Chapter 8. Climate Change

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Solar panels at the Environmental Cooperative at the Vassar Barns, Vassar Farm and Ecological Preserve.
Photo credit: Karl Rabe for Vassar College

Climate Change in New York

There is widespread scientific consensus that the Earth's climate is changing as a result of human activity. Generated by the burning of fossil fuels and other industrial processes, greenhouse gases like carbon dioxide accumulate in the planet's atmosphere, trapping heat that would normally escape into space and heating the planet over time (NASA, 2018). The evidence is overwhelming: the planet's average surface temperature has risen 2° F since the late 19th century, sea levels are rising, and the number of extreme heat and weather events is increasing (NASA, 2018). In 2014, the New York State Energy Research and Development Authority (NYSERDA) updated their ClimAID, Responding to Climate Change in New York State,

Figure 8.1. Climate Regions of New York State (Rosenzweig 2011). Dutchess County is located in Region 5 – East Hudson and Mohawk River Valleys.

technical report with new projections of the impact of climate change in New York State, including Dutchess County (Region 5, Figure 8.1) (Rosenzweig, et al., 2011; Horton, Bader, Rosensweig, DeGaetano, & Solecki, 2014). Additionally, in 2014, Governor Andrew Cuomo signed the Community Risk and Resiliency Act (CRRA) requiring the adoption of sea-level rise projections for three geographic regions of the state (NYS Department of Environmental Conservaiton, 2019) (Figure 8.2).

	Region	Long Island					New York City/Lower Hudson					Mid-Hudson				
	Descriptor	Low	Low-Medium	Medium	High-Medium	High	Low	Low-Medium	Medium	High-Medium	High	Low	Low-Medium	Medium	High-Medium	High
Time Interval	2020s	2	4	6	8	10	2	4	6	8	10	1	3	5	7	9
	2050s	8	11	16	21	30	8	11	16	21	30	5	9	14	19	27
	2080s	13	18	29	39	58	13	18	29	39	58	10	14	25	36	54
	2100	15	21	34	47	72	15	22	36	50	75	11	18	32	46	71

Figure 8.2. NYS sea-level rise projections in inches by time period relative to 2000-2004 baseline data, 6 NYCRR Part 490. Poughkeepsie is located in the New York City/Lower Hudson Region

Air Temperature

Air temperature is predicted to increase in Poughkeepsie and the Hudson Valley (Figure 8.3). Based on the 2014 ClimAID Report (Horton, Bader, Rosenzweig, DeGaetano, & Solecki, 2014), the annual average air temperature is projected to rise as much as 6.1-11.4 °F by the year 2100, with an estimated minimum rise in temperature of 4.4 °F . The annual average temperature of this region has already risen by 2.4°F since 1970, including a winter temperature increase of more than 4.4°F (NYS Department of Environmental Conservation, 2018), exceeding these low projections. Rising temperature can be a human health concern as warmer temperatures exacerbate asthma, allergies, and other respiratory conditions, especially in susceptible individuals such as young children and the elderly. Risk of Lyme disease may also increase: a lengthening of the warm season allows ticks to be active for longer and for a greater number of people to be exposed (United States Environmental Protection Agency, 2016).

AIR TEMPERATURE PROJECTIONS FOR REGION 5

	Baseline 1971-2000	2020s	2050s	2080s	2100
Annual average air temperature	50°F	52.3 - 53.2°F	54.5 - 56.2°F	55.6 - 59.7°F	56.1 - 61.4°F
Increase in annual average	-	2.3 - 3.2°F	4.5 - 6.2°F	5.6 - 9.7°F	6.1 - 11.4°F

Figure 8.3. Air temperature projections for Region 5 of the Hudson Valley, including Poughkeepsie. Table from *Climate Change Projections in the Hudson River Estuary* (Zemaitis, 2017); adapted from data presented in *Responding to Climate Change in New York State* (Rosenzweig, et al., 2011 and Horton, Bader, Rosenzweig, DeGaetano, & Solecki, 2014).

