

Cross-Sectoral Economic Impact Analysis of Climate Change in New York State

Chapter 1: Methodology

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Cross-Sectoral Economic Impact Analysis of Climate Change in New York State

Chapter 1: Methodology

Final Report

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Notice

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Abstract

This chapter summarizes the overall methodology used throughout the report. The analyses in the report project the impacts and economic costs of climate change within eight sectors under different climate, socioeconomic, and adaptation scenarios, reflecting key uncertainties in future climate impacts for New York State through 2100. A literature search was conducted to identify information and models relevant to this study. Climate change inputs and scenarios were then developed for use as inputs to the impact models and approaches. Projected socioeconomic inputs, including population and gross domestic product (GDP) were developed, as other inputs as required by the models. The models were then run, resulting in estimates of projected economic impacts across New York State

Keywords

climate change, impacts, economics, projections, scenarios, adaptation, socioeconomic

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We also wish to acknowledge the valuable insights and contributions from IEc subcontractors Resilient Analytics, Dr. Cameron Wobus, and Dr. Michael Craig, as well as collaborators from Energy and Environmental Economics (E3). Resilient Analytics provided detailed impact and adaptation modeling for the Transportation sector (Chapter 8); Dr. Wobus supported the inland flood risk analyses in the Buildings sector (Chapter 3); and Dr. Craig supported analyses of the impact of warming on thermal generation performance and transmission line capacity in the Energy sector (Chapter 5).

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Acronyms and Abbreviations

AEO	Annual Energy Outlook
CMIP6	Coupled Model Intercomparison Project Phase 6
EPA	Environmental Protection Agency
EPPA	Economic Projection and Policy Analysis
GCM	global climate models
GDP	gross domestic product
GHG	greenhouse gas
ICLUS	Integrated Climate and Land Use Scenarios
IPCC	Intergovernmental Panel on Climate Change
NCA	National Climate Assessment
NOAA	National Oceanographic and Atmospheric Administration
NYS	New York State
NYSCIA	New York State Climate Impacts Assessment
PAC	Project Advisory Committee
SSP	Shared Socioeconomic Pathway
VSL	value of statistical life

Report Summary

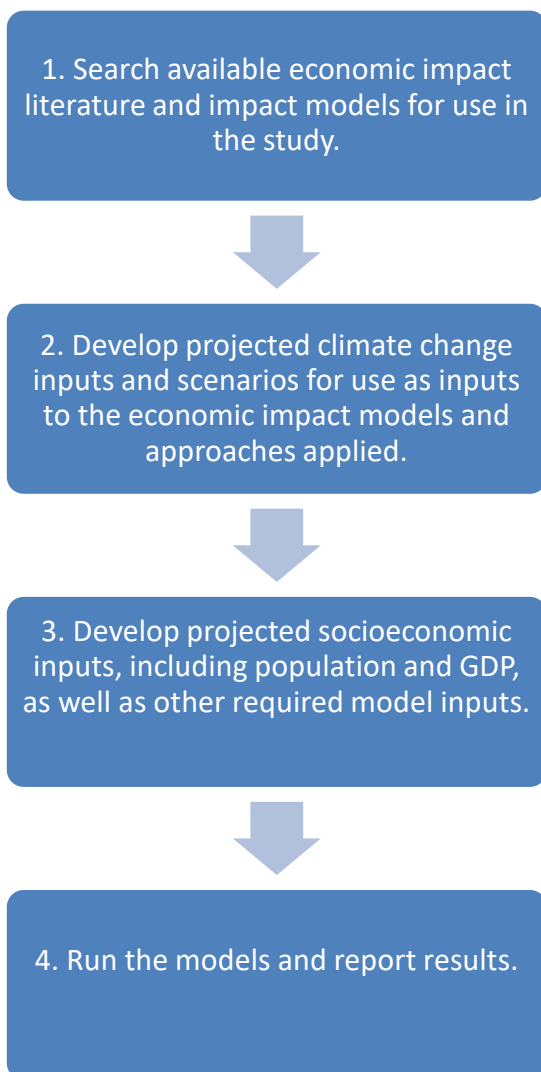
This chapter is part of a report that projects the economic impacts of climate change in New York State across eight sectors through 2100 under multiple climate, socioeconomic, and adaptation scenarios. The research team identified and applied existing literature and models to quantify or qualitatively assess climate-related impact categories, using standardized climate and socioeconomic inputs. The analysis used downscaled Coupled Model Intercomparison Project Phase 6 (CMIP6) climate data and gross domestic product (GDP)/population projections to estimate sector-specific impacts under Shared Socioeconomic Pathway (SSP)2-4.5 and SSP5-8.5 emissions scenarios. While the estimates reflect current best practices and modeling capabilities, limitations such as data availability, missing feedback loops, and gaps in demographic sensitivity likely lead to underestimation of total impacts.

