Economic Impacts of Climate Change on New Jersey

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The Center for Integrative Environmental Research
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INTRODUCTION

Policymakers across the country are now seeking solutions to curb greenhouse gas emissions and to help us adapt to the impending impacts triggered by past emissions. The debate to date has primarily focused on the perceived costs of alternative solutions, yet there can also be significant costs of inaction. Climate change will affect our water, energy, transportation, and public health systems, as well as state economies as climate change impact a wide range of important economic sectors from agriculture to manufacturing to tourism. This report, part of a series of state studies, highlights the economic impacts of climate change in New Jersey and provides examples of additional ripple effects such as reduced spending in other sectors and resulting losses of jobs, wages, and even tax revenues.

A Primer on Climate Change

Earth's climate is regulated, in part, by the presence of gases and particles in the atmosphere which are penetrated by short-wave radiation from the sun and which trap the longer wave radiation that is reflecting back from Earth. Collectively, those gases are referred to as greenhouse gases (GHGs) because they can trap radiation on Earth in a manner analogous to that of the glass of a greenhouse and have a warming effect on the globe. Among the other most notable GHGs are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and chlorofluorocarbons (CFCs). Their sources include fossil fuel combustion, agriculture, and industrial processes.

Each GHG has a different atmospheric concentration, mean residence time in the atmosphere, and different chemical and physical properties. As a consequence, each GHG has a different ability to upset the balance between incoming solar radiation and outgoing long-wave radiation. This ability to influence Earth's radiative budget is known as climate forcing. Climate forcing varies across chemical species in the atmosphere. Spatial patterns of radiative forcing are relatively uniform for CO_2, CH_4, N_2O and CFCs because these gases are relatively long-lived and as a consequence become more evenly distributed in the atmosphere.

Steep increases in atmospheric GHG concentrations have occurred since the industrial revolution (Figure 1). Those increases are unprecedented in Earth's history. As a result of higher GHG concentrations, global average surface temperature has risen by about 0.6°C over the twentieth century, with 10 of the last 12 years likely the warmest in the instrumental record since 1861 (IPCC 2007).

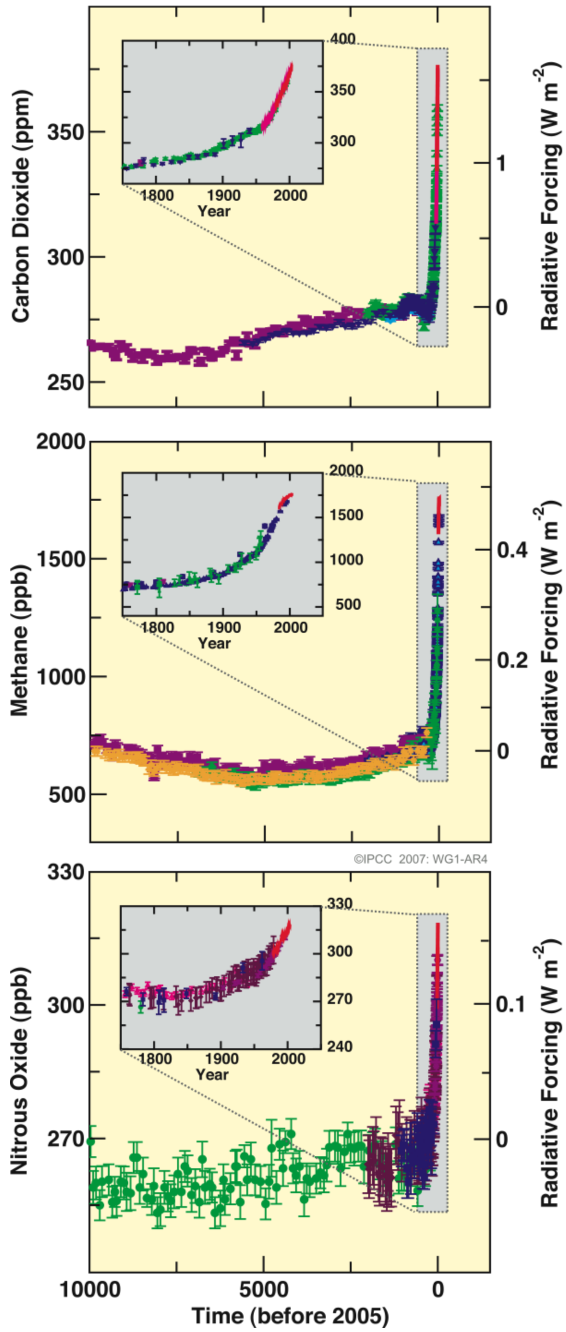


Figure 1: Atmospheric Concentrations of Carbon Dioxide, Methane and Nitrous Oxide (Source: IPCC 2007)

A change in average temperatures may serve as a useful indicator of changes in climate (Figure 2), but it is only one of many ramifications of higher GHG concentrations. Since disruption of Earth's energy balance is neither seasonally nor geographically uniform, effects of climate disruption vary across space as well as time. For example, there has been a widespread retreat of mountain glaciers during the twentieth century. Scientific evidence also suggests that there has been a 40 percent decrease in Arctic sea ice thickness during late summer to early autumn in recent decades and considerably slower decline in winter sea ice thickness. The extent of Northern Hemisphere spring and summer ice sheets has decreased by about 10 to 15 percent since the 1950s (IPCC 2007).