Precipitation

Up to a 21% increase in precipitation can be expected for the Eastern Hudson Region of New York by the year 2100 (NYS Department of Environmental Conservation, 2014). Projections of total annual precipitation for the Hudson Valley show an increase from the baseline of 51 inches per year to as much as 61.5 inches in 2100 (Figure 8.4) (Horton, Bader, Rosenzweig, DeGaetano, & Solecki, 2014). The year-to-year and decade-to-decade variability of precipitation in this region, and around the globe, is becoming more pronounced. Between 1958 and 2012, the Northeast saw a 71% increase in the precipitation that came down in heavy events (US Global Change Research Program, 2014). As precipitation increases in general, it is likely to increase in the winter and spring with no significant changes in the summer and fall (United States Environmental Protection Agency, 2016). Flash flooding will become more persistent with heavy rainfall and will increase the risk of erosion (NYS 2100 Commission, 2013).

PRECIPITATION PROJECTIONS FOR REGION 5

	Baseline 1971-2000	2020s	2050s	2080s	2100
Total annual precipitation	51"	52" - 54.5"	53" - 57"	53.5" - 58.5"	53.5" to 61.5"
% Increase in annual precipitation	-	2 - 7%	4 - 12%	5 - 15%	5 - 21%
# Days with precipitation > 1"	10	14 - 15	14 - 16	15 - 17	*
# Days with precipitation > 2"	1	3 - 4	4	4 - 5	*

Figure 8.4. Precipitation projections for Region 5 of the Hudson Valley, including Poughkeepsie. Table from *Climate Change Projections in the Hudson River Estuary* (Zemaitis, 2017); adapted from data presented in *Responding to Climate Change in New York State* (Rosenzweig, et al., 2011 and Horton, Bader, Rosenzweig, DeGaetano, & Solecki, 2014)

Severe Weather

Flooding and drought are risks associated with both the increase of precipitation and air temperature. As temperatures get warmer, snow will melt earlier in the spring and evaporation will increase, causing drier soils in the summer. Combined with higher summer temperatures and flashier rain events, this will cause an increase in drought conditions (United States Environmental Protection Agency, 2016). Extreme heat events are described as days where the air temperature is at or above 90 °F, and heatwaves are when there are three days in a row when the temperature is at or above 90 °F (Figure 8.5) (Horton, Bader, Rosenzweig, DeGaetano, & Solecki, 2014). Heatwave health concerns disproportionally affect low-income populations due to lack of access to air conditioning and green space. In cities with a high density of asphalt and buildings that absorb heat, a "heat island" effect can take place as the absorption of heat increases air temperature. Municipalities can combat increasing air temperature by planting trees in urban areas, creating a canopy of leaves that shades both asphalt and people from the sun and decreases the need for air conditioning, thus keeping energy needs low. Trees, especially conifers, can also shield buildings from cold winds in the winter, decreasing the energy used for heating (NYS 2100 Commission, 2013). Cooling centers are becoming common practice to provide relief for residents without access to air conditioning. In 2018, for example, a City cooling center was available at the Public Safety Building at 505 Main Street. In addition to increasing temperatures and rainfall, the occurrence of superstorms, such as Sandy in 2012, will increase. During Sandy, the City of Poughkeepsie measured the highest watermark in the Hudson Valley resulting in a 5.1 ft.

inundation (Blake, Kimberlain, Berg, Cangialosi, & Beven II, 2012). These storms are no longer abnormalities, and flooding events are predicted to increase in frequency due to climate change (Figure 8.6) (NYS 2100 Commission, 2013).

HEAT WAVE PROJECTIONS FOR REGION 5

	Baseline 1971-2000	2020s	2050s	2080s	2100
# Days per year above 90˚F	10	26 - 31	39 - 52	44 - 76	*
# Days per year above 95˚F	1	2 - 4	3 - 10	6 - 25	*
# Heat waves per year	1	3 - 4	5 - 7	6 - 9	*
Average # days of each heat wave	4	5	5 - 6	5 - 7	*
# Days per year ≤ 32˚F	155	127 - 136	104 - 119	84 - 109	*

