

Economic Vulnerability to Climate Change in Coastal New Jersey: A Stakeholder-Based Assessment

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This study investigates economic vulnerabilities to climate extremes and climate change in coastal New Jersey before and after Hurricane Sandy. Drawing upon methodological best-practices in climate adaptation and disaster risk management, which emphasize co-production of climate assessment information, the study employs a stakeholder-based approach to identify key climate-related economic stresses, risks and vulnerabilities. Interviews with stakeholders conducted in the months prior to Sandy highlighted a myriad of climatic, environmental and economic stresses in the region and revealed a wide range of economic assets, activities, and populations that are economically vulnerable. Post-Sandy meetings with stakeholders reinforced findings of the pre-Sandy interviews but also brought to light some new and unexpected vulnerabilities. The study illustrates the value of stakeholder participation in economic vulnerability assessments, including deeper and more nuanced understanding of local economic assets, activities, and populations at risk to climate extremes and climate change. The study also demonstrates the importance of stakeholder-engagement for creating buy-in to the climate assessment process and for facilitating new learning opportunities in a post-disaster context. Given climatic non-stationarity and continually evolving economic conditions, stakeholder-based assessments will need to be conducted and updated on an on-going basis in order to ensure continual relevance to post-disaster learning and response.

Keywords: Economic vulnerability; Climate impact assessment; Co-production; Post-disaster learning.

1. Introduction

While economic impacts and costs of climate extremes and climate change have long been a topic of research and policy concern, growing public awareness of loss

and damage from climate change has brought new urgency to questions of what is at risk and who is vulnerable (Warner and van der Geest 2013; Vincent and Cull 2014). These questions have particular resonance in highly exposed regions, such as coastal zones, where evidence of climate change has become increasingly visible and decision-makers at all levels are exploring options and strategies to foster climate resilience. In addition to climate risk projections and baseline sectoral economic information, answering questions about economic risks and vulnerabilities also requires input from local stakeholders who possess detailed knowledge about specific economic sectors within a region and who are likely to be on the front line for adaptation planning. This study relies upon local-level, stakeholder knowledge to investigate economic vulnerability to climate extremes and climate change in coastal New Jersey during the periods before and after Hurricane Sandy. Focusing primarily on Ocean County, New Jersey, the study delineates critical climatic and non-climatic stresses affecting the study area, specifies key economic assets and activities at risk, and identifies populations that are economically vulnerable to climate extremes and climate change.

Hurricane Sandy brought home the economic devastation that is often associated with extreme storm events in developed coastal zones. However, awareness and concern about coastal New Jersey's environmental and climate change vulnerability is long-standing (Najjar et al. 2000; Psuty and Ofiara 2002; Wu et al. 2002; Cooper et al. 2008; Leichenko 2012). Located approximately 80 miles south of New York City, Ocean County is experiencing stresses common to urbanized coastal watersheds, including a rapid pace of population growth and new residential and commercial construction, loss of wetlands and natural areas for development, and intensification of land use. Temperature and precipitation records suggest that climate change is already underway in the region. Temperature and precipitation records since 1960 indicate that the region's climate has been gradually warming and that heavy precipitation events have become more frequent (see Figures 1 and 2) (Leichenko et al. 2013). Continued climate change is anticipated to exacerbate already present environmental risks and hazards in the region including sea level change, nor'easters, and hurricanes, and it is also anticipated to bring new stresses by altering long-term temperature and precipitation patterns and accelerating rates of sea level rise (NPCC 2013; Leichenko and Solecki 2013).

The study methodology draws upon emerging best-practices in climate adaptation and disaster risk management which emphasize creation of climate risk and adaptation information via two-way engagement between scientists and a plurality of stakeholders (Lemos and Morehouse 2005; Vogel et al. 2007; NRC 2009; Moser 2010; Weichselgartner and Kaspersen 2010; Lane et al. 2011;

