strategy, many utility companies are likely to be negatively impacted by reduced energy consumption. While it is likely that there will be a decrease in energy consumption, it is expected to last only for a short period of demand stabilization. The utility companies will continue to maintain their profitability through enhanced efficiency and lower operating costs. However, it is likely that this fear of negative economic impacts is likely to prevent utility companies from actively pursuing an energy conservation agenda. Therefore, it is important that local governments engage with utility companies to work out the phased implementation of energy conservation strategies that minimize fiscal impacts on utility companies. It is therefore recommended that the local administration facilitates dialogue between utility companies and infrastructure pricing experts to help these companies identify ways and means to promote resource conservation without negatively impacting their viability. These trust-building initiatives between utility companies and local communities will go a long way in enabling open dialogues to enhance the resiliency of existing and new critical infrastructure facilities in the region.

Potential Agency/Actor: Utility companies, local governments, non-profits, and advocacy groups

Suggested Implementation Time-frame: Near term to short term (1-6 yrs.)

Measures of Success: Increased support for energy conservation

Suggested Indicators:

1. Number of households enrolled in energy conservation programs supported by utility companies

CRS - 12 Work with local businesses and homeowners to meet (at a minimum) and preferably exceed the Renewable Portfolio Standard set by the state.

The State of New York has adopted a Renewable Portfolio Standard (RPS) policy to increase the proportion of renewable electricity used by retail customers to 30%. While this is a laudable target, it is vital to further expand the program and promote local initiatives that go beyond the state mandated target. Therefore, it is recommended that local government work with NYSERDA and local businesses to achieve a more desirable target of 50% renewables by 2025. This will contribute to a significant reduction in energy consumption and provide increased savings for local businesses and homeowners, which can be used towards implementing building-level climate change response strategies.

Potential Agency/actor: Local government, NYSERDA, non-profits, advocacy groups and utility companies

Suggested Implementation Time-frame: Long-term (1-10 yrs.)

Measures of Success: Increased share of energy derived from renewable sources

Suggested Indicators:

1. Percentage of energy derived from renewable sources

CRS - 13 Prepare community-scale public health plans

Climatic changes are likely to result in extreme temperatures, reduced air quality, changes in the types and distribution of disease vectors, and hindered access to basic needs such as water and food. Combined with an increasing proportion of vulnerable individuals in the community, it is imperative that local governments undertake proactive planning to minimize such negative effects on human health and better prepare residents for disasters that could hurt their health. It is therefore recommended that communities invest in the preparation of public health plans to address possible extreme weather situations. A public health plan will provide a sense of direction and management options to deal with impending climatic changes and extreme weather emergencies in the region. This plan should be developed in partnership with various authorities in the region and outline the responsibilities of the various involved organizations and departments.

Potential Agency/Actor: Local government, non-profits, and local advocacy groups

Suggested Implementation Time-frame: Near to Short-term (1-6 yrs.)

Measures of Success: Effective public health plans that respond to local public health challenges and take into account climatic and socio-economic factors

Indicators:

1. Number of communities with climate change sensitive public health plans

Neighborhood Scale

NRS - 1 Promote Low Impact Development (LID) and Green Infrastructure Projects

LID and green infrastructure projects provide multiple environmental benefits to communities (Gill et al. 2007). Climate change benefits include lowered urban heat island effect and better management of storm water run-off in present and future weather conditions. Unlike single-purpose gray storm water infrastructure that uses pipes to dispose of rainwater, green infrastructure uses vegetation and soil to manage rainwater where it falls. By incorporating and enhancing natural processes into the built environment, green infrastructure provides resilient and affordable solutions to communities for storm water management, flood mitigation, air quality management, and other environmental benefits. This will result in better services without the large scale investments required to upgrade existing infrastructure facilities. It is therefore recommended that communities target neighborhoods with existing localized flooding problems and near the CSO outfall locations to implement green infrastructure opportunities within their jurisdictions.

Potential Agency/Actor: Local communities

Suggested Implementation Time-frame: Near- to long-term (1-10 yrs.)

Measures of Success: Decreased CSO and localized flooding

Suggested Indicators:

1. Number of green infrastructure projects implemented
2. Drainage area covered by green infrastructure projects

Green Infrastructure Benefits

Benefit	Reduces Stormwater Runoff											Improves Community Livability						
	Reduces Water Treatment Needs	Improves Water Quality	Reduces Grey Infrastructure Needs	Reduces Flooding	Increases Available Water Supply	Increases Groundwater Recharge	Reduces Salt Use	Reduces Energy Use	Improves Air Quality	Reduces Atmospheric CO_2	Reduces Urban Heat Island	Improves Aesthetics	Increases Recreational Opportunity	Reduces Noise Pollution	Improves Community Cohesion	Urban Agriculture	Improves Habitat	Cultivates Public Education Opportunities
Practice										CO_2								
Green Roofs	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	Maybe	Yes	Maybe	Maybe	Yes	Yes
Tree Planting	Yes	Yes	Yes	Yes	No	Maybe	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Maybe	Yes	Yes
Bioretention & Infiltration	Yes	Yes	Yes	Yes	Maybe	Maybe	No	No	Yes	Yes	Yes	Yes	Yes	Maybe	Maybe	No	Yes	Yes
Permeable Pavement	Yes	Yes	Yes	Yes	No	Maybe	Yes	Maybe	Yes	Yes	Yes	No	No	Yes	No	No	No	Yes
Water Harvesting	Yes	Yes	Yes	Yes	Yes	Maybe	No	Maybe	Maybe	Maybe	No	No	No	No	No	No	No	Yes

Yes Maybe No

Source: Center of Neighborhood Technology, 2010. The Value of Green Infrastructure (Pg. 3).