Figure 8.5. Heat wave projections for Region 5 of the Hudson Valley, including Poughkeepsie. Table from *Climate Change Projections in the Hudson River Estuary* (Zemaitis, 2017); adapted from data presented in *Responding to Climate Change in New York State* (Rosenzweig, et al., 2011 and Horton, Bader, Rosenzweig, DeGaetano, & Solecki, 2014)

FLOOD PROJECTIONS FOR COASTAL NY

	Baseline 1971-2000	2020s	2050s	2080s	2100
Increase in probability of 100-year flood	0%	20 - 50%	70 - 190%	140 - 610%	*
Flood height of 100-year flood	15'	15.3 - 15.7'	15.9 - 16.8'	16.5 - 18.3'	*

Figure 8.6. Flood projections for Coastal NY. Table from *Climate Change Projections in the Hudson River Estuary* (Zemaitis, 2017); adapted from data presented in *Responding to Climate Change in New York State* (Rosenzweig, et al., 2011 and Horton, Bader, Rosenzweig, DeGaetano, & Solecki, 2014)

Sea Level

Coupled with a projected increase in the probability of major flooding events in the coming decades, sea-level rise (SLR) poses a pressing challenge to Poughkeepsie's infrastructure. Projections estimate the potential for 8-30 inches of sea-level rise by the 2050s (Figure 8.7) (Horton, Bader, Rosenzweig, DeGaetano, & Solecki, 2014). The higher the water level, the greater the potential for costly damage to waterfront property. For example, predictions from Columbia University's Center for International Earth Science Information Network (CIESIN) show that after 72 inches of sea-level rise, close to $3.4 million in damage following a 100-year flood event may occur (Figure 8.8) (Center for International Earth Science Information Network, 2018). This predicted cost includes 18 damaged buildings, four wastewater discharge sites, one mile of power transmission line, and 53 acres of total inundated land in Poughkeepsie's waterfront area. Based on projections of sea-level rise from these models, it would be in the City's best interest to consider flooding as a serious threat to infrastructure when discussing development projects along the Hudson River shoreline. Additionally, the census block groups impacted by such flood events are considered "highly socially vulnerable," a CDC definition that includes high poverty rates, lack of access to transportation, and overcrowded housing (Agency for Toxic Substance and Disease Registry, 2018; Center for International Earth Science Information Network, 2018).

Both Scenic Hudson and (CIESIN) (Center for International Earth Science Information Network, 2018; Scenic Hudson, 2013) offer interactive, online flood mapping tools for the Hudson Valley. Pictured below (Figures 8.9-8.13) is an example of one flooding model (72

inches SLR) for the City of Poughkeepsie from the CIESIN mapper (Center for International Earth Science Information Network, 2018).

Please refer to one or both of the following sites to explore the full range of future flood scenarios in the City of Poughkeepsie:

- CIESIN's Hudson River Flood Impact Decision Support System Version 2: newly updated in 2018 this is a sophisticated modeling tool. It allows the user to input different flood scenarios and gives information on the cost of damage as well as areas impacted.
  http://www.ciesin.columbia.edu/hudson-river-flood-map/
- Scenic Hudson's Sea Level Rise Mapper: User-friendly mapper allows a user to input different scenarios of sea level rise. Good for a non-technical audience.
  http://www.scenichudson.org/slr/mapper.

SEA LEVEL RISE PROJECTIONS FOR THE HUDSON

	Baseline 1971-2000	2020s	2050s	2080s	2100
Mid-Hudson region	-	1 - 9"	5 - 27"	10 - 54"	11 - 71"
NYC/Lower Hudson region	-	2 - 10"	8 - 30"	13 - 58"	15 - 75"

Figure 8.7. Ranges of projected sea level rise for the Hudson Valley. Graphs adapted from data presented in *Responding to Climate Change in New York State* (Rosenzweig, et al., 2011 and Horton, Bader, Rosenzweig, DeGaetano, & Solecki, 2014) and summarized in *Climate Change Projections in the Hudson River Estuary* (Zemaitis, 2017).