1 Introduction

This chapter summarizes the overall methodology used throughout the report. The analyses in the report project the impacts and economic costs of climate change within eight sectors under different climate, socioeconomic, and adaptation scenarios, reflecting key uncertainties in future climate impacts for New York State through 2100.

The study uses a four-step approach, as shown in Figure 1-1.

Figure 1-1. Four Steps for Assessing Economic Impacts of Climate Change in New York State



For the first step, the project team searched literature and contacted experts in impact assessment methodology to identify relevant literature and models that might be applied in this study. The result formed the sectoral and impact scope of the quantitative assessment. Some studies and models identified in this step could not feasibly be applied for New York State resources or for multiple climate and socioeconomic scenarios, but they formed the basis for the partially quantified and qualitative analyses of impacts that supplement the more fully quantitative estimates.

The second step involved accessing relevant climate change projections for use as inputs to the models identified in the first step. The climate change projections developed by Columbia University for the New York State Climate Impacts Assessment (NYSCIA) were used, but some adjustments were applied to ensure the climate scenarios matched the temporal and spatial scale climate hazard input requirements for the models identified in Step 1.

The third step involved developing socioeconomic inputs for future population and economic activity (gross domestic product, or GDP) for use in the economic impact models. This step was designed to ensure the projections of economic impact reflect the future, rather than current, socioeconomic context in which they are expected to be experienced.

The fourth step involved applying the models and approaches identified in step 1 and reporting results. The details of this step are provided in Chapters 2 through 9 for individual impact categories (e.g., Energy: Electric Energy Supply and Demand, or Human Health and Safety: Extreme Temperature Mortality). Estimating future impacts in all cases involved certain impact specific data collection, assumptions, and modeling limitations that differ across impact categories—additional methodological details and specific data references for each sector and impact category are provided in Appendix B.

The results are presented for three future eras:

- The 2030s (2020–2049), centered on 2035, also called near century
- The 2050s (2040–2069), centered on 2055, also called midcentury
- The 2080s (2070–2099), centered on 2085, also called late century

Consistent with the climate modeling performed for the NYSCIA, results are also presented for two greenhouse gas (GHG) emissions scenarios: a moderate emissions variant (Shared Socioeconomic Pathway (SSP), SSP2-4.5, and a high-emissions variant, SSP5-8.5.

Ranges of results are also presented for each impact category that reflect the results of individual global climate models, providing a measure of the climate forecasting uncertainty in the impact results.

An analysis was also done to estimate the fiscal impacts to New York State government expenditures and revenues, including both physical outputs (e.g., new cases of asthma attributed to climate change) and economic outputs (e.g., changes in the repair costs required to keep roads in New York State in good condition). It should be noted that this type of fiscal impact analysis is less well developed in the climate impacts literature; as such, the results are not included in the aggregate economic analysis. However, this information is of increasing interest to governments, so the detailed methodology and results for the fiscal impact analysis is described in Appendix C.

2 Identifying the Scope of Impacts for the Study

The project team conducted a literature review to identify a broad array of potentially relevant studies that constitute the landscape of past and ongoing research related to economic climate change impacts likely to affect New York State. The literature review process had three main components: review of major multi-sectoral climate impact studies, general web-based literature search, and subject matter expert network contacts.