NRS - 2 Adopt and implement urban forestry, greenways and trail plans

Green areas in the community serve the dual purpose of absorbing greenhouse gases (or acting as carbon sinks), and providing an evaporative cooling effect from the combination of green corridors, street trees, and other green areas (Nowak and Crane 2002, Hamada and Ohta 2010). Urban forestry projects, greenways and trails will also enhance local quality of life in neighborhoods. It is therefore recommended that local governments work with community groups and non-profits to promote urban forestry in open areas within the community.

Potential Agency/Actor: Local government, non-profits, and local advocacy groups

Suggested Implementation Time-frame: Near to Short-term (1-6 yrs.)

Measures of Success: Increased green cover

Suggested Indicators:

1. Adoption of urban forestry, greenways and trails plans
2. Area brought under green features

NRS - 3 Preparation and adoption of Surface Water Management Plan (SWMP) to implement erosion control techniques and maintenance of existing drainage systems

At the neighborhood scale, local governments need to focus efforts on understanding and managing the issues in existing drainage pathways. A comprehensive neighborhood scale surface water management plan should be implemented. This plan would include detailed mapping and assessment of existing drainage channels in the neighborhood. The plan would also explore the implementation of surface water management strategies including: (i) identify and remove 'bottlenecks' in local drainage channels; (ii) create or strengthen small scale hard barriers or channel realignment schemes to avoid localized flooding, and; (iii) replace existing hard surfaces with permeable pavement, gravel or grass to increase ground water recharge. This local surface water management strategy will provide direct benefits of managing localized flooding, enhancing local quality of development, and creating awareness about the challenges of climate change. Strategies to enable local participation through self-help groups and neighborhood planning groups would further increase the effectiveness of such local initiatives.

Potential Agency/Actor: Local government, non-profits, and local advocacy groups

Suggested Implementation Time-frame: Near to Short-term (1-6 yrs.)

Measures of Success: Implementation of best practices in surface water management

Suggested Indicators:

1. Percentage of community covered under local surface water management plans
2. Number of surface water management projects implemented

Building Scale

CRS - 1 Lobby and support initiatives to implement programs that promote increased generation of clean energy by home owners

Fossil fuel based energy generation is the primary source of increasing greenhouse gas emissions. It is therefore necessary to promote alternative energy projects both at the state level and the local level. Specifically, it is recommended that local governments work with non-profits and advocacy groups to lobby for the implementation of policies and programs that will enhance decentralized, individual scale renewable energy production in the region. Such household scale alternative energy projects will not only provide direct greenhouse gas reduction benefits, but will also increase local energy security. Decentralized energy generation will enhance local resilience to the likelihood of increased power failures with changing climatic conditions. Individual energy generators will also be able to safeguard themselves from possible volatility in future energy prices.

BRS -1.1 Implement Feed-in-Tariff (FIT) programs

FIT programs have been found to be successful in promoting a revenue model that encourages small and medium alternative energy projects in a community (Mendonça 2009). While a similar program does exist in Long Island, it has not yet been adopted in this region. It is recommended that NYSERDA consider adopting a similar program for this region to promote small and medium scale alternative power generation projects in the region. Partnering with local advocacy groups such as the Energy Committee of the Niagara Group of the Sierra Club will help in ensuring the effective development and implementation of the program.

Potential Agency/Actor: NYSERDA, local government, non-profits, and advocacy groups

Suggested Implementation Time-frame: Short-term (1-6 yrs.)

Measures of Success: Successful adoption of small scale alternative energy projects

Suggested Indicators:

1. Number of communities with FIT programs
2. Number of consumers enrolled post program adoption
3. Estimated energy generated through this program

BRS -1.2 Expand the remote net-metering program so that residential consumers can act as hosts

Net metering is another policy instrument that promotes small-scale renewable energy production. Under this mechanism electricity generators receive bill credits for the amounts of electricity that they add to the grid. For example, if a customer has a PV system on the rooftop, it may generate more electricity than the customer uses during daylight hours. If the home is net-metered, the electricity meter will run backwards to provide a credit against what electricity is consumed at night or other periods where the home's electricity use exceeds the system's output. Remote net metering enables renewable energy that is produced to be allocated between several utility accounts. The account that is connected to a renewable energy technology is referred to as a “host account” and the accounts to which extra credits are applied to are known as “satellite accounts.” Presently, farm and non-residential utility customers can serve as both host and satellite accounts, but residential customers can only serve as satellite accounts. This is a disincentive for residences to install high-generation renewable energy systems though. Thus, it is recommended that the local administration work with local utility providers and the state public service commission to expand the remote net-metering program to residential users and ultimately encourage the wide-spread production of renewable energy.

Potential Agency/actor: NYSERDA, local government, non-profits, utility companies, and advocacy groups

Suggested Implementation Time-frame: Near-term (1-3 yrs.)

Measures of Success: Successful implementation of alternative energy projects

Suggested Indicators:

1. Number of residential consumers enrolled in the program as hosts
2. Estimated energy generated through this program

BRS -1.3 Implement Property Assessed Clean Energy (PACE) program

In comparison to FIT and net metering programs that provide generation based incentives, PACE financing allows a property owner to fund the capital costs of energy efficiency, water efficiency, and renewable energy projects. With PACE, residential and commercial property owners living within a participating district can finance 100% of their project and pay it back over time as a voluntary property tax assessment through their existing property tax bill. A study of the PACE program in Boulder County in Colorado concluded that within the first phase of the program (3 years) it led to the creation of 85 short-term jobs, more than $5 million in earnings, and almost $14 million in economic activity in the county (Goldberg, Cliburn, and Coughlin 2011). Countywide or community scale PACE programs can be effectively implemented within the framework of existing local property laws. It this therefore recommended that local governments explore the implementation of a PACE program within their jurisdiction to promote household level renewable energy generation and additional infrastructure efficiency benefits.