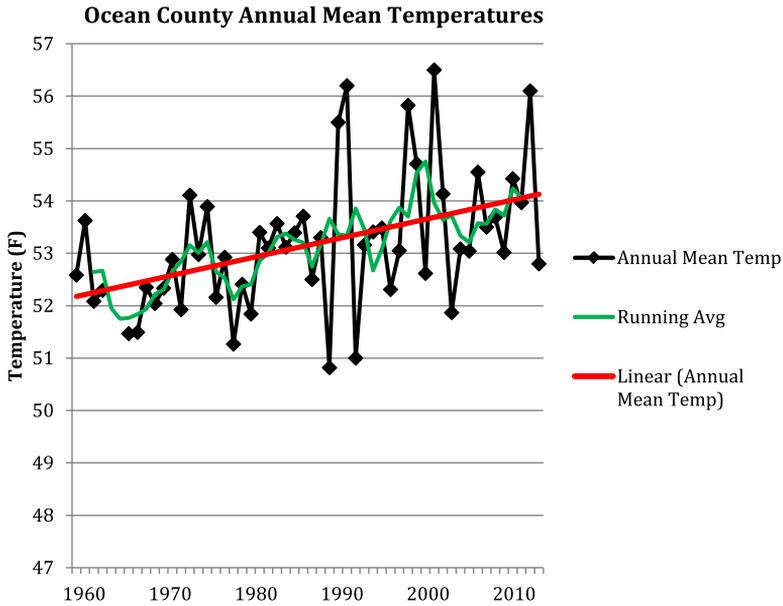


Figure 1. Mean Annual Temperatures in the Ocean County, 1960–2013. Toms River, Brant Beach, Tuckerton, and Berkeley Twp Stations, Ocean County. Data Source: Office of New Jersey State Climatologist (ONJSC) 2014

Corfee-Morlot *et al.* 2011; Cornell *et al.* 2013; Ford *et al.* 2014). The importance and relevance of local involvement is increasingly recognized in climate change and disaster risk research (Saldaña-Zorrilla 2008; Frazier *et al.* 2010; Hunt and Watkiss 2011; Horton *et al.* 2011; Rosenzweig 2011; Whatmore and Landström

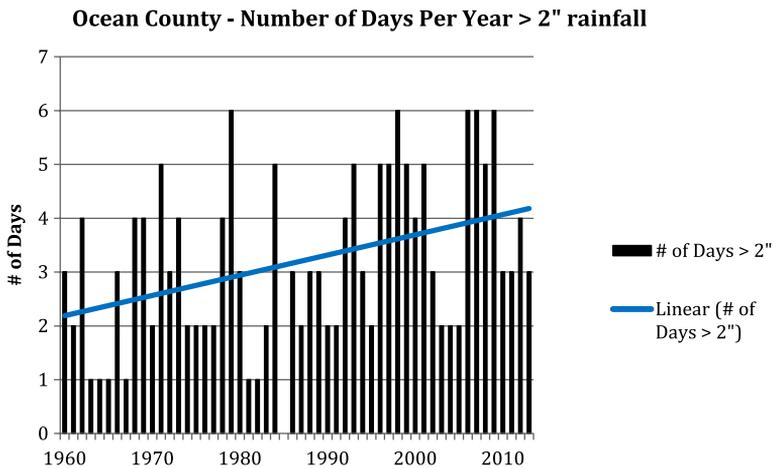


Figure 2. Extreme Precipitation Events in Ocean County, 1960–2013. Data Source: ONJSC 2014

2011; Birkmann *et al.* 2012; Lathrop *et al.* 2014; Wagner *et al.* 2014), and the newly formed international Future Earth initiative, has suggested that co-design and co-production is a vital component of global environmental change research (Future Earth 2014). In addition to providing highly detailed, locally relevant information about assets, activities and populations at risk, the additional value of local engagement is that it can create buy-in and learning opportunities, which, in turn, set the stage for efforts to build post-disaster resilience. Given climatic non-stationarity and continually evolving economic conditions, it is expected that these types of locally-based climate impact assessments will need to be conducted and updated regularly in order to ensure continual relevance to future post-disaster learning and response.

2. Defining Economic Vulnerability

As with the concept of vulnerability more generally, economic vulnerability has a range of different usages and interpretations. In this section, we briefly describe prominent research areas that explore different types of economic vulnerability, including: (1) economic vulnerability of national economies; (2) economic vulnerability of populations and communities; and, (3) vulnerability of economic assets and activities. The 3 areas highlight different facets of economic vulnerability to climate change, each of which is incorporated into our stakeholder-based assessment.