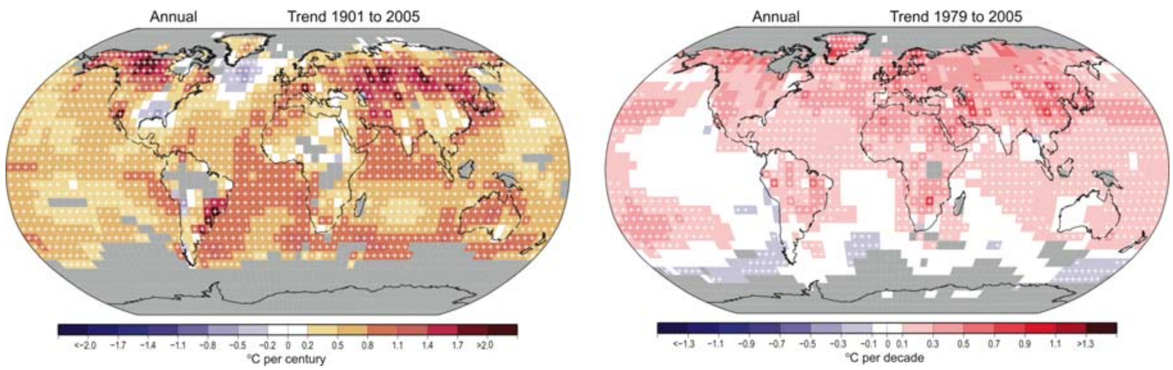


Figure 2: Annual Temperature Trends (Source: IPCC 2007)

The net loss of snow and ice cover, combined with an increase in ocean temperatures and thermal expansion of the water mass in oceans, has resulted in a rise of global average sea level between 0.1 and 0.2 meters during the twentieth century, which is considerably higher than the average rate during the last several millennia (Barnett 1984; Douglas 2001; IPCC 2001).

Changes in heat fluxes through the atmosphere and oceans, combined with changes in reflectivity of the earth's surface and an altered composition of may result in altered frequency and severity of climate extremes around the globe (Easterling, et al. 2000; Mehl, et al. 2000). For example, it is likely that there has been a 2 to 4 percent increase in the frequency of heavy precipitation events in the mid and high latitudes of the Northern Hemisphere over the latter half of the twentieth century, while in some regions, such as Asia and Africa, the frequency and intensity of droughts have increased in recent decades (IPCC 2001). Furthermore, the timing and magnitude of snowfall and snowmelt may be significantly affected (Frederick and Gleick 1999), influencing among other things, erosion, water quality and agricultural productivity. And since evaporation increases exponentially with water temperature, global climate change-induced sea surface temperature increases are likely to result in increased frequency and intensity of hurricanes and increased size of the regions affected.

Impacts of Climate Change throughout the US

This study on the economic impacts of climate change in the State of New Jersey is part of a series of state-focused studies to help inform the challenging decisions policymakers now face. It builds on a prior assessment by the Center for Integrative Environmental Research, US Economic Impacts of Climate Change and the Costs of Inaction, which concluded that throughout the United States, individuals and communities depend on sectors and systems that are expected to be greatly affected by the impacts of continued climate change.

- The **agricultural sector** is likely to experience uneven impacts throughout the country. Initial economic gains from altered growing conditions will likely be lost as temperatures continue to rise. Regional droughts, water shortages, as well as excess precipitation, and spread of pest and diseases will negatively impact agriculture in most regions.

- Storms and sea level rise threaten extensive **coastal infrastructure –** including transportation networks, coastal developments, and water and energy supply systems.

- Current **energy** supply and demand equilibria will be disrupted as electricity consumption climbs when demand grows in peak summer months. At the same time, delivering adequate supply of electricity may become more expensive because of extreme weather events.

- Increased incidence of asthma, heat-related diseases, and other respiratory ailments may result from climate change, affecting **human health** and well-being.

- More frequent and severe **forest fires** are expected, putting ecosystems and human settlements at peril.

- The reliability of **water supply networks** may be compromised, influencing agricultural production, as well as availability of water for household and industrial uses.

As science continues to bring clarity to present and future global climate change, policymakers are beginning to respond and propose policies that aim to curb greenhouse gas emissions and to help us adapt to the impending impacts triggered by past emissions.

While climate impacts will vary on a regional scale, it is at the state and local levels where critical policy and investment decisions are made for the very systems most likely to be affected by climate change – water, energy, transportation and public health systems, as well as important economic sectors such as agriculture, fisheries, forestry, manufacturing, and tourism. Yet, much of the focus, to date, has been on the perceived high cost of reducing greenhouse gas emissions. The costs of inaction are frequently neglected and typically not calculated. These costs include such expenses as rebuilding or preparing infrastructure to meet new realities and the ripple economic impacts on the state's households, the agricultural, manufacturing, commercial and public service sectors.