Potential Agency/actor: NYSERDA, local government, non-profits, and advocacy groups

Suggested Implementation Time-frame: Near-term (1-3 yrs.)

Measures of Success: Successful implementation of alternative energy projects

Suggested Indicators:

1. Number of projects implemented under PACE
2. Estimated energy generated through PACE projects

CRS - 2 Modify local building codes to promote climate friendly development that incorporates new techniques and technologies

In the last decade a number of building techniques and materials have emerged that can directly contribute to reducing risks from climate change. Specifically, use of cool or porous pavements offer an effective way for reducing increasing urban temperatures and also provide storm water management benefits to reduce flooding. Similarly cool roofs and green roofs can significantly reduce the energy demands for cooling and also help reduce the urban heat island effect. Rainwater harvesting systems and greywater recycling systems will result in reduced water demands, easing pressure on the water supply system and also reducing the risk of flooding during storms by storing rainwater and buffering run-off before it reaches the storm water system. However, existing building codes do not provide the opportunity to incorporate these green systems into building and site developments. It is therefore recommended that local governments work with the green construction industry to incorporate increased use of green technologies in building construction.

Potential Agency/Actor: Local government, the construction industry, and developers

Suggested Implementation Time-frame: Near to Short-term (1-6 yrs.)

Measures of Success: Adoption of green technologies into new construction

Suggested Indicators:

1. Adoption of changes to the building codes
2. Number of construction projects implemented with green building technologies

CRS - 3 Adopt stricter energy codes for new construction

All communities in the region adhere to the 2009 Energy Conservation Construction Code adopted by New York State that addresses the design and construction of building envelopes and the efficiency of mechanical, lighting and power systems. It is recommended that local communities adopt the better 2012 IECC energy codes that will result in a 30% reduction in the energy use of buildings compared to the baseline code (2006 IECC). The U.S. Department of Energy has designated these as the new National Model Energy Code (Mendon, Lucas, and Goel 2013). Therefore, they are likely to be adopted by most states in the next few years. Key aspects of building construction addressed under these codes include: (1) Sealing requirements to reduce heating and cooling losses; (2) Improvements in the efficiency of windows and skylights; (3) Increased insulation in ceilings, walls and foundations; (4) Reductions in wasted energy from leaky heating and cooling ducts; (5) Improvements in hot-water distribution systems to reduce wasted energy and water in piping; and, (6) Boosted lighting efficiency. Adoption of these codes will result in significant reductions in energy consumption and increased savings for residential and commercial customers.

Potential Agency/Actor: Local government,

Suggested Implementation Time-frame: Near to Short-term (1-6 yrs.)

Measures of Success: Decreased emery consumption

Suggested Indicators:

1. Adoption of changes to building codes
2. Number of construction projects implemented with new IECC codes

CRS - 4 Establish a regional/county revolving fund for promoting energy efficient rehabilitation of existing buildings.

Buildings, both residential and commercial, consume a significant portion of energy (generated from fossil fuels) for heating and cooling purposes. Energy efficient rehabilitation of existing structures will result in significant reductions in energy consumption and reduced greenhouse gas emissions. Easy access to low cost loans and grants for rehabilitation projects is key to promoting such rehabilitation projects. While there are a number of existing weatherization programs that can be linked and expanded to promote energy efficient rehabilitation, it is recommended that a regional (or county) revolving loan fund be created to support energy efficient rehabilitation and weatherization projects in the region. This fund should provide loans and grants to not only individual property owners, but also community based organizations that work with local residents in rehabilitation projects. Of particular importance is providing funds for projects that strengthen the envelopes of buildings, to ensure that energy used for heating or cooling needs is not wasted due to leaks.

Potential Agency/Actor: County departments, local communities, and advocacy groups

Suggested Implementation Time-frame: Near term (1-3 yrs.)

Measures of Success: Decreased energy consumption in residential and commercial sectors

Suggested Indicators:

1. Amount of money earmarked for the fund
2. Number of loans provided by the fund

C. Importance of Outreach and Education

Public understanding of environmental problems is vital for the formulation of a successful policy responses (Bostrom et al. 1994). Historically, widespread public concern for an environmental issue has preceded any formal policy action for environmental conservation. With respect to climate change, research evidence demonstrates that public anxiety tends to wax and wane with weather fluctuations and media attention (Bord, O'Connor, and Fischer 2000). The issue is further complicated by the complexity of the underlying phenomena, which poses additional challenges for creating clear communication and outreach material. Lack of certainty in predicting the nature and severity of climate change impacts makes it a challenging problem to comprehend in the social arena. Most people experience climate change through local changes in weather events of precipitation, temperature, and at times extreme storms. The lag time between greenhouse gas emissions and detectable weather changes results in a relatively 'weak signal' that is often interpreted as a minor impact of climate change. However, these weak weather signals, such as mean temperature changes of 2-3 deg. F, can have significant secondary impacts that can compromise critical functions in a community. Therefore, it is imperative that continued outreach efforts be made to educate the public about the causes and consequences of climate change. Increased public understanding of the issues is likely to result in broader support of various response strategies identified in this report.