In the macro-economic literature, the concept of economic vulnerability is typically used to specify the degree to which national economies may be more or less subject to harm from external economic shocks and perturbations (Briguglio *et al.* 2009). Economic shocks stem from factors such as changes in trade policy, exchange rate fluctuations, or shifts in commodity prices. Economies that are more subject to harm from shocks are typically smaller and less diversified. Climate change has been implicated as a source of economic shocks, including dramatic shifts in food commodity prices (Wheeler and von Braun 2013). Several studies have explored the effects of past and possible future climate-related changes in commodity production and prices on economic growth and poverty at the national level (Ahmed *et al.* 2009 2011; Hertel *et al.* 2010). Within this line of work, higher levels of economic vulnerability are associated with greater economic dependence on specific commodity sectors and lower overall income levels (Dell *et al.* 2012).

Climatic and economic shocks are also recognized as important factors within the literature on vulnerability and multiple stressors. Vulnerability studies emphasize identification of which types of populations, social groups, and communities are more likely than others to be harmed by climate change or are less

able to adapt to climate-related shocks and stresses (Cutter *et al.* 2003; Adger 2006; Eakin and Luers 2006; Füssel 2007; Polsky *et al.* 2007; Turner 2010; Preston *et al.* 2011; Stern *et al.* 2013). Multiple stressors work has highlighted how economic stresses and shocks apart from climate change interact with shifting environmental conditions to shape regional, community, and population vulnerabilities (O'Brien *et al.* 2004; Eakin 2006; Keskitalo 2008; Leichenko and O'Brien 2008; Silva *et al.* 2010; Jeffers 2013; Burton and Peoples 2014). A recent study by Thatcher *et al.* (2013) includes both physical and economic factors in an index of economic vulnerability for the U.S. Northern Gulf Coast. The Coastal Economic Vulnerability index (CEVI) incorporates factors thought to contribute to societal risk from rising sea levels, such as population, urban land cover, economic value of key types of infrastructure, and residential and commercial building values. Other recent work in this vein has explored past and expected future changes in socio-economic exposure to sea level rise, storm surge and other climatic hazards (Frazier *et al.* 2010; Preston 2013).

Studies of economic assets and activities at risk emphasize the value of property, infrastructure, capital assets, and inventories that has been or may potentially be damaged by different facets of climate change, including changes in the frequency of climate related hazard events, sea level rise, and changes in agricultural growing conditions (Leichenko and Thomas 2012). A number of studies have also evaluated the direct and indirect economic costs of recent hurricanes for coastal regions located in the U.S. Gulf Coast and Atlantic Seaboard regions. These studies consider the impacts of past storms using economic indicators such as number of affected business establishments (Jarmin and Miranda 2009), taxable sales (Baade *et al.* 2007), production and employment (Hallegate and Ghil 2008), and housing prices and wages (Vigdor 2008). The studies also project future economic impacts of extreme storm events based on costs associated with past events (e.g., LeBlanc and Linkin 2010; Major *et al.* 2013). Asset-based studies have also explored the value of property and infrastructure assets at risk from sea level rise and heightened storm surge (Kirshen *et al.* 2008; Neumann *et al.* 2010 2014; Tate and Frazier 2013).

While each of these three areas of literature provides valuable insights into different dimensions of economic vulnerability, relatively few studies have made use of stakeholder input to identify critical economic risks and vulnerabilities (e.g., Frazier *et al.* 2010; Corfee-Morlot *et al.* 2011; Rosenzweig *et al.* 2011; Jeffers 2013). This study draws on local stakeholder knowledge to identify climatic and economic stresses in the study region and to specify economic assets, activities and populations at risk.

3. Methods

The study methodology draws conceptually from the framework of climate impact assessment, highlighting key economic components with significant potential impacts and costs and where adaptation action is needed. The approach is informed by recognition of the importance of joint creation of assessment reports, whereby researchers and stakeholders work collaboratively in the production of assessment reports with the goal of generating actionable science (Moser 2010; Weichselgartner and Kaspersen 2010).

Stakeholder data were obtained via in-depth interviews with key informants in the public, private, and non-profit sectors in the region.¹ We initially developed a stakeholder matrix that identified major economic and coastal management sector categories (e.g., tourism, fisheries, conservation and land management, emergency management, economic development, etc.) for the public, private and non-profit sectors. This matrix was then populated with names and contact information of individuals operating at the local, state and federal levels based on consultation with researchers and staff from the Barnegat Bay Partnership (BBP) and Jacques Cousteau National Estuary Research Reserve (JCNEER). The participation of the BBP, part of the National Estuary Program administered by the U.S. Department of Environmental Protection, and JCNEER, part of the National Estuary Research Reserve System administered by the U.S. National Oceanic and Atmospheric Administration, was a vital component of the project. Both BBP and JCNEER may be understood as “boundary organizations” (Cash and Moser 2000; Corfee-Morlot et al. 2011), playing an active role in facilitating interactions between researchers and stakeholders. In addition to input from BBP and JCNEER, names of stakeholders were obtained through a “snowball” sampling technique whereby individuals that we interviewed recommended other key informants with expertise on particular topics.