The process began with a review of the 2011 ClimAID study (focusing on Annex III, “An Economic Analysis of Climate Change Impacts and Adaptations in New York State”) (Leichenko et al. 2014). This report provides a base set of economic analyses of climate change in the State. These analyses not only offer methodological options for the current work but also give a sense of the sectors that were important in 2011. Next, the team reviewed relevant models from the U.S. Environmental Protection Agency’s (EPA) CIRA2.0 Technical Report supporting the Fourth National Climate Assessment (NCA4) (EPA 2017a). The CIRA2.0 report quantifies potential physical and economic damages nationally and across seven U.S. regions using a consistent modeling framework and climate scenarios. Finally, the team reviewed work from the Climate Impact Lab (Hsiang et al. 2017 and associated literature), which includes a broad range of published studies of national climate impacts.

The expert review included the internal project team and external contacts with expertise in the agriculture, water resources, infrastructure, natural sciences, and human and public health disciplines. Each internal expert provided a list of contacts and provided summaries of their conversations with external contacts, as well as recommended citations or research groups with potentially relevant work.

This provided a check on the process to ensure full coverage of potentially relevant studies. Appendix B provides details on the approach and scope of expert contacts.

Finally, the literature review was supplemented with a formal literature search using Scopus and Google Scholar, conducted by the authors of this analysis. In addition, some literature was suggested by New York State Energy Research and Development Authority (NYSERDA) staff, the economic analysis Project Advisory Committee (PAC), and the expert team described in the previous paragraph. This process yielded a database of 292 citations, 182 of which quantified impacts, with 105 of those quantifying economic impacts. Appendix B provides additional details.

The list was winnowed by considering several factors, which included the following:

- Geographic coverage of the study—State-level studies in New York State were preferred, with all else being equal.
- Types of economic outcomes covered—Many physical impacts have associated economic losses, so it is important to consider which losses are modeled in each study, get a sense of the complete quantifiable loss, and look for opportunities to combine or layer studies without double counting.
- Sound/accepted methodology—In general, peer-reviewed studies were prioritized. Experts also offered specific feedback as to the accepted methods for analyzing each of the sectors of damage.
- Adaptation considerations—Studies that consider adaptation were preferred, because recent history has shown that adaptation is a realistic response to climate stressors, which most often has the effect of reducing economic estimates of impacts (that is, adaptation is very often a cost-effective response to climate stress, where the costs of adaptation are less than the benefits of risk reduction).

The result of this process is shown in Table 1-1. A total of 21 impact categories are fully quantified in this study. A fully quantified impact is one for which a peer-reviewed publication provides an indicator of high quality, one that produces economic or monetizable physical impacts as results, and one where the result can be re-estimated using the climate scenarios applied in this study. Another 30 impact categories are partially quantified or discussed qualitatively. These impacts have a well-established conceptual basis linking the impact to a climate hazard, but the impact method is not yet peer reviewed or cannot produce an economic impact or monetizable physical impact or where the result cannot yet be re-estimated using updated climate scenarios.

The fully quantified categories provide different measures of economic impact. The types of results vary from lost revenue, increased expenditures, lost wages, or loss of economic welfare, such as the value of statistical life (VSL), which is a measure of willingness of potentially affected individuals to pay to reduce the risk of mortality. Strictly speaking, comparison of the magnitude of impact across these metrics should consider the differences in metrics, and aggregation across multiple economic metrics, while not a main goal of this study, is often presented (see, for example, EPA 2017a).

Note that the eight sectors used to organize this study follow the structure of the overall NYSCIA. The definitions of the scope of each sector can be found on the NYSCIA website (NYSERDA 2026).

Table 1-1. Quantified and Partially Quantified Impacts for Each Sector

Note: Economic impacts are measured as lost revenues (R), lost wages (W), lost economic welfare (EW), increased expenditures (E), or a combination of multiple metrics.