Existing Weatherization Assistance Providers

Weatherization Assistance Provider	Website	Service Area
Lt. Col. Matt Urban Human Services Center of WNY	www.urbanctr.org	East side of the City of Buffalo & some other areas of Erie County.
Also a HOME Local Program Administrator and community based housing assistance.		
Neighborhood Housing Services Of South Buffalo, Inc.	www.nhssouthbuffalo.org	Parts of the City of Buffalo.
Also provides community based housing assistance.		
Supportive Services Corporation	www.supportiveservices.org	Erie County (except the City of Buffalo & Cattaraugus Reservation)
Niagara Community Action Program, Inc.	www.niagaracap.org	Niagara County.
Also provides community based housing assistance.		
PUSH Buffalo	www.greendevelopment-zone.org	West Side of Buffalo
FLARE, Inc.	www.flarecenter.org/housing	City of Buffalo

Source: New York State Homes & Community Renewal (www.nyshcr.org)

An earlier unpublished survey of decision makers in the region conducted by Dr. Himanshu Grover in 2012 revealed a lack of understanding of this issue among most decision makers. While this region is home to a number of progressive environmental organizations, there seems to be a lack of information and knowledge sharing among the governmental agencies, advocacy groups, and other decision makers. It is therefore recommended that a comprehensive online information sharing and capacity building platform be created to provide information on various incentives and grants available for weatherization, rehabilitation, and other sustainability programs in the regions. This will help increase the local impact of sustainable policies and enhance regional adaptive capacity.

Potential Agency/Actor: Local government, GBNRTC, and advocacy groups

Suggested Implementation Timeframe: Near to Short-term (1-6 yrs.)

Measures of Success: Increased understanding of climate change issues and its relevance to local development

Suggested Indicators:

1. Number of visits to the online education and knowledge-sharing platform
2. Post-intervention surveys to evaluate the role of climate change knowledge in local decision-making

C. Opportunities for Collaborative Implementation

The State of New York has been one of the leaders in promoting climate change response actions. A number of analytical studies have been undertaken and plans adopted to combat the increasing challenge of climate change. The state's initiative has also prompted regional and local efforts that are relevant to the proposed climate change response strategy. This section briefly summarizes such existing policies and initiatives that offer opportunities for collaborative implementation.

Executive Order No. 88 : This executive order adopted in 2012 directs state agencies and authorities to improve the energy efficiency of State buildings. The target is to reduce the average Energy Use Intensity (EUI) by at least 20% from a baseline average EUI for the State fiscal year 2010/2011. This order covers more than 16,000 state buildings. The New York Power Authority (NYPA) has developed guidelines that ensure that these buildings meet the required targets. Among other things this report provides detailed guidelines for conducting energy audits, retrocommissioning, and operations and maintenance. Funding and technical support is available to state agencies to implement EUI reduction measures. Additionaly, the guidelines provided by NYPA can be utilized for implementing similar energy efficiency measures in other governmental and private buildings.

New York State Climate Action Plan : The interim plan report was released in 2011. This report outlines strategies and actions necessary to achieve the established state goal of reducing greenhouse gas emissions to below 80 percent from 1990 levels by the year 2050 . The plan emphasizes the adoption of energy efficiency policies in the early phase of implementation. At the same time, the plan also indicates that these alone will be insufficient to meet the targeted reductions in state greenhouse gas emissions levels. In order to achieve the desired targets the plan outlines a portfolio of efficieny and energy use reduction policies focused on buildings and industry, power supply and delivery, agriculture, forestry, and waste sectors. The plan calls for the adoption of multiple policies from this portfolio at the local level in order to realize the targeted reductions by the year 2050.

Responding to Climate Change in New York (ClimAID) 2011 : The ClimAID project funded by NYSERDA assessed climate change impacts and adaptations for the State of New York. This report examined five themes of climate, vulnerability, adaptation, equity, and economics across eight sectors of water resources, coastal zones, ecosystems, agriculture, energy, transportation, telecommunications, and public health. A number of recommendations listed in the statewide plan are echoed in this plan. As such, the state plan does not provide any guidance for funding or financing of policy recommendations, but it does indicate that local proposals for state funding need to adress the policy priorities listed in the plan.

New York State Energy Plan 2014 : This plan outlines five strategies for promoting a clean energy system in the state: (1) Improving energy affordability; (2) Encouraging private sector energy financing; (3) Providing a resilient and flexible power grid; (4) Increased control to customers over their energy use; and, (5) Aligning energy innovation with market demand. The plan adopts the goals of reducing the intensity of energy sector carbon emissions by 50% by 2030 in line with the long term goal of 80% reduction in total emissions by 2050. An important recommendation of the plan is the establishment of a $1 billion Green Bank to encourage the investment in and development of the clean energy sector. This state-sponsored bank actually opened in February of 2014 and has been working with private businesses to increase investment and support for the state's clean energy industry, in order to develop a more sustainable energy system. The plan also supports the adoption of stricter building codes and standards to support energy efficiency and clean energy, among other recommendations. In addition the plan lays special emphasis on addressing the issues of environmental justice communities charcterized by low-income and minority residents.

Climate Smart Communities Program: As part of the overall community sustainbility initiative, the New York State Department of Environmental Conservation (DEC) provides support and guidance for communities that join the Climate Smart Communities program by formally adopting the pledge. The DEC provides support to these communities through the Climate Smart Network. Member communties receive advantages in accessing state assistance program funds and partnering with other communties that have already implemented climate smart programs. The network also provides periodic notifications to members about federal and state assistance opportunities to help adopt low-carbon technologies and energy conservation programs. Only a few communities in the Buffalo-Niagara region have adopted the climate smart communities pledge. These include Erie County, the Town of Amherst, Town of Brant, Town of Evans, Village of East Aurora, Town of Lewiston, Town of Porter, Town of Royalton, and Town of Somerset. As part of the pledge these communities are expected to appoint climate change coordinators or a task force to provide guidance and promote action to respond to climate change issues.