The conclusions from our nation-wide study highlight the need for increased understanding of the economic impacts of climate change at the state, local and sector level:

- Economic impacts of climate change will occur throughout the country.
- Economic impacts will be unevenly distributed across regions and within the economy and society.
- Negative climate impacts will outweigh benefits for most sectors that provide essential goods and services to society.
- Climate change impacts will place immense strains on public sector budgets.

- Secondary effects of climate impacts can include higher prices, reduced income and job losses.

Methodology

This report identifies key economic sectors in New Jersey which are likely affected by climate change, and the main impacts to be expected for these sectors. The report provides examples of the direct economic impacts that could be experienced in the state and presents calculations of indirect effects that are triggered as impacts on individual sectors in the economy ripple through to affect others.

The study reviews and analyzes existing studies such as the 2000 Global Change Research Program National Assessment of the Potential Consequences of Climate Variability and Change which identifies potential regional impacts. Additional regional, state and local studies are used to expand on this work, as well as new calculations derived from federal, state and industry data sources. The economic data is then related to predicted impacts of climate change provided from climate models. To standardize the results, all of the figures used in this report have been converted to 2007 dollars (BLS 2008).

Since the early 1990s, and especially during the 21st century, significant progress has been made in understanding the impacts of climate change at national, regional, and local scales. The Canadian and Hadley climate change models are cited most frequently and we look first to these, yet there are many other valuable models used by some of the specialized studies we cite in this report.

In addition to looking at data that illustrates the direct economic impacts of climate change, the report also provides examples of the often overlooked ripple economic effects on other sectors and the state economy. To calculate these, we employed a modified IMPLAN™ model from the Regional Economic Studies Institute (RESI) of Towson University. This is a standard input/output model and the primary tool used by economists to measure the total economic impact by calculating spin-off impacts (indirect and induced impacts) based upon the direct impacts which are inputted into the model. Direct impacts are those impacts (jobs and output) generated directly by the project. Indirect economic impacts occur as the project (or business owners) purchase local goods and services. Both direct and indirect job creation increases area household income and results in increased local spending on the part of area households. The jobs, wages, output and tax revenues created by increased household spending are referred to as induced economic impacts.

After reviewing climate and economic information that is currently available, the study identifies specific data gaps and research needs for further understanding of the significant economic impacts. There is no definitive total cost of inaction. Given the diversity in approaches among existing economic studies and the complexity of climate-induced challenges faced by society, there is a real need for a consistent methodology that enables more complete estimates of impacts and adaptation costs. The report closes with basic recommendations and concluding lessons learned from this series of state-level studies.

Not all environmentally induced impacts on infrastructures, economy, society and ecosystems reported here can be directly or unequivocally related to climate change. However, historical as well as modeled future environmental conditions are consistent with a world experiencing changing climate. Models illustrate what may happen if we do not act now to effectively address climate change and if adaptation efforts are inadequate. Estimates of the costs of adapting environmental and infrastructure goods and services to climate change can provide insight into the very real costs of inaction, or conversely, the benefits of maintaining and protecting societal goods and services through effective policies that avoid the most severe climate impacts. Since it is typically at the sectoral and local levels where those costs are borne and benefits are received, cost estimates can provide powerful means for galvanizing the discussion about climate change policy and investment decision-making.

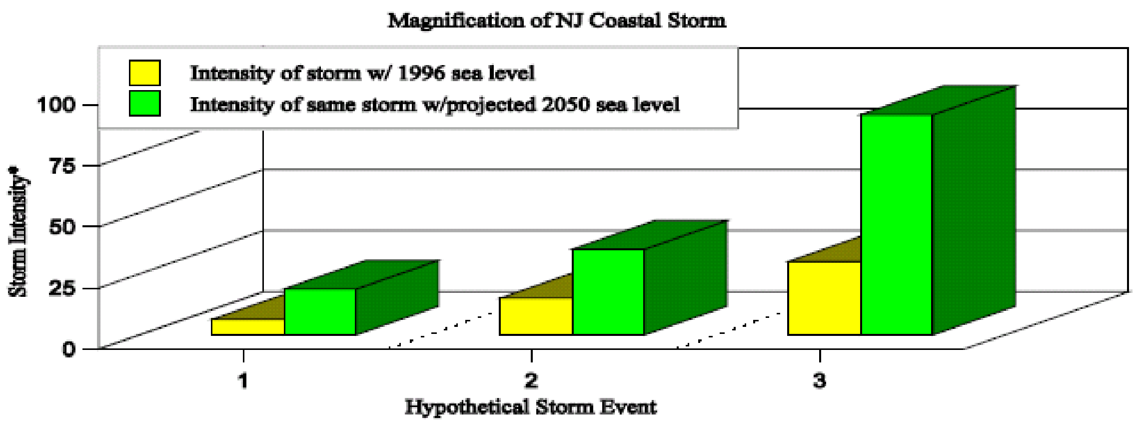
These cost estimates may understate impacts on the economy and society to the extent that they simply cover what can be readily captured in monetary terms, and to the extent that they are calculated for the more likely future climate conditions rather than less likely but potentially very severe and abrupt changes. The broader impacts on the social fabric, long-term economic competitiveness of the state nationally and internationally, changes in environmental quality and quality of life largely are outside the purview of the analysis, yet likely not trivial at all. Together, the monetary and non-monetary, direct, indirect and induced costs on society and the economy provide a strong basis on which to justify actions to mitigate and adapt to climate change.