A total of 29 stakeholders from a wide range of sectors (see Table 1) were interviewed for the study during period between December 2011 and July 2012. Interviews were conducted with either one or two individuals or with a small group of individuals. Each interview lasted approximately 90 minutes. Most interviews were held in person. In a few instances where in-person interviews were not possible, interviews were conducted via telephone.

Stakeholder interview questions were designed to elicit information on different facets of economic vulnerability in Ocean County (Figure 3), and particularly the shore and barrier island communities surrounding the Barnegat Bay. Interviews

¹Institutional Review Board (IRB) approval from Rutgers University was obtained for all research on human subjects included in this study. IRB protocol number 11–604 M.

Table 1. Number and Type of Stakeholders Included in the Study

Stakeholder Category	Pre-Sandy Interview Subjects	Post-Sandy Meeting Participants
Public Sector		
Conservation and Land Management	3	10
Fishing and Fisheries Management	—	1
Tourism and Recreation	2	—
Planning and Economic Development	2	6
Emergency Management — Federal and State	4	5
Emergency Management — Local	5	—
Environmental Regulation	—	4
Education	—	4
Private and Non-Profit Sectors		
Conservation and Land Management	3	5
Fishing and Fisheries Management	2	1
Tourism and Recreation	4	—
Real Estate and Insurance	2	—
Infrastructure	2	—
Total	29	36

began with discussion of the stakeholder’s role and area of sectorial expertise with respect to coastal New Jersey. Questions then focused on climatic and non-climatic shocks and stresses affecting the region and on potentially vulnerable populations, assets, and activities. Stakeholder responses to these questions are presented in the next section. Our interviews with stakeholders also delved into several related topics including implications for emergency management and opportunities and barriers for enhancing regional resilience. The discussion of those topics is presented elsewhere (Leichenko *et al.* 2013).

The researchers took detailed notes during the interviews and also tape-recorded them.² Written transcripts of all of the interviews were developed based on the tape-recordings and interview notes. Once the interview process was complete, the transcript data were coded and indexed in order to identify key topics and themes that emerged in response to each set of interview questions (e.g., assets at risk, activities at risk, populations at risk), and to identify commonly cited stresses (e.g., sea level rise, population growth). Summary results tables were developed for each set of questions based on the key topics and common themes. Interview transcripts

²All of the subjects agreed to be tape-recorded. In two instances, technical failures occurred with the tape recording equipment. When this occurred, interviewers wrote up as complete a transcript of the interview as possible based on their written notes and their recollection of the discussion.