Quantification	Chapter 2 Agriculture Sector	Chapter 3 Buildings Sector	Chapter 4 Ecosystem Sector	Chapter 5 Energy Sector	Chapter 6 Human Health and Safety	Chapter 7 Society and Economy	Chapter 8 Transportation Sector	Chapter 9 Water Resources Sector
Fully Quantified	• Dairy production (R) • Crop production (R)	• Coastal properties (E) • Inland flooding (E)	None quantified ^a	• Electric transmission and distribution (E) • Energy supply and demand (E)	• Extreme temperature (EW, E) • Air quality (EW, E) • Aeroallergens (E) • Infectious disease (E)	• Labor (W) • Recreational freshwater fishing (EW) • Winter recreation (R) • Other outdoor recreation (EW)	• Roads (E) • Rail (E) • Coastal roads (EW, E)	• Water quality and harmful algal blooms (EW) • Municipal and industrial water supply (E) • Urban drainage (E)
Partially Quantified or Qualitative	• Wine production • Apple production • Livestock and poultry • Maple syrup production • Aquaculture	• Military installations • Great Lakes water levels	• Water turbidity • Soil erosion • Forest health • Invasive species • Biodiversity	• Communication infrastructure	• Cognition and learning • Food safety • Health effects of power outages/extreme events • Indoor air quality • Mental health (EW) • Wildfire	• Commercial marine fishing • Crime • Shellfish • Shoreline/Beach access • Recreational marine fishing • Timber harvesting	• Ports and small harbors • Air transport • Bridges • Subways	• Saltwater intrusion • Harmful algal blooms

^a The Ecosystems sector includes a wide range of impacts that affect economic output, but none of these impacts could be reliably quantified for this report.

3 Climate Scenarios

Climate scenarios are fundamental to a climate change impact study. When applied across sectoral studies, a consistent set of climate scenarios provides a reliable means for comparing sectoral results across projection years and provides a stronger basis for prioritizing investments in climate risk mitigation and adaptation action. Coupled with consideration of GHG emissions scenarios, the climate scenarios used as inputs to the sectoral studies provide a means to understand the sensitivity of sectoral inputs to varying levels of climate stress.

The climate scenarios applied in this report are based on available United Nations Intergovernmental Panel on Climate Change (IPCC) global climate models (GCMs), from the Coupled Model Intercomparison Project Phase 6 (CMIP6) suite of models. The data were further processed for use in this study by Columbia University, as described in the NYSCIA report on climate projections.¹

In light of computational and resource limitations, many ongoing climate impact modeling efforts strategically choose a subset of the available climate models to reflect a range of outcomes, from warm and wet, to hot and dry, compared to a current baseline (e.g., EPA 2017a, 2021).² That approach is adopted in this report as well. The overall NYSCIA team, including climate scientists and impact assessors, worked collaboratively to identify a set of six GCMs that represent a range of potential temperature and precipitation outcomes across New York State. A daily resolution of downscaled climate forecasts was then developed and includes estimates for daily minimum and maximum temperature, as well as daily total precipitation. Finally, a transient climate projection, representing a full twenty-first century time series of daily results, was developed from the NYSCIA climate scenarios. The technical details describing the process of developing these estimates are described in more detail in Appendix A.

This study makes use of two GHG scenarios—SSP2-4.5 and SSP5-8.5. The IPCC has not assigned likelihoods to its GHG scenarios SSPs, and scientists and policymakers continue to debate which of these trajectories seems most plausible.

¹ See <https://nysclimateimpacts.org/explore-the-assessment/new-york-states-changing-climate/> for more information on the official New York State Climate Impact Assessment climate projections and the methods used. Additional information is also available in Appendix A of this report.

² The process used to identify the six GCMs used in this report is described in Appendices A and B.

The projections methodology report for the NYSCIA provides a detailed rationale for focusing on SSP2-4.5 and SSP5-8.5 in the projections developed for the assessment. Among other factors, the methodology report notes that even if GHG emissions are likely to be lower than the SSP5-8.5 trajectory, retaining SSP5-8.5 can help to capture the broad range of plausible climate impacts, including high-consequence impacts that are critical for risk management.

4 Socioeconomic Scenarios

Socioeconomic condition forecasts are a desired component of an economic impact analysis to ensure that impacts are measured in their proper future context, rather than in the context of current socioeconomic conditions. Two types of socioeconomic inputs are used in this economic impact analysis: population forecasts and GDP forecasts. Impacts are estimated at the county level or finer spatial scale through 2100.

4.1 Population Forecasts

Population forecasts are used as an input for a broad range of health, infrastructure, agricultural, and ecosystem sector impact studies. Spatial differentiation of populations across rural and urban contexts is important, particularly for health studies, where the marginal impact of climate stressors can vary. For example, extreme temperature mortality in the studies applied in this analysis are differentiated across urban and rural settings at the county level.