CLIMATECHANGE IN NEW JERSEY

In the last century, New Jersey has experienced rising temperatures, increased precipitation, more frequent severe weather events, and a rise in sea level. Average annual temperatures for the state have increased 2° F (1° C) since 1900 while average winter temperatures have increased 4° F (2° C) since 1970 (US EPA 1997; Frumhoff et al. 2007). Precipitation has increased by 5 to 10 percent in parts of New Jersey and the entire Mid-Atlantic region of the US has received 12-20 percent more major weather events relative to the previous century (US EPA 1997; IPCC 2001). The sea level along the New Jersey coastline has risen at a rate of 3.5 mm/year (.14 inch/year) over the last century – nearly twice the global average of 2 mm/year (.08 inch/year) (Oppenheimer et al. 2005).

These trends are predicted to continue or worsen if climate change progresses unchecked. Average yearly temperatures are expected to increase by 2-8° F (1-4.5° C) with summer and fall temperatures increasing the most (US EPA 1997; IPCC 2001). Precipitation will increase by 10-20 percent in New Jersey with more rainfall in the winter and less in the spring and summer (US EPA 1997). As climate change raises ocean temperatures, alters weather patterns, and contributes to the melting of polar icecaps and subsequent sea level rise, New Jersey can expect significant coastal impacts. Major coastal storms will be more intense and more frequent (See Figure 3). By 2050, a large storm that currently occurs once every 20 years will occur every 5 years (NJ Department of Environmental Protection 1999). Perhaps most significant to New Jersey, sea level rise will increase by .61-1.22 m (24-48 inches) over the next century along the coast (Oppenheimer et al. 2005).

Figure 3. Increasing Intensity of Coastal Storms in New Jersey with Climate Change



Source: New Jersey Department of Environmental Protection 1999

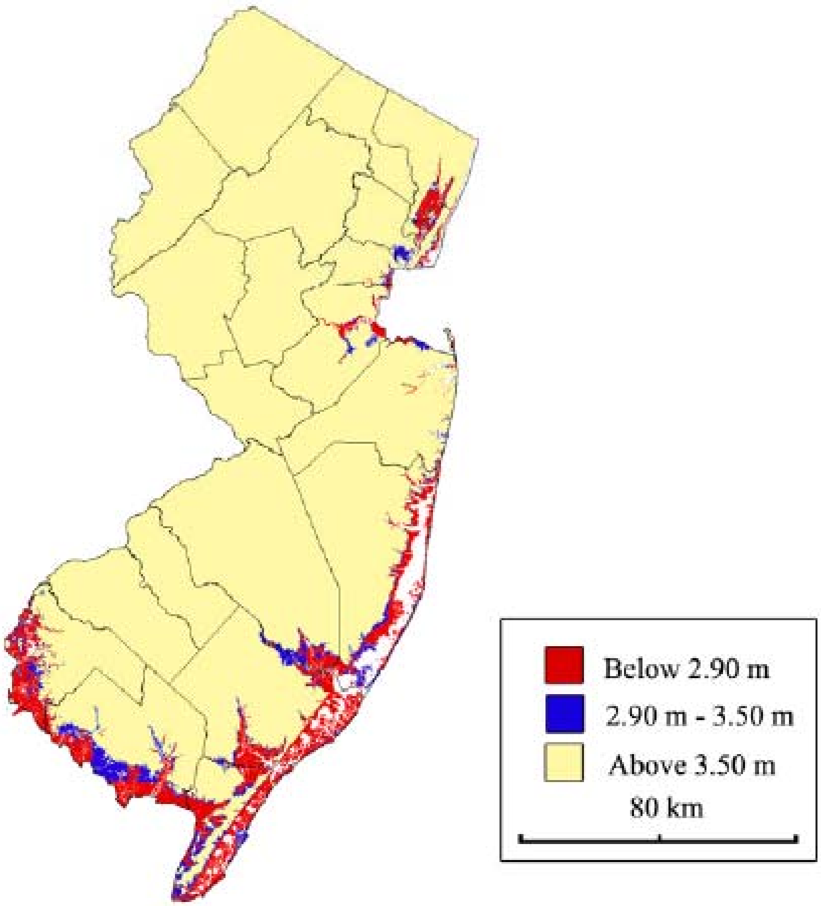
MAJOR ECONOMIC IMPACTS

The largest economic impact of climate change for New Jersey will be on its **coastal infrastructure** and **development**. By the end of the century, expanding ocean water and melting polar ice caps will raise sea levels and expedite shoreline erosion; an estimated 1-3 percent of New Jersey's 210-mile shoreline (includes Raritan and Delaware Bays) will be inundated by 2100. Based on current 100-year flood levels and predicted rises in sea level, 6.5-9 percent of the state's coastal area will occasionally be inundated by flooding (See Figure 4) (Oppenheimer et al. 2005). Considerable strain will be placed on New Jersey's coastal development and transportation infrastructure, not to mention the estimated 6 million people that will live in New Jersey's coastal counties by 2020.