NYS 2100 Commission Recommendations to Improve the Strength and Resilience of the Empire State's Infrastructure: This report was commissioned in the aftermath of Superstorm Sandy to make recommendations to be taken to enable the state to respond more effectively to future storms and other extreme events. The major recommendations of the report include: (1) Protecting, upgrading, and strengthening of existing systems; (2) Smarter replacement of aging systems and infrastructure with more efficient options and alternatives; (3) Increased use of green infrastructure; (4) Intergated planning for capital investments; and, (5) Creation of new incentive programs to reduce vulnerabilities and encourage resilient behavior in local communities.

Chapter References

Bord, Richard J., Robert E. O'Connor, and Ann Fischer. 2000. "In what sense does the public need to understand global climate change?" Public Understanding of Science 9 (3):205-218.

Bostrom, A, MG Morgan, B Fischhoff, and D Read. 1994. "What Do People Know About Global Climate Change? 1. Mental Models." Risk Analysis 14 (6):959-970.

Brisman, Avi. 2001. "Considerations in establishing a stormwater utility." S. Ill. ULJ 26:505.

Doll, A, G Lindsey, and R Albani. 1998. "Stormwater Utilities: Key Components and Issues." Proc. Adv. in Urban Wet Weather Pollut. Reduction, Cleveland, Ohio, WEF (CP3805).

Gill, SE, JF Handley, AR Ennos, and Stephan Pauleit. 2007. "Adapting cities for climate change: the role of the green infrastructure." Built Environment (1978-):115-133.

Goldberg, Marshall, Jill K Cliburn, and Jason Coughlin. 2011. "Economic Impacts from the Boulder County, Colorado, ClimateSmart Loan Program: Using Property-Assessed Clean Energy (PACE) Financing." Contract 303:275-3000.

Hamada, Shuko, and Takeshi Ohta. 2010. "Seasonal variations in the cooling effect of urban green areas on surrounding urban areas." Urban forestry & urban greening 9 (1):15-24.

Mendon, Vrushali V, Robert G Lucas, and Supriya Goel. 2013. Cost-effectiveness Analysis of the 2009 and 2012 IECC Residential Provisions: Technical Support Document: Pacific Northwest National Laboratory.

Mendonça, Miguel. 2009. Feed-in tariffs: accelerating the deployment of renewable energy: Routledge.

Nowak, David J, and Daniel E Crane. 2002. "Carbon storage and sequestration by urban trees in the USA." Environmental pollution 116 (3):381-389.

8.

APPENDICES

APPENDIX A:

CHECKLIST FOR NEW DEVELOPMENT [1]

This checklist summarizes the key issues that need to be considered when climate proofing new development against the impacts of climate change.

1 Adapted from Shaw, R., Colley, M., & Connel, R. (2007). Climate change adaptation by design. TCPA.

Location		CHECK
1.	Establish existing FEMA flood risk designation(s) for the site and ensure that adequate setbacks and freeboard is incorporated into the design	
2.	Undertake a strategic flood risk assessment if the development is located within a designated flood risk zone (e.g., 100 or 500 yr. zones) or near a natural water body, taking into account the changes in local rainfall patterns, to evaluate the flood risk over the design life of the development. Ensure that the outcomes are acceptable for the proposed use(s) and, at a minimum, that there will be no overall increase in the likelihood and negative impacts of floods to downstream areas.	
Site Layout		
3.	Ensure that the overall layout and massing of the development:	
	A. Does not increase localized flood risk and where possible reduces risk	
	B. Minimizes solar gain in the summer to reduce energy demands for cooling	
	C. Maximizes natural ventilation to reduce energy demands for cooling	
4.	Determine if the development helps reduce the urban heat island effect; for example, by planning for green space and using appropriate shade when locating the development	
5.	Incorporate appropriate green infrastructure techniques for use on the site	
6.	Ensure that adequate consideration (including designation of responsibility) is given to future maintenance requirements of green infrastructure, including the need for space requirements, and where necessary, the removal of silt, which is to be treated as a controlled waste	
7.	Consider using permeable pavement when possible in all sidewalks, driveways, foot paths, car parking areas and access roads	
8.	Consider the implications of erosion when planning a development near a body of water	

9.	Ensure that the selection of vegetation with longer lives (more than 10 years) takes into account future climate change impacts	
10.	Ensure that water features have minimal net water use	
11.	Provide a rainwater collection/grey-water recycling system for watering gardens and landscaped areas	
12.	Ensure that there are arrangements for storing waste that allow for separation of waste types and prevent the emergence of excessive odors in hotter conditions	
13.	Ensure that the drainage plan for the site takes into account expected changes in precipitation patterns and is able to control excess flow safely	
Building Structure		
14.	Ensure that the structure is strong enough or able to be strengthened if wind speeds increase in the future due to climate change	
15.	Ensure that the envelope of the building is designed so that drainage systems and entrance thresholds can cope with more intense rainfall events	
16.	Ensure that there are opportunities for incorporating green roofs and/or walls	
Materials		
17.	Ensure that the materials specified will perform adequately in the climate throughout the lifetime of the development	
18.	Ensure that the exterior materials of the buildings reduce heat gain during the summer	
19.	Ensure that exterior cladding materials are able to cope with higher wind speeds	
20.	Ensure that the overall building envelope avoids infiltration from increased wind and temperatures	
Ventilation and Cooling		
21.	Ensure that the building has, or is capable of having installed, a ventilation system that will deliver comfortable temperatures for the expected climate throughout the design life of the development	
22.	Ensure that cooling and ventilation systems are as energy efficient as practicable	
Water		
23.	Ensure that the development can meet estimates of net water consumption under normal use as well as under water conservation conditions (i.e. during a drought), both initially and throughout the lifetime of the development	
24.	Minimize water use in buildings by installing water efficient cisterns	
22.	Consider the use of dual water supply systems with recycled water for non-drinking purposes	
Emergency Management		
29.	Ensure that there are backup systems in case of the failure of critical infrastructure facilities	
Community Context		
30.	Identify immediate neighborhood impacts as well as cumulative impacts and increased demand for services	
31.	Consult with utility companies and other local agencies about the capacity and resiliency of services and infrastructure for the development	