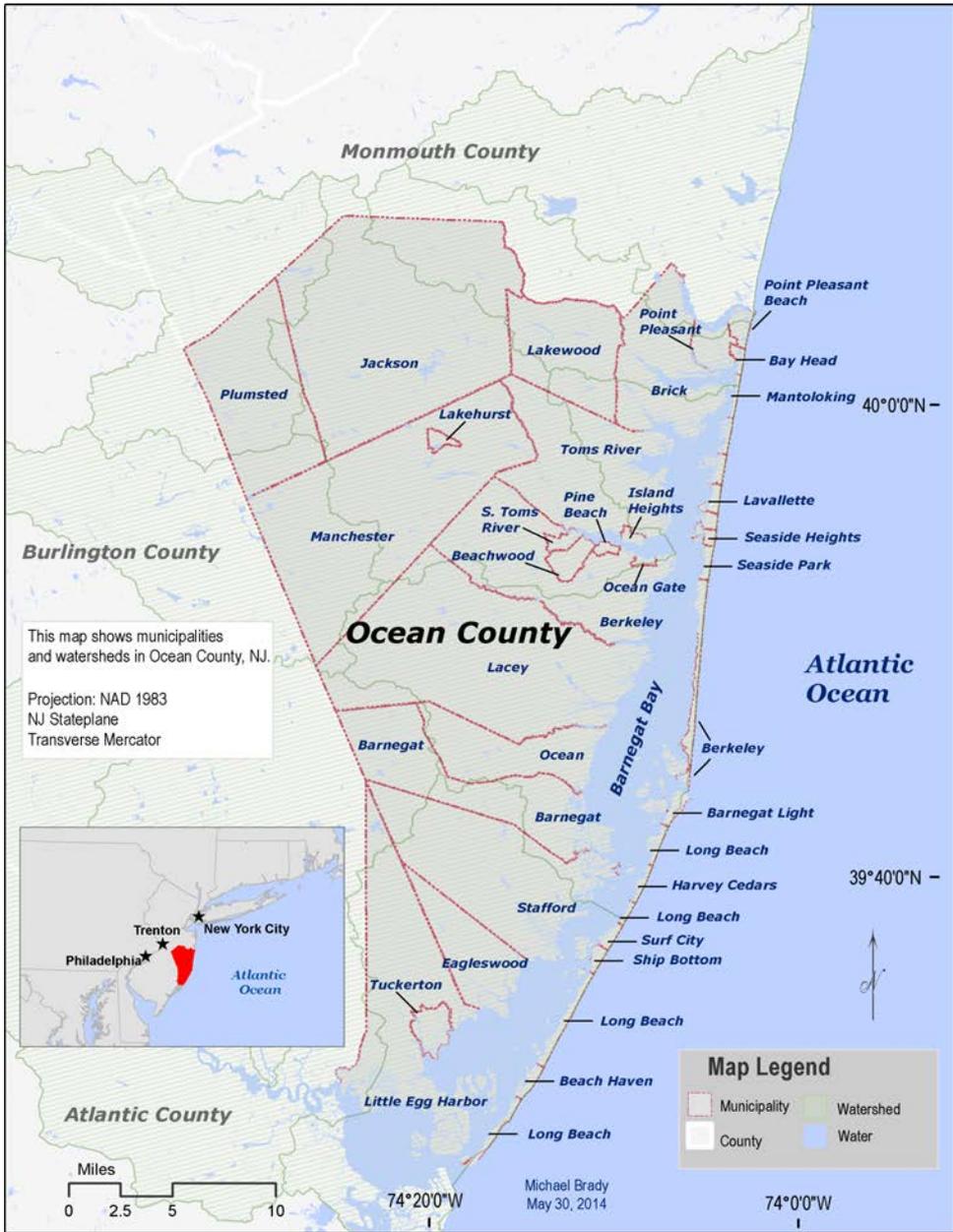


Figure 3. Study Area: Ocean County and the Barnegat Bay Region

were also reviewed in order to identify quotations that were illustrative of stakeholder views on different issues.

The coding and processing of the stakeholder interviews was completed just days prior to the arrival of Hurricane Sandy, which hit the region on October 29, 2012. The immediate phase of recovery from the Sandy lasted several months, and our first opportunity to present the interview results to stakeholders occurred at a BBP Science and Technical Advisory Committee meeting held in March 2013. At the meeting, results from the interviews were presented in a group setting with approximately 36 stakeholders in attendance. The group included roughly one quarter of the individuals who had been interviewed in the initial round of interviews, as well as other federal, state, and local stakeholders in the areas of conservation and land management, economic development, emergency management, environmental protection, and others. Comparison of the types of stakeholders interviewed in the first phase of the study with those who attended the meeting (see Table 1) reveals substantial overlap among stakeholder types but also indicates a few notable differences. In particular, the interviews included a larger range of stakeholders from the private and non-profit sectors while the meeting included a larger range from the public sector, with heavier concentration in the area of conservation. During and following the presentation of the results, stakeholders at the meeting provided feedback and suggestions for refinement of the results and future information needs in light of Sandy's impact.

4. The Pre-Sandy Regional Context: Climatic and Non-Climatic Stresses

Our first set of questions to stakeholders explored climatic and non-climatic stresses in the study region. These questions were intended to set the context for discussion of specific assets, activities and populations that may be vulnerable to the effects of climate extremes and climate change.

4.1. Climate risks and stresses

Our questions about climatic risks and stresses in the region were intended to probe stakeholders' perceptions of key climate hazards and climate change. In particular, the questions were intended to elicit perceptions about exposure and the types of climate impacts that stakeholders have observed and to identify what stakeholders are concerned about for the future, including which types of climatic events were likely to have significant economic effects in the region.