This study adopts county-level population forecasts from U.S. EPA's Integrated Climate and Land Use (ICLUSv2) model. The spatial pattern of population change in ICLUSv2 is dependent upon underlying assumptions regarding fertility, mortality, migration rate, and international immigration. These assumptions were parameterized using the storyline of the IPCC's SSP2, which suggests medium

levels of fertility, mortality, and international immigration.³ The impacts of climate change on future U.S. population are not factored into the ICLUSv2 projections. As such, the population projection does not include feedbacks of climate impacts that may lead to higher or lower populations at the regional level.⁴

This study adopts county-level population forecasts from U.S. EPA's Integrated Climate and Land Use (ICLUSv2) model. The spatial pattern of population change in ICLUSv2 is dependent upon underlying assumptions regarding fertility, mortality, migration rate, and international immigration. These assumptions were parameterized using the storyline of the IPCC's SSP2, which suggests medium levels of fertility, mortality, and international immigration.⁵ The impacts of climate change on future U.S. population are not factored into the ICLUSv2 projections. As such, the population projection does not include feedbacks of climate impacts that may lead to higher or lower populations at the regional level.⁶

4.2 Gross Domestic Product Forecasts

GDP inputs are used in several sector studies, sometimes as a direct driver. For example, the study of impacts on roads and rail uses GDP as a driver of future freight traffic for both transportation modes. More commonly, GDP is used in combination with a population growth forecast to estimate future changes in household income, assumed to approximately track with GDP per capita. Projections of GDP at fine spatial scales are sometimes developed but are not available through 2100.

This study adopts a national, full-century-scale projection of GDP growth that combines a commonly used GDP projection through 2050 with one of the few available projections through 2100. The short-term projection is from the most recent version of the U.S. Energy Information Administration's (EIA) *Annual Energy Outlook* (AEO) available at the time analytic commitments were made for the economic impact modeling. The AEO 2021 variant has projections to 2050 but does not extend beyond that year.

³ The ICLUSv2 model, as well as the assumptions used in this run of the model, represent one framework for projecting population and demographic change across the U.S. Alternative models or specifications could lead to different outcomes than those reported in the report.

⁴ The New York State Department of Labor provides official statewide, county-level population projections generated by Cornell University. However, the projections are only available through 2040. Because the data do not extend through 2100, these data were not used in this economic impact analysis.

⁵ The ICLUSv2 model, as well as the assumptions used in this particular run of the model, represent one framework for projecting population and demographic change across the U.S. Alternative models or specifications could lead to different outcomes than those reported in the report.

⁶ The New York State Department of Labor provides official statewide, county-level population projections generated by Cornell University. However, the projections are only available through 2040. Because the data do not extend through 2100, these data were not used in this economic impact analysis.

The AEO estimates are also consistent with modeling performed for the Chapter 6 energy sector. The average annual GDP growth rate from AEO between 2020 and 2050 is about 2.15% per year.⁷ Because the AEO projections end at 2050, a different source of projected growth rates was needed beyond 2050. This study applies projected growth rates from the Massachusetts Institute of Technology's Economic Projection & Policy Analysis version 6 (EPPA6) model (Chen et al. 2015) to extend the projections to 2100. The EPPA6 projects GDP growth of 1.75% in 2051, with rates falling 0.05% every 5 years to 1.3% in 2100.

It is also important to note that not all socioeconomic parameters that might be important in estimating future impacts are incorporated in the impact estimates in the study. For example, the labor study includes a forecast of future wages, because wages are reasonably closely linked to the overall projection of GDP per capita used in the study. However, for the dairy study, milk prices are kept constant, because prices are connected to both in-state and broader changes in supply and demand, and in the dairy case, prices are regulated. Chapter 11 does note that, as a recommendation for future work, some improvements in a consistent application of socioeconomic drivers might be achieved if an economy-wide economic model specific to New York State and capturing interactions between the New York State economy and the broader U.S. and world economies and markets were to be deployed in economic impact studies.