Coastal Development

New Jersey's coastal counties are home to 60 percent of the state's population in addition to hosting numerous tourist destinations, industrial sites, and extensive commercial development. The land and property value in Monmouth, Ocean, Atlantic, and Cape May counties totals $106 billion (Oppenheimer et al. 2005). Sea level rise, flooding, and major storm events will take an exacting toll on New Jersey's multi-faceted and economically valuable coastal communities.

Figure 4. Inundation Scenarios Resulting From Sea Level Rise and Episodic Flooding



Source: Oppenheimer et al. 2005

Sea level rise in New Jersey is predicted to claim more land than the national average due to local conditions that make the state's shoreline particularly vulnerable to soil erosion and land subsidence. For instance, a 0.3-meter (1 foot) rise in sea level along the New Jersey coast will advance the shoreline inward 36.6 meters (120 feet); the US average is only 23.8 meters (78 feet) of shoreline advancement for an equal rise in sea level (Zhang et al. 2004). Of significant economic importance is the fact that residential/urban land is second only to wetlands in land type predicted to be inundated by a rise in sea level (See Table 1) (Oppenheimer et al. 2005).

Table 1. New Jersey Land Use Classes Below Future Sea Levels

Land use class	Land below 0.61m contour (km^2)	Land below 1.22m contour (km^2)	Land below 2.90m contour (km^2)
Wetlands	141.9	367.6	906.5
Forest	3.9	10.1	57.0
Beach	5.4	14.1	18.1
Residential/Urban	17.4	44.9	196.8
Industrial	1.8	4.7	28.5
Agricultural	0.3	0.7	44.0
Total	170.7	442.1	1251.0

Source: Oppenheimer et al. 2005

Protecting coastal development from inundation, beach erosion, and salt-water intrusion will be costly. The Environmental Protection Agency conducted a study at Long Beach Island, New Jersey, on sea level rise and the cost of circumventing inundation and found that to protect a stretch of this 18-mile long island and its residents, $160-790 million would need to be spent for each 1-3 foot increase in sea level (Titus 1990). Adaptation options included moving entire houses ($41,200/house) or building levees ($31,700/house) (Titus 1990). Given the length of New Jersey's coastline and the extensive development on vulnerable barrier islands such as Long Beach Island and Atlantic City, the damage costs associated with a 4-foot rise in sea level would exceed 10 billion dollars.

New Jersey will incur economic costs not only from a rise in sea level and increased flooding, but also from more frequent and intense storms. Hurricane damage along the Northeast US coast has cost an estimated $5 billion per year with much of this cost coming from single major storm events (Frumhoff et al. 2007). Take for example, the December northeaster of 1992; it struck the New Jersey coast during the high spring tide and high water levels persisted for seven days. The maximum wave height reached 3.05 meters during the course of this event and the total cost in damage after the storm totaled $503 million (Psuty et al. 1996; Gaul and Wood 2000). Additionally, the insurance sector will likely face unstable periods as a result of increased flooding and shoreline inundation. Insurance accounted for $11.2 billion of New Jersey's Gross State Product in 2005 and it is predicted that by 2080, insurers' capital requirements to cover the cost of hurricane damage in the US will increase by 90 percent (NJ Department of Labor and Workforce Development 2007; Association of British Insurers 2005).

Transportation Infrastructure

It costs $3.98 billion each year to operate, repair, and develop New Jersey's transportation infrastructure (Regional Plan Association 2005). There are 420 miles of interstate highway serving as main routes between large metropolitan areas of the Eastern US. In New Jersey, 93 percent of employees use the state's transportation infrastructure to commute to work (US DOT 2000). New Jersey's roads, bridges, buses, and rails facilitate the state and national economies immensely. However, inundation, flooding, and shoreline erosion will likely deteriorate much of this system, particularly in densely populated Northern New Jersey.

The rails, bridges, and tunnels that serve to connect Northern New Jersey with New York City, operate below, at or near sea level. When portions of Boston's subway tunnels were flooded in 1996, an estimated $121 million in damages were incurred (Frumhoff et al. 2007). Based on the Boston incident and the comparatively larger mass transit system of NYC, it is estimated that annual transit maintenance costs could increase by several million dollars while recovery efforts following major flooding would likely exceed $1 billion for the tri-state metropolitan region. Also, with mass transit becoming a less viable travel option due to increased risk of subway flooding, bridges and roads may facilitate more of the travel between New York City and New Jersey. The cost of maintaining bridges would likely increase with more commuter demand and as sea level rise and coastal erosion weaken bridge support structures and restrict maintenance access.