Table 2. Climate Stresses: Stakeholder Perceptions

Extreme Events

- General increase in all types of extreme events
- Flooding, both riverine and coastal
- Hurricanes
- Coastal snowstorms (Nor'easters)
- Droughts and heat waves
- Forest fires

Gradual Changes

- Sea level rise
- Marsh die-back due to salt water intrusion
- Shore erosion
- Ocean acidification, decrease in ocean salinity
- Temperature increases
- Out-migration of fish
- Increase in pests and invasive species

Illustrative Stakeholder Quotes

On a state-wide level, over the past five years, we've seen an unprecedented number of storms that are drastic in nature. *Emergency Manager*

Because of the change in weather patterns, we've had worse snowstorms recently. We had a hurricane. Nor'easters, that one year we were getting like eight or nine of them, eleven of them. I don't remember. So certainly the storms in that respect seem to have worsened. *Emergency Manager*
... Extreme amounts of rainfall and then localized flooding, the most recent being Hurricane Irene and Tropical Storm Lee. ... We also got hit with a storm the week prior to the hurricane. That was unnamed; it wasn't a tropical storm. So those three right in a row ended up being the flood of record for most of the municipalities around the state. *Emergency Manager*

The biggest, most immediate impact [of climate change] is sea level rise. It has been documented and it's happening ... The question for us is, are our marshes and shorelines keeping up with the sea level rise ... *Natural Lands Manager*

The whole shoreline is receding. There is very little marsh remaining, which is important for wildlife up here. In my observation it's going on faster. *Natural Lands Manager*

... The forests become more vulnerable to pests ... the borers, the adelgid borer, eastern caterpillars, that type of thing. *Conservation Stakeholder*

Although a few of our interviewees were reluctant to discuss human-caused climate change, all were willing to share their perceptions about the region's climate and its key climate hazards. The perception that the region's climate has changed was widespread among the stakeholders. Climate stresses observed and expected by stakeholders entailed both extreme events and gradual changes (Table 2). Flooding was the most commonly mentioned extreme event, while sea level rise was the most widely discussed gradual change. Some types of changes were only noticed by particular types of stakeholders (e.g., natural resource managers), but all stakeholders named one or more changes that they have already noticed and anticipate seeing in the future.

Extreme events: Nearly all stakeholders noted that there has been an increase in extreme events. Flooding, both riverine and coastal, was the most cited example. Inland river flooding was described as both an immediate and a novel threat caused by extreme precipitation events. Emergency managers in particular noted recent record-breaking river floods. Coastal flooding was anticipated from the interaction of increased storms with sea level rise, but several people noted that coastal flooding is already an occasional problem. Some noted that barrier islands are both accustomed to coastal flooding and have favorable topography for recovery, while bayside communities would find increased coastal flooding both unexpected and more damaging. While stakeholders noted that few hurricanes have touched down in New Jersey, several cited an increase in tropical storm activity, leading several respondents to anticipate an increase in hurricanes in the near future. Emergency managers noted increased coastal snowstorms heavy enough to cause emergency declarations. Emergency managers and utilities stakeholders cited droughts and heat waves occurring in the last few years, though drought concerns were recently replaced with concern about excess precipitation. They also anticipated an increase in forest fires from the same conditions that created the droughts and heat waves.

Gradual changes: Sea level rise was cited by the majority of respondents, making it the most discussed gradual driver of environmental change. It is also noteworthy that a number of the individuals who avoided discussing human-induced climate change did not hesitate to identify sea level rise as a real trend. The effects of sea level rise were posed in complex interaction with natural topography and built structures as well as with the extreme events discussed above. Natural land managers perceived a current, ongoing rise contributing to observed marsh die-back and beach erosion. They also noted that even a small rise in sea level can disproportionately magnify the effects of large storms. Other stakeholders were more speculative. Several noted that while they expect sea level rise to affect the future, their location on bulkheads and the current ubiquity of beach replenishment programs make any current sea level rise less perceptible. Nevertheless, all who mentioned sea level rise expected it to become a serious problem in the future. Other gradual changes include temperature increases, movement of species, and changes in ocean water composition. Some mentioned warming of ocean water, while others noted warmer winters and summers. Fisheries stakeholders have noticed significant out-migration of valuable fish species due to the warming of ocean water as well as occasional in-migration of more southerly species. A number of stakeholders noted the rise of pests and invasive species associated with warmer seasons, with a particular threat to the forests of the Pinelands. Stakeholders familiar with ocean chemistry noticed a steady decrease in the salinity of ocean water, and they also projected that ocean acidification would have serious impacts on marine life.