5 Consideration of Adaptation

The capability to incorporate adaptation and human system response scenarios in economic impact of climate change modeling has long been recognized as an important dimension in the field (see for example Mendelsohn and Neumann 1999). Sectors that have the longest history of characterizing adaptation include coastal infrastructure, infrastructure in general, energy, and agriculture (Sussman et al. 2014). Characterizing adaptation in human health and other sectors is a currently active research topic. Existing literature on the economic impacts of adaptation focus on adaptation measures where net benefits (that is, reduction in damages less the cost of adapting) are likely to be the largest—in other words, where adaptation actions are likely to be most cost-effective in reducing damages from climate impacts.

⁷ There is some unavoidable inconsistency between the population and GDP projections. While some studies have made use of GDP projections from the SSP2 database, those have typically not been applied in some of the more detailed models used in this study (in particular, the energy supply and demand study). The resulting per capita income calculations used to support adjustments to future VSL, for example, are nonetheless consistent with those used in other U.S. studies (such as EPA 2017a). Note also that while a New York State-specific wage rate is used for valuation in the Labor study, differences between New York State and U.S. income levels, or between urban and rural incomes, are otherwise not taken into account in the study.

This study considers two potential response scenarios: reactive response and proactive adaptation. In the reactive response scenario, response and associated costs increase as impacts and damages increase but practices stay the same and continue to assume historical climate, rather than incorporating future climate change. With proactive adaptation, near-term investments increase, but practices change to anticipate future climate and therefore reduce future damages and costs over time. These types of investments typically involve incurring additional costs in the near term in return for enhanced protection from climate impacts in the future, so they involve careful planning and upfront financing.

In this study, the adaptation assumptions used for each sector and impact category reflect the current state of the economic impact literature. For most sectors, it is not yet possible to model the impact of investing in more cost-effective, forward-looking measures than are currently practiced. Therefore, this economic analysis generally assumes a reactive response scenario for the majority of sectors. However, while it is not currently possible to model proactive adaptation statewide or for all sectors, there is some evidence in the literature that these types of investments could be cost-effective and could reduce impacts. This is particularly true in the case of the human health and safety sector, where greater adoption of air conditioning and reduction in urban heat island effects could reduce what is the largest economic impact estimated for New York State: the premature mortality associated with extreme heat events.⁸

For sectors where proactive adaptation scenarios were able to be modeled (buildings, energy, and transportation), the results show a potentially large benefit of adaptation on reducing impact estimates. For example, for the buildings sector, this type of proactive adaptation could decrease the net annual costs (considering both the costs of investments and their later benefits) by \$20 million to \$35 million annually by the 2050s. In the transportation sector, proactive adaptation could have an even larger effect, reducing costs by 10 to 20 times for roads and 40 times for rail.

Table 1-2 summarizes the adaptation assumptions used in this study.

⁸ For a more thorough review of the opportunities for adaptive action, see the *Adaptation Chapter of the U.S. Fifth National Climate Assessment* (Wasley et al. 2023).

Table 1-2. Summary of the Impact of Adaptation on Economic Impacts

Note: The impact of adaptation is not evaluated for the ecosystem services sector, where all economic impacts presented are qualitative.

Sector and Impact Category	Reactive Response Assumptions for Economic Impact Estimates	Impact of Proactive Adaptation on Economic Impact Estimates
Agriculture	• Adjustment to planting and/or harvesting dates • Optimizing irrigation in response to climate and weather • Implementation of some heat abatement strategies for dairy production	Not quantitatively estimated
Buildings	• Currently practiced reactive coastal and inland flood prevention methods, such as cost-effective elevation of structures above current flood stage	• Proactive adaptation: Adopting forward-looking flood protection could decrease annual coastal properties costs by \$20 million to \$35 million in the 2050s
Energy	• Current actions to protect transmission and distribution infrastructure • Market adjustments toward cost-effective electricity supply • New demand-side energy efficiency investments	• Proactive adaptation: Investing in forward-looking upgrades to transmission and distribution infrastructure reduces impacts (relative to reactive adaptation): - by ~50% in the 2030s - by ~60% in the 2050s - by ~two-thirds in the 2080s
Human Health and Safety	• Increased air conditioning use • Some new market penetration of air conditioning • Heat avoidance behavior • Currently practiced outreach to vulnerable populations to mitigate extreme heat impacts	Not quantitatively estimated
Society and Economy	• Current accommodations for labor during extreme heat • Current activity levels and supplier adjustment for recreation in response to weather (e.g., snowmaking for skiing)	Not quantitatively estimated
Transportation	• Currently practiced reactive road and rail prevention and repair actions • Rerouting during sunny-day flooding events	• Proactive adaptation: Investing in forward-looking, cost-effective adaptations through the 2050s could decrease annual costs: - by nearly 10x for inland roads - by 12x to 20x for coastal roads - by 40x for rail
Water Resources	• Some market-based adaptation in water-use optimization from low-value uses (e.g., outdoor landscaping) to high-value uses (e.g., drinking water) to adjust to potential shortages	Not quantitatively estimated