APPENDIX B:

SELF-ASSESSMENT GUIDE TO ADDRESS THE CLIMATE CHANGE SENSITIVITY & READINESS OF YOUR COMMUNITY[1]

All communities in this region are likely to face adverse impacts of climate change in the coming decades. These challenges could include a variety of extreme weather events including but not limited to more intense storm events, higher temperatures, reduced ice cover, and greater wind speeds. This self-assessment guide is designed to help local communities in the processes of planning, decision-making, and policy making for effectively addressing climate readiness issues based on recent changes they have experienced.

This self-assessment is designed as an appraisal worksheet for community leaders, administrators, planners, engineers, public works directors, and/or natural resource managers. The objective is to create a simple, straightforward and inexpensive method to review the potential climate change risks to a community. It is primarily aimed at deciphering climatic trends using experiential signals, on the basis of which the community can formulate an effective climate change response strategy.

The following worksheets in this guide address both the climate change sensitivity and readiness of a community. The cumulative impact of sensitivity and readiness will determine the present level of climate change risk faced by a community. This self-assessment guide will allow various departments in cities or townships within the two counties to conduct assessments that fit under the purview of their expertise. This evaluation will help identify areas of concern that need to be addressed to create a more resilient community.

1 This guide is adapted from "A Self-Assessment to Address Climate Change Readiness in Your Community." Chicago Metropolitan Agency for Planning, Chicago. Retrieved 2013, from http://www.cmap.illinois.gov/documents.

Worksheet 1: Built Environment Infrastructure

Anticipated climatic changes will result in increased stress on infrastructure in communities. This worksheet will assist in evaluating these impacts on your community's built environment. Responses to the following items should be available in your local hazard mitigation plan. Please record your response as "Yes" or "No".

Built Environment Infrastructure	YES (0)	NO (0)
Is there critical infrastructure (e.g., related to storm sewer or culverts) that is susceptible to extreme storm events?		
Is there any presence of significant shoreline infrastructure (e.g., related to residences, water and wastewater treatment, tourism, transportation, or industry) within the purview of the Special Flood Hazard Areas (100 yearflood)?		
Is the stipulated time limit needed to clear roads and bridges blocked by storm debris more than 3 days?		
After a 100 yr storm event		
After a 500 yr storm event		
Is the stipulated time limit needed for road washouts to be passable more than 3 days?		
After a 100 yr storm event		
After a 500 yr storm event		
Could ports and marinas be affected by extreme weather events (e.g., related to high winds or water level fluctuations)?		
Is there any shoreline structure present in the regional vicinity (e.g., levees, piers, or breakwaters) that is susceptible to extreme storm events, large waves, or erratic water level fluctuations?		
Are there any land depressions or low-lying areas within the shoreline of the local community that pose a threat to the built environment?		
Is it difficult for residents to access public transportation in the case of an evacuation required for health and safety purposes?		
Are considerations such as mitigating greenhouse gas emissions and incorporating energy efficient features included in design standards?		
Total Points (Built Environment)		

Built Environment Infrastructure Sensitivity Index Calculations

Number of Points	Sensitivity Index
9-11	3 - HIGH
5-8	2 - MEDIUM
0-4	1 - LOW

Worksheet 2: Critical Infrastructure

This worksheet provides an appraisal of the risk to critical infrastructure with respect to increased instances of flooding. Identify the expected severity of impacts for each scenario highlighted in the column headings (1- Low; 2- Medium; 3- High).

Infrastructure	Expected Flooding in relation to a 100-year, 24-hour storm	Expected Flooding in relation to a storm event that is 50% greater than the event described in column 1	Expected Flooding in relation to a 500-year, 24-hour storm
Sewage Treatment System			
Power Grid			
Drinking Water Systems			
Major Evacuation Routes			
Railway Routes			
Petroleum and Chemical Storage Facilities			
Total Points (Built Environment)			

Critical Infrastructure Sensitivity Index Calculations

Number of Points	Sensitivity Index
> 10	3 - HIGH
6-10	2 - MEDIUM
0-5	1 - LOW

Worksheet 3: Essential Facilities

This worksheet provides an appraisal of the risk of flood events to critical facilities. Identify the severity of impact for each scenario highlighted in the column headings (1- Low; 2- Medium; 3- High).

Infrastructure	Expected Flooding in relation to a 100-year, 24-hour storm	Expected Flooding in relation to a storm event that is 50% greater than the event described in column 1	Expected Flooding in relation to a 500-year, 24-hour storm
Police Station(s)			
Fire Station(s)			
City Hall			
Emergency Operation Centers			
Evacuation Shelter(s)			
Hospital(s)			
Communications Center(s)			
Public Works Facilities			
Total Points (Facilities)			

Critical Infrastructure Sensitivity Index Calculations

Number of Points	Sensitivity Index
> 16	3 - HIGH
9-16	2 - MEDIUM
0-8	1 - LOW

Worksheet 4: Operations and Maintenance

This appraisal will highlight future needs for operations and maintenance work in the community based on past experiences. Please record your response as 1 (Yes) or 0 (No).