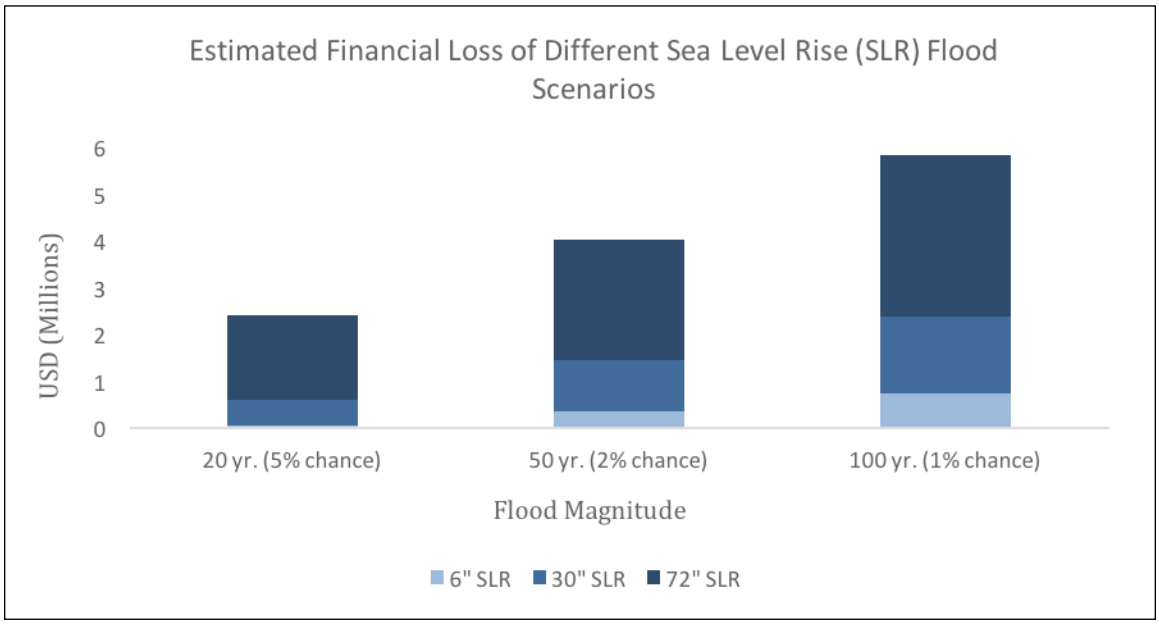

Figure 8.8. A comparison costs of different flood scenarios from CIESIN's Hudson River Flood Impact Decision Support System Version 2. Data from CEISN, 2018

Figure 8.9

Figure 8.10

Figures 8.9- 8.13. . A series of screenshots from the CEISIN flood impact mapper showing the extent of flooding along the shore of the Hudson in the City of Poughkeepsie. This flooding scenario was created using the mapper for a 100yr flood at 72 in of sea-level rise (Center for International Earth Science Information Network, 2018).

Figure 8.11

Figure 8.11

Figure 8.12

Climate Resiliency

Though the impacts of climate change are impossible to predict, many of the current and likely outcomes of climate change warrant an effective and comprehensive response at both the community and legislative scale. In 2018, Cornell Cooperative Extension, Dutchess County, completed a Climate Smart Resiliency Planning Tool (CSRP) for the City of Poughkeepsie (Gluck, 2018) (Appendix H). This tool evaluates opportunities, strengths, and gaps in the City of Poughkeepsie's planning process, focusing on improving resilience to flooding and climate change. The CSRP Tool lists recommendations for the City in regard to future Climate planning and are summarized in Appendix H, these include:

- Comprehensive Plan Update
- Zoning Code Update/Downtown Rezoning Initiative
- Creation of a Climate Resiliency Plan
- Local Waterfront Revitalization Project (LWRP) Update
- Creation of an Emergency Preparedness Plan
- Website Updates/Public Outreach Opportunities
- Creation of a Conservation Advisory Council

The CSRP was presented to the Waterfront Advisory Council which then submitted a recommendation to the City Council to adopt the NYS Climate Smart Communities Pledge on October 22, 2018. On May 20, 2019 the Poughkeepsie City Council passed a resolution (Resolution R19-53) approving the adoption of a Climate Smart Communities Pledge.