In general, an economic framework for adaptation suggests that any entity potentially affected by climate change considers the costs of climate impacts and adaptation and optimizes to reach at least a cost solution that balances adaptation costs and the residual impacts—that is, impacts that would be too costly to avoid, even if there is potential for adopting measures to avoid impacts. In practice, however, there remain many barriers to implementing cost-effective adaptations in all settings. In a general sense, technological, behavioral, and financial barriers stand in the way of achieving an economically optimal adaptation outcome (see a thorough discussion in Chambwera et al. 2014, and more specific examples for the U.S. coastal zone in Moser et al. 2014).

6 Limitations

Projected physical and economic impacts from this study are intended to provide insights about the potential magnitude of climate change impacts in New York State. However, none of the estimates should be interpreted as definitive predictions of future impacts and damages. Instead, the intention is to produce estimates of future effects using a consistent approach that reflect the current best available modeling tools and data. These estimates might require revisiting and updating over time as science and modeling capabilities continue to advance.

In addition to the uncertainties in estimates identified in the previous section, the results provided in this study should be used and interpreted with consideration of the following limitations:

- **Coverage of Sectors and Impacts**
This study employs a broad range of quantitative tools and qualitative characterizations of economic impacts, chosen based on current understanding, available data and methods, and demonstrated magnitudes of economic effect. The broader NYSCIA further identifies impacts not addressed in this report, including cross-sectoral impacts and incomplete coverage of effects within sectors. Examples of key missing sectors in this economic study include the impacts of climate change on forestry, migration, broad-scale effects on ecosystem services and species, and political instability. Further, the sectoral studies largely omit potentially important indirect effects (e.g., how road and electricity distribution infrastructure failure affect health and welfare, particularly during extreme events), the potential for cascading failures, and the inability comprehensively to value all outcomes (e.g., the underestimation that results from using only cost to treat illness in some health sector studies, as opposed to the full willingness to pay to avoid sickness). As a result, the scope of estimates included in this report very likely underestimates impacts that could be reasonably expected under future climate scenarios.
- **Cross-Sectoral Impacts Modeling**
The sectoral impact models that were used to develop estimates in this study were run independently of each other. However, some sectors could reasonably interact with each other, and these intersectoral effects are not reflected in the results.

- **Variability in Societal Characteristics**
The results in this study do not separately report impacts for overburdened populations, nor does the report analyze how individual behavior affects vulnerability to climate. Instead, results are aggregated across demographic groups.
- **Feedbacks**
The socioeconomic scenarios that drive the modeling analyses do not incorporate potential feedbacks from climate change impacts to the socioeconomic system (e.g., changes in albedo from land-use change or increased GHG emissions resulting from vegetative changes) nor from sectoral damages to the economy (e.g., significant expenditures on protective adaptation measures, such as seawalls, would likely reduce available financial capital to the economy for other productive uses). Also, this study does not incorporate the feedback impact of income growth over time on adaptive capacity.
- **Co-benefits and Ancillary Benefits and Costs of Climate Policy**
This study focuses on the direct impacts of climate change and indirect economic implications, such as lost income associated with incidence of climate-induced human morbidity. It does not, for example, estimate the benefits of reducing co-emitted air pollutants (e.g., nitrogen oxides, volatile organic carbons, or particulate matter) due to climate policy.

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