Operations and Maintenance	YES (1)	NO (0)
Has snowplowing and snow removal increased?		
Is there a noticeable increase in the frequency of road buckle and pot hole repairs?		
Is there an increase in the frequency of sanitary sewer overflow incidents (e.g. sanitary waste overflowing into the storm sewer system)?		
Is there an increase in beach closures due to water quality issues, erosion, or high water levels?		
Is there an increase in urban tree maintenance and replacement?		
Total Points (Operations and Maintenance)		

Operations and Maintenance Sensitivity Index Calculations

Number of Points	Sensitivity Index
> 3	3 - HIGH
3	2 - MEDIUM
0-2	1 - LOW

Worksheet 5: Water Resources

This worksheet highlights areas of concern with respect to water resources. Please record your response as '1' (yes) or '0' (No)..

Water Resources	YES (1)	NO (0)
Have there been instances in the recent past during which there was a failure to meet drinking water demand or there was a need to implement restrictions on total water use?		
Has there been any reduction in water capacity or quality among private wells or community groundwater supplies?		
Are there any threats or impacts on water resources due to the results of a wildfire (related to an increase in erosion or sedimentation)?		
Is there any future beneficial use for delegated water bodies in the areas that are affected by water quality issues?		
Is any amount of untreated sewage during rain events discharged by the community waste water treatment plant?		
Is there any unnatural occurrence of shoreline erosion (e.g., along the lakes) observed?		
Total Points (Water Resources)		

Water Resources Sensitivity Index Calculations

Number of Points	Sensitivity Index
> 4	3 - HIGH
3-4	2 - MEDIUM
0-2	1 - LOW

Worksheet 6: Tourism and Recreation

This worksheet will provide an assessment of local tourism and recreation facilities with respect to the anticipated impacts of climate change. Please record your response as '1' (yes) or '0' (No).

Tourism and Recreation	YES (1)	NO (0)
Have there been any negative effects on winter tourism and recreation as a result of climate change impacts?		
Have there been any negative effects to summer tourism and recreation as a result of climate change impacts?		
Will there be a direct negative effect on park and recreation facilities due to an increase in required maintenance duties?		
Total Points (Tourism and Recreation)		

Tourism and Recreation Sensitivity Index Calculations

Number of Points	Sensitivity Index
> 1	3 - HIGH
1	2 - MEDIUM
0	1 - LOW

Worksheet 7: Climate Change Readiness Index

This worksheet provides an appraisal of community plans that are in place to address climate change issues. Please record your response as '1' (Yes) or '0' (No).

Tourism and Recreation	YES (1) (adopted or updated within the last 5 years)	NO (0) (more than 5 years since plan was adopted or updated)
Is there a local or regional climate change response plan that estimates future changes in local weather conditions?		
Is there a Hazard Mitigation Plan or Emergency Preparedness Plan in place that includes future climate change scenarios?		
Is there an evacuation plan for the community?		
Is there a storm water plan that includes estimates based on future climate change scenarios?		
Is there a land use plan in place that is sensitive to likely land-scape changes as a result of local climate change impacts?		
Is there a local/regional transportation plan in place that addresses climate change issues?		

Is there a tourism, recreation or parks plan in place that responds to future climatic changes in the community?		
Is there a local/regional plan in place by the Chamber of Commerce that addresses funding and financing opportunities for local climate change responses?		
Is climate adaptation included in private, local or state forestry management planning and projects?		
Is there a public health management plan that considers future climatic changes in the community?		
Is there a food systems management plan that considers future climatic changes to local agricultural production and distribution systems?		
Is there a water resources management plan that considers future climatic changes in resource availability projections, demand management, and pricing strategies?		
Is there a plan to promote the implementation of green infrastructure projects in the community?		
Has the community developed a baseline greenhouse gas emission database as well as a plan for reducing emissions?		
Is there a community engagement and outreach strategy to share information about the local impacts of and responses to local climatic changes expected in the future?		
Total Score (Community Plans)		

Climate Change Readiness Index Calculations

The readiness index indicates the local community's current ability to perform at an acceptable level of functionality in the face of climate impacts presently and in the future.

Number of Points	Sensitivity Index
11-15	3 - HIGH
6-10	2 - MEDIUM
0-5	1 - LOW

Worksheet 8: Estimating Climate Change Risk to the Community

Use this worksheet to estimate the overall climate change risk to the community based on the responses recorded in the preceding worksheets.

Step 1: Calculate the Overall Climate Change Sensitivity Index as the sum of all sensitivity indices calculated on worksheets 1-6.

Number of Points	Community Sensitivity Index
> 12	3 - HIGH
7-12	2 - MEDIUM
0-6	1 - LOW

Community Climate Change Sensitivity Index is: ________

Step 2: Retrieve the Climate Change Readiness Index from worksheet 7

Community Climate Change Readiness Index is: ________

Step 3: Estimate the Overall level of Climate Change Risk to the Community using the table below

Climate Change Risk		Community Sensitivity Index		
		1	2	3
Community Readiness Index	1	MEDIUM	HIGH	HIGH
	2	LOW	MEDIUM	HIGH
	3	**LOW**	**MEDIUM**	**MEDIUM**

Interpreting the Climate Change Risk Index

A HIGH risk index indicates the greatest need for climate change response actions. It signifies that a community has the greatest risks related to climate change due to its increased exposure to potential problems and lack of adaptation strategies. This type of community should immediately create and perform a vulnerability assessment, as well as identify the climate change impacts that should be incorporated into local policy actions.

A MEDIUM risk index indicates that creating climate change response actions is a medium priority for a community. This index suggests that the community either faces fewer risks or has implemented and incorporated effective strategies that have increased its climate change readiness. Nonetheless, specific sectors that require attention should be addressed at the earliest.