4.2. Non-climatic stresses

The economy of the Ocean County is highly diverse, a reflection of its heritage as a natural resource, and agricultural economy, its continued importance as a major recreational and tourism destination, and its emergence over the past several decades as a major destination for suburban commuters and retiree populations (Leichenko et al. 2013). The largest sector by share of employment is the health care industry, followed by, professional and other services, retail, hospitality/recreation, and construction and finance/insurance tied for fifth largest sector. These six economic sectors, which account for approximately 87 percent of the employment in the region, serve the region's growing populations (health care; construction) as well as its tourists (retail; restaurants and accommodation) (Leichenko et al. 2013). The draw of Barnegat Bay and the ocean underlies the region's attractiveness to both tourists and new residents, and economic sectors that are directly dependent on the resources of the bay continue to play an important role in the region. These include shore-front tourism, commercial and recreational fisheries, and other activities that require access to the bay.

The non-climatic stresses that were identified by the majority of stakeholders generally fell into three interrelated areas, including (1) population pressures, (2) economic uncertainty and downturn, and (3) environmental degradation (Table 3). Stakeholders also generally recognized that these issues are closely intertwined. For example, population pressures were recognized to be closely related to the dependence of the region's economy on new housing development, which also drives many of the environmental stresses. Meanwhile, the economic downturn was recognized as having adverse effects on business owners but was also thought to reduce environmental pressures by slowing down development. Many stakeholders commented on these complex interactions and suggested novel interdependencies. Stakeholders also commented on positive dimensions associated with several of the observed conditions (e.g., an increased proportion of seniors in the region were associated with an increase in volunteer activities by this population group).

Demographic stresses: Ocean County has experienced rapid population growth over the last several decades (see Figure 4), and respondents reflected on this mainly through comments on the spatial extent and magnitude of new development. Figure 4 illustrates population growth in Ocean County and its municipalities from 1990 through 2010. The county's total population increased by approximately 33 percent during this 20-year period from approximately 433,000 to approximately 576,000. This rate is more than double the growth rate for the state of New Jersey as a whole, which grew by approximately 14 percent during

Table 3. Non-Climatic Stresses: Stakeholder Perceptions

Demographic Stresses

- Population increase
- High proportion of senior citizens
- Decline in environmental/climate awareness

Economic Stresses

- Recession
- Budget cuts
- Dependency on development and construction
- Lack of public transit
- Increased global and local demand for seafood

Environmental Stresses

- Development
- Pollution of Barnegat Bay
- Marsh die-off
- Alteration of sedimentation activity

Illustrative Stakeholder Quotes

We're a marine county, but some people have never been to the ocean . . . In the 1950s, there were 50 thousand, but now there are 600 thousand people here, and they didn't originate here. They don't know about the county. They don't relate to the bayman culture. *Natural Lands Manager*

So it's unfair, a retired couple on a limited income, lived here all their life, paid all their taxes and the (tax) assessment on their little bungalow is now 1.5 million dollars. . . . And nobody wants the bungalow . . . Usually it's a tear-down. *Economic Development Stakeholder*

I mean, you know, we're suffering hard economic times at the Shore in certain parts, [in certain] industries anyway. The commercial fishing industry, and especially the recreational fisheries have had a real collapse in this economy already. So the economy is playing a big part of the role [in fisheries decline]. *Fisheries Stakeholder*

. . . Our primary business is tourism, our secondary business is home-building, driven by the tourism market. Of course we know what happened to home building. We got our eggs back in one basket again. *Economic Development Stakeholder*

So I've seen a lot of changes. A lot of changes in the sea life, a lot of changes in what's going on around Barnegat [Bay]. Obviously it's mostly from the development that has taken place. *Economic Development Stakeholder*

. . . To really protect Barnegat Bay, you can't continue to pave over the watershed. You can't continue to have unfettered development. You've got to put larger investment to remediation of existing pollution sources. *Conservation Stakeholder*

the same period. In addition to the region's overall population growth, a number of stakeholders also commented on shifts in the shares of permanent residents, with some townships experiencing substantially increased permanent settlement as the result of new housing development, and others losing permanent residents as modest single-family homes were replaced with higher value second homes and properties used as summer rentals. Regarding the region's demographic profile, respondents noted the unusually high and rapidly growing percentage of