Many of the ecosystem services that natural areas provide assist in climate resiliency. Healthy natural areas are able to respond to environmental changes more easily and can buffer infrastructure and people from impacts due to climate change. These ecosystem-based approaches for climate adaptation and resiliency have been shown to be both cost-effective and broadly applicable for a variety of climate threats and scenarios while providing co-benefits such as neighborhood beautification (Munang, et al., 2013).

By taking stock of the natural resources within the City of Poughkeepsie, this NRI provides a foundation for future sustainability and climate adaptation efforts. Other chapters in the NRI provide information that is relevant to developing a climate resilient community (Table 8.1).

Table 8.1. An index of the NRI maps in relation to how the natural resources they illustrate are related to Climate Change impacts and resiliency.

Chapter	Maps	Comments
3. Water Resources	Culverts Water Quality Imperviousness Floodplains Wetlands Watersheds Groundwater & Aquifers	Knowing the locations of culverts and wastewater discharge areas, especially in relation to impervious surfaces and flood hazard areas, will help prioritize flood mitigation/Green Infrastructure projects. The wetlands, groundwater, and watershed maps show us where our water is flowing and collecting, which will help prevent contamination and flooding events as well as provide insight into sources of runoff and impacts on water quality and quantity.
4. Biological Communities/Habitats	(Hudsonia Maps) Significant Habitats Large Habitat Patches Public Access Greens-paces Shoreline Materials Habitat Envelopes Conservation Zones	Large open spaces and parks should be preserved to provide natural areas for the infiltration of groundwater and access by residents to shaded, cooler areas for recreation. Habitat envelopes and large habitat patches should be preserved throughout the city. Shore-line materials should be maintained to prevent major flooding damage. Sustainable shorelines that incorporate vegetation could be considered that create habitat as well as buffer flooding, tidal and storm impacts.
5. Land Use	Land Use Street Trees Canopy Cover EAB	Tree canopy along streets, parks, private lots and open spaces should be increased to help increase shade, reduce air temperature, and decrease runoff during rain events. The EAB map will help prioritize tree planting sites. The Land Use map will allow us to identify vacant lots/brownfields and other areas that can be used for green infrastructure or urban ecology projects.
6. Recreational Resources	Recreational Resources	Parks and other vegetated open spaces in the City provide resilience by cooling air, infiltrating precipitation and runoff, and sequestering atmospheric carbon.
7. Historical Resources	Historic Resources (Downtown and Full City)	These maps display important historic sites that may be at risk due to sea-level rise and flooding. These areas may be fortified to protect against potential damage or destruction. Locations of Historic Resources in relation to flood zones and other sensitive areas is important when considering future planning and development in the City.

Collaboration with neighboring communities—and especially those in the Fall Kill and Casperkill watershed—is important as storm events and flooding become more frequent and severe. For example, increases in impervious surfaces throughout the watershed will have an impact on the amount of water flowing into the City of Poughkeepsie. In 2009 a Memorandum of Agreement was signed by four of the five municipalities in the Fall Kill Watershed to create a Fall Kill Intermunicipal Council (Appendix I). This council has been inactive in recent years, but revisiting the effort may be worthwhile as the impact and costs of climate change become more apparent. The City of Poughkeepsie cannot work in isolation when considering climate change and collaborating with neighboring municipalities will help to promote solutions and adaptations that are more cost-effective and benefit more of the residents of the Hudson Valley.

Additional Resource:

New York State Climate Change Science Clearinghouse -https://www.nyclimatescience.org

Appendices

A: Significant Habitats in the City of Poughkeepsie

B: Ash Tree Assessment and Emerald Ash Borer Management Plan

C: College Hill Park Invasive Species Survey

D: Poughkeepsie Scenic Resources Inventory

E: Metadata for maps included in the Natural Resources Inventory

F: Species of Conservation Concern in the City of Poughkeepsie, NY

G: City of Poughkeepsie Zoning Map

H: Climate Smart Resiliency Planning for the City of Poughkeepsie

I: Fall Kill Intermunicipal Agreement