As for coastal **shipping**, sea level rise poses a serious threat to accessing and operating ports along New Jersey. Low-lying access roads are at risk to flooding while shipping ports will have to adjust infrastructure to establish a working land-sea interface. The Port of New Jersey and New York provides 228,900 jobs and serves as the hub for $44 billion in economic exchange (New Jersey Coastal Management Program 2002). Commercial **fishing** generates more than $100 million annually and in 2006, **manufacturing** contributed $42 billion to the Gross State Product – both of which are dependent on reliable access to ports from both land and sea (New Jersey Coastal Management Program 2002; New Jersey Department of Labor and Workforce Development 2007).

Since the coastal infrastructure is so vital to the state's economy, even a 1% increase in extreme storms every year over the next ten year period from 2007 to 2017, would raise indirect economic impact from $3.9 million in 2007 to over $45 million in just 10 years, resulting in combined impacts on jobs in the construction sector and the rest of the economy of 56 in 2007 and 648 in 2017. The construction sector benefits from flooding or the destruction of infrastructure because it will be involved in rebuilding. Depending on employment demand and other economic drivers, however, the capacity to construct new infrastructure to accommodate population growth may be limited. The insurance sector maybe impacted, but it would likely adjust its rates to reflect the new probabilities of flooding and storm damage. This increase in rates would divert disposable income from consumption to that sector.

OTHER ECONOMIC IMPACTS

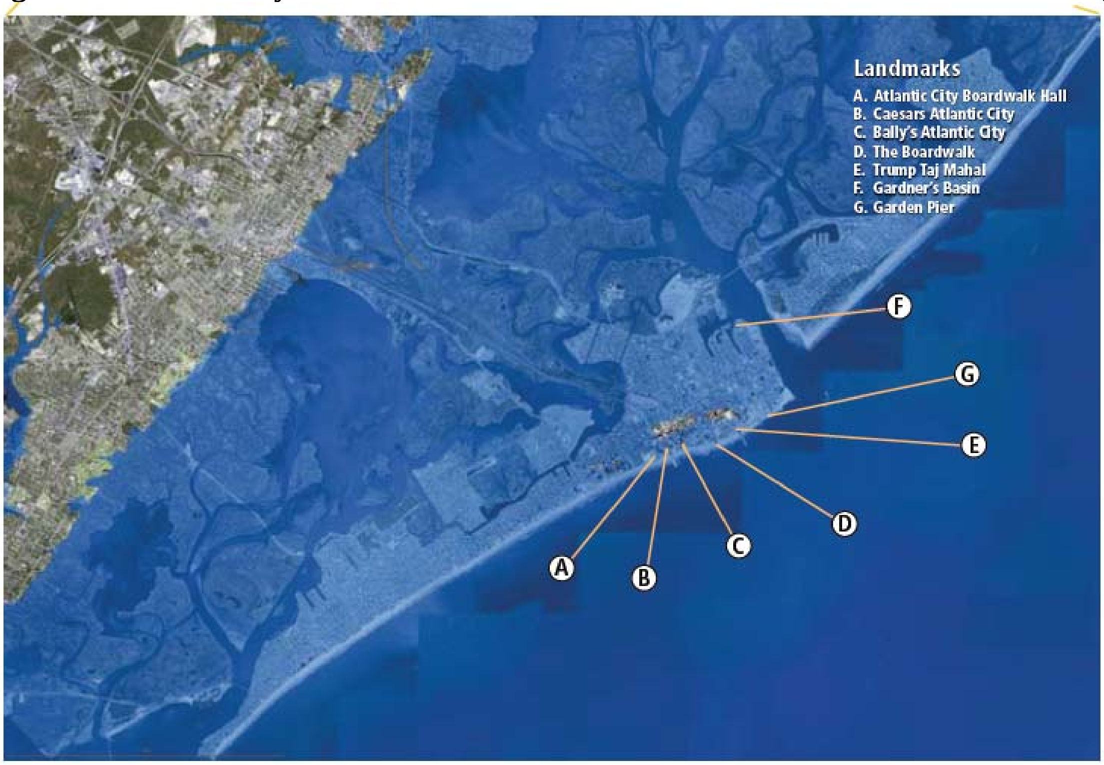
In addition to the economic hurdles that will impair New Jersey's coastal development and transportation infrastructure, tourism, agriculture and health-related economic losses will likely transpire as a result of climate change.

Tourism

New Jersey's **tourism** revenue exceeded $30 billion in 2005 – 70% of which was generated in the state's coastal counties, renowned for the public beaches, beachfront real estate, and tourist hotspots, such as Atlantic City (Frumhoff et al. 2007). However, with a weakening coastal infrastructure, beach erosion, and the very real threat of seawater inundation in locations like Atlantic City, tourism is likely to suffer in New Jersey.