A LOW risk index indicates that a community has the least vulnerability and/or has effectively implemented adaptation strategies. Constant updating and monitoring of local plans and policies is required for these communities in order to ensure that their high readiness state is continually maintained into the future

APPENDIX C:

SUMMARY OF RECOMMENDATIONS

Ref. Code	Recommendation	Potential Agency/Actor	Suggested Implementation Time-Frame	Suggested Indicators
Regional/Community Scale Response Strategies				
CRS – 1	Encourage regional planning in order to coordinate development and incorporate climate change considerations into decision-making.	GBNRTC, local communities, and advocacy groups	Near- to long-term (1-10 yrs.)	• Decreased urban sprawl • Communities that are less vulnerable to the impacts of climate change
CRS – 2	Discourage the outward expansion of urban areas, and preserve large, contiguous areas of open and agricultural space.	Local communities	Near- to long-term (1-10 yrs.)	• Adoption of an adequate public facilities ordinance
CRS – 3	Promote alternative transportation infrastructure.	GBNRTC, local communities, and advocacy groups	Near- to long-term (1-10 yrs.)	• Increased length of the metro system • Increased length of bike lanes and trailways • Increased number of charging station for electric vehicles
CRS – 4	Implement enhanced flood protection measures in the region.	Local communities and advocacy groups	Near- to long-term (1-10 yrs.)	• Update of flood maps • Number of communities with enhanced floodplain management ordinances • Cumulative value of property within the 100 yr. and 500 yr. floodplain
CRS – 5	Establish storm water utility districts (SUDs).	Local communities	Near- to long-term (1-10 yrs.)	• Establishment of SUDs
CRS – 6	Conduct community scale water resource management studies.	Local communities	Near- to long-term (1-10 yrs.)	• Number of communities with updated water resource management plans
CRS – 7	Implement combined sewer overflow abatement programs in communities with CSO facilities.	Local communities	Near- to short-term (1-6 yrs.)	• Decreased instances of CSO in each community
CRS – 8	Conduct community scale climate change sensitivity analyses.	Local communities and county administrations	Near- to long-term (1-10 yrs.)	• Decreased risk to critical infrastructure facilities due to floodsGreater number of local plans and programs that incorporate climate change considerations
CRS – 9	Incorporate climate change considerations into local planning.	Local communities and county administrations	Near- to long-term (1-10 yrs.)	• Number of local plans that incorporate climate change considerations
CRS – 10	Consider adoption of dark sky legislation.	Local communities	Near term (1-3 yrs.)	• Percentage of area covered by dark sky overlay zones

Ref. Code	Recommendation	Potential Agency/Actor	Suggested Implementation Time-Frame	Suggested Indicators
CRS – 11	Work with utility companies to promote energy conservation and remove disincentives associated with reduced consumption.	Utility companies, local governments, non-profits, and advocacy groups	Near term to short term (1-6 yrs.)	• Number of households enrolled in energy conservation programs supported by utility companies
CRS – 12	Work with local businesses and homeowners to at a minimum meet, but preferably exceed the renewable portfolio standards set by the state.	Local governments, NYSERDA, non-profits, advocacy groups and utility companies	Long-term (1-10 yrs.)	• Percentage of energy derived from renewable sources
CRS – 13	Prepare community scale public health plans.	Local governments, non-profits, and local advocacy groups	Near to short-term (1-6 yrs.)	• Number of communities with climate change sensitive public health plans
Neighborhood Scale				
NRS – 1	Promote low impact development (LID) and green infrastructure projects	Local communities	Near- to long-term (1-10 yrs.)	• Number of green infrastructure projects implemented • Drainage area covered by green infrastructure projects
NRS-2	Adopt and implement urban forestry, as well as greenways and trailways plans.	Local governments, non-profits, and advocacy groups	Near to short-term	• Adoption of urban forestry, greenways and trails plans • Area brought under green features
NRS-3	(1-6 yrs.)	Local governments, non-profits, and advocacy groups	Near to short-term (1-6 yrs.)	• Percentage of community covered under local Surface Water Management Plans • Number of surface water management projects implemented
Building Scale				
CRS-1	Lobby and support initiatives to implement programs that promote the increased generation of clean energy by home owners.			
BRS -1.1	Implement a Feed-in-Tariff (FIT) program.	NYSERDA, local government, non-profits, utilities, and advocacy groups	Short-term (1-6 yrs.)	• Number of communities with FIT programs • Number of consumers enrolled post-program adoption • Estimated renewable energy generated through this program
BRS -1.2	Expand remote net-metering program to residential consumers by allowing them to be hosts.	NYSERDA, local government, non-profits, and advocacy groups	Near-term (1-3 yrs.)	• Number of residential consumers enrolled in the program as host • Estimated energy generated through this program

Ref. Code	Recommendation	Potential Agency/Actor	Suggested Implementation Time-Frame	Suggested Indicators
BRS -1.3	Implement Property Assessed Clean Energy (PACE) program.	NYSERDA, local governments, non-profits, and advocacy groups	Near-term (1-3 yrs.)	• Number of projects implemented under PACE • Estimated renewable energy generated through PACE projects
CRS-2	Modify local building codes to promote climate friendly development that incorporates new techniques and technologies.	Local governments, construction industry, and developers	Near to short-term (1-6 yrs.)	• Adoption of changes to the building codes • Number of construction projects that include green building technologies
CRS – 3	Adopt stricter energy codes for new construction.	Local governments, construction industry, and developers	Near to short-term (1-6 yrs.)	• Adoption of changes to building codes • Number of construction projects implemented with new IECC codes
CRS - 4	Establish a regional/bi-county revolving fund for promoting energy efficient rehabilitation of existing buildings.	County departments, local communities, and advocacy groups	Near term (1-3 yrs.)	• Amount of money earmarked for the fund • Number of loans provided by the fund

ONE REGION FORWARD

Learn more by visiting us online.
www.oneregionforward.org