The population of several New Jersey coastal communities doubles or triples as tourists and vacationers move closer to the beach for the summer months (Frumhoff et al. 2007). With increasing beach erosion and more major storms, however, the New Jersey coast may become a less attractive tourist destination. Public and private beaches will erode at a rate of 50 to 100 times faster than the rate of sea level elevation and it is estimated that the state will need $6 billion over the next 50 years to keep up with beach maintenance (Zhang 2002; Gaul and Wood 2000). By 2100, under all emissions scenarios, Atlantic City is predicted to flood as a result of sea level rise and storm surges to the current 100-year flood level every one to two years on average (Frumhoff et al. 2007) (See Figure 5). Furthermore, losses in ecotourism are likely to occur as a 21% reduction in mid-Atlantic wetlands between now and 2100 will constrain shorebird nesting and fish nurseries (Najjer et al. 2000). As a result of just a 1% decrease in the amount of tourists visiting New Jersey's coastal region each year we can expect an indirect economic impact of over $3.7 billion by 2017 and over 40,000 jobs (RESI-3).

Figure 5. Atlantic City in 2100 With an Increased Sea Level and 100-Year Flooding

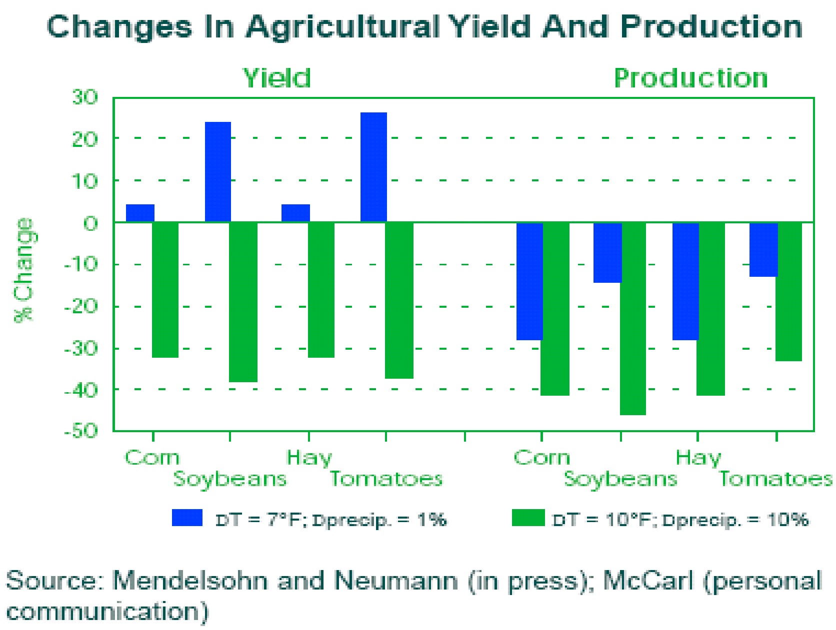


Source: Frumhoff et al. 2007

Agriculture

The net value of **agricultural** products from New Jersey is a little under $864 million annually with crops accounting for two-thirds of the total value (USDA 2002). Although New Jersey has a diverse agriculture portfolio, hay, corn and soybeans are historically the most valuable products. The total production of these crops is predicted to decrease under a range of precipitation and temperature change scenarios (See Figure 6) (US EPA 1997). Altogether, the state may see benefits from warmer temperatures and longer growing seasons in the near term, but drought caused by rapidly rising temperatures and increased water demand will restrict agriculture by the end of the century.

Figure 6. Agricultural Production and Yield Based on Two Climate Change Scenarios



Source: EPA 1997

The greatest economic losses in the agriculture sector will likely result from decreased dairy and fruit production. Dairy cows begin to lose milk productivity when temperatures exceed 75° F because of heat stress. As a result of increased temperatures, New Jersey is predicted to have a 10% reduction in milk production by 2100; given the states' dairy industry was valued at $33 million in 2002, reduced production could result in a $3.3 million loss by 2100 (Frumhoff et al. 2007). The third largest economic subsection of New Jersey crop agriculture, fruits, berries and tree nuts, accounted for $100 million in sales in 2002 (USDA 2002). Apples, and many other fruits and berries, must be exposed to a specific amount of time below 45° F to properly develop, but under the current emissions situation this will occur less frequently as winters become shorter and warmer (Frumhoff et al. 2007). Fruit also responds poorly to drought and unseasonably warm summer weather. For example, in 2007 the USDA forecasted a yield of 180 million pounds of cranberries for Massachusetts, but a warm autumn and drought caused the yield to be short by 31 million pounds, or about $14 million in lost revenue relative to predicted revenues (Azios, 2008).

Forests are also at risk from warming temperatures, longer seasons and altered precipitation patterns. Forestry, fishing and related activities generated $161 million in 2005 (New Jersey Department of Labor and Workforce Development 2007). Forest densities in New Jersey will decrease by as much as 20% as a result of native trees migrating to cooler northern regions and increased wildfire (EPA 1997). Native species such as maple, beech, and birch will be largely absent from Northern New Jersey by 2100 (Frumhoff et al. 2007). Additionally, the length of the wildfire season will increase by 10-30% while the likelihood of fires in New Jersey will increase with warmer temperatures and the introduction of fire prone trees (Brown et al. 2004).

Health

Health impacts related to warmer temperatures and water quality will likely develop in New Jersey in the coming century. Temperature increases will be higher in cities and developed regions relative to surrounding rural areas as a consequence of heat absorbing buildings and concrete. Known as the urban heat island effect, this phenomenon will have a detrimental impact on the densely populated regions of Northern New Jersey and vulnerable populations throughout the state’s more urban areas. For example, as a result of unseasonably warm summer temperatures in 1993, 300 died in New York City from heated related illness (Kalkstein, 1993). Current summer surface temperatures in Camden, New Jersey, are 7-10° F (4-6° C) warmer than nearby suburbs (Solecki et al. 2004). As summer temperatures grow throughout the next century, inner city temperatures will become considerably more dangerous. It is predicted that summer heat related mortality could increase by 55 percent by 2020 and more by the 2050s as temperatures continue to rise (Solecki et al. 2004).

Higher temperatures will also increase demand for water supplies used for both drinking and irrigation. To be sure, low quantities of water are a serious threat to human health, but perhaps more insidious is the problem of impaired water associated with a reduced supply and flooding. Reduced water supplies lead to a higher concentration of bacteria, pesticides and other unwanted bodies than would be present under normal conditions. Moreover, warmer water and longer seasons facilitate the growth of algae and harmful bacteria that lead to fish kills and general water contamination. Where warmer temperatures do not impair water quality, flooding from an elevated sea could potentially introduce bacteria, harmful chemicals and salt water into fresh drinking water sources (Frumhoff et al. 2007). In 1992 for example, salt water recharged the Potomac-Raritan-Magothy aquifer and the chloride concentrations increased from 10mg/liter to 70mg/liter; a less than ideal amount of chloride for drinking water (Oppenheimer et al. 2005). Lastly, as evidenced by Hurricane Katrina, mildew and mold grow rampant in the wake of flooding creating numerous respiratory problems such as asthma.

MISSING INFORMATION AND DATA GAPS

This study is subject to the uncertainties inherent in measuring global climate change and climate change itself and attempts to reflect this as best as possible through use of scenarios and ranges of confidence. Additionally, quantifying the economic impacts of climate change deserves significantly more focus as this paper and much of the literature on the topic primarily qualify the potential impacts. Further, data gaps exist between the effects of climate change in one particular sector and the ripple effects that manifest in interconnected sectors. Analysis of this sort would be useful to policy-makers and businesses at all levels and sizes. Information that would be especially useful for policy makers would be more precise figures for land and property along the highly threatened portions of New Jersey's coast.

CONCLUSIONS

The state of New Jersey's greatest challenge is likely to be in adapting to climate change along its expansive coast, as this is where the most significant economic and ecological impacts will occur. The state's economy is particularly vulnerable because of the scale of development along the coast and the high rate at which coastal erosion and subsequent water elevation will afflict its shoreline. Along the same line, further development along the state's shoreline needs to be carried out with the understanding that the shoreline is not stationary and will steadily move inwards throughout the coming century. Lastly, legislators may want to consider legislation to circumvent health related impacts of climate change related to the urban heat island effect and decreases in fresh drinking water quality and quantity. The urban heat island effect can be mitigated through careful city planning and smart growth (e.g., incorporating more green space into development sites). One tactic for maintaining water quality is to encourage streamside tree planting and plant buffer strips as they absorb harmful pollutants as well as reduce water warming.

Lessons Learned

As we begin to quantify the potential impacts of climate change and the cost of inaction, the following five lessons are learned:

1. There are already considerable costs to society associated with infrastructures, agricultural and silvicultural practices, land use choices, transportation and consumptive behaviors that are not in synch with past and current climatic conditions. These costs are likely to increase as climate change accelerates over the century to come.

2. The effects of climate change should not be considered in isolation. Every state's economy is linked to the economies of surrounding states as well as to the national and global economy. While the economic costs of climate change are predicted to vary significantly from state to state, the negative impacts that regional, national and global markets may experience are likely to affect all states and many sectors.

3. While some of the benefits from climate change may accrue to individual farms or businesses, the cost of dealing with adverse climate impacts are typically borne by society as a whole. These costs to society will not be uniformly distributed but felt most among small businesses and farms, the elderly and socially marginalized groups.

4. The costs of inaction are persistent and lasting. Benefits from climate change may be brief and fleeting -- for example, climate does not stop changing once a farm benefited from temporarily improved growing conditions. In contrast, costs of inaction are likely to stay and to increase.

5. Climate models and impact assessments are becoming increasingly refined, generating information at higher spatial and temporal resolutions than previously possible. Yet, little consistency exists among studies to enable "summing up" impacts and cost figures across sectors and regions to arrive at a comprehensive, state-wide result.

6. To provide not just a comprehensive state-wide assessment of impacts and cost, but to develop optimal portfolios for investment and policy strategies will require support for integrative environmental research that combines cutting-edge engineering solutions with environmental, economic and social analysis. The effort and resources required for an integrative approach likely pales in comparison to the cost of inaction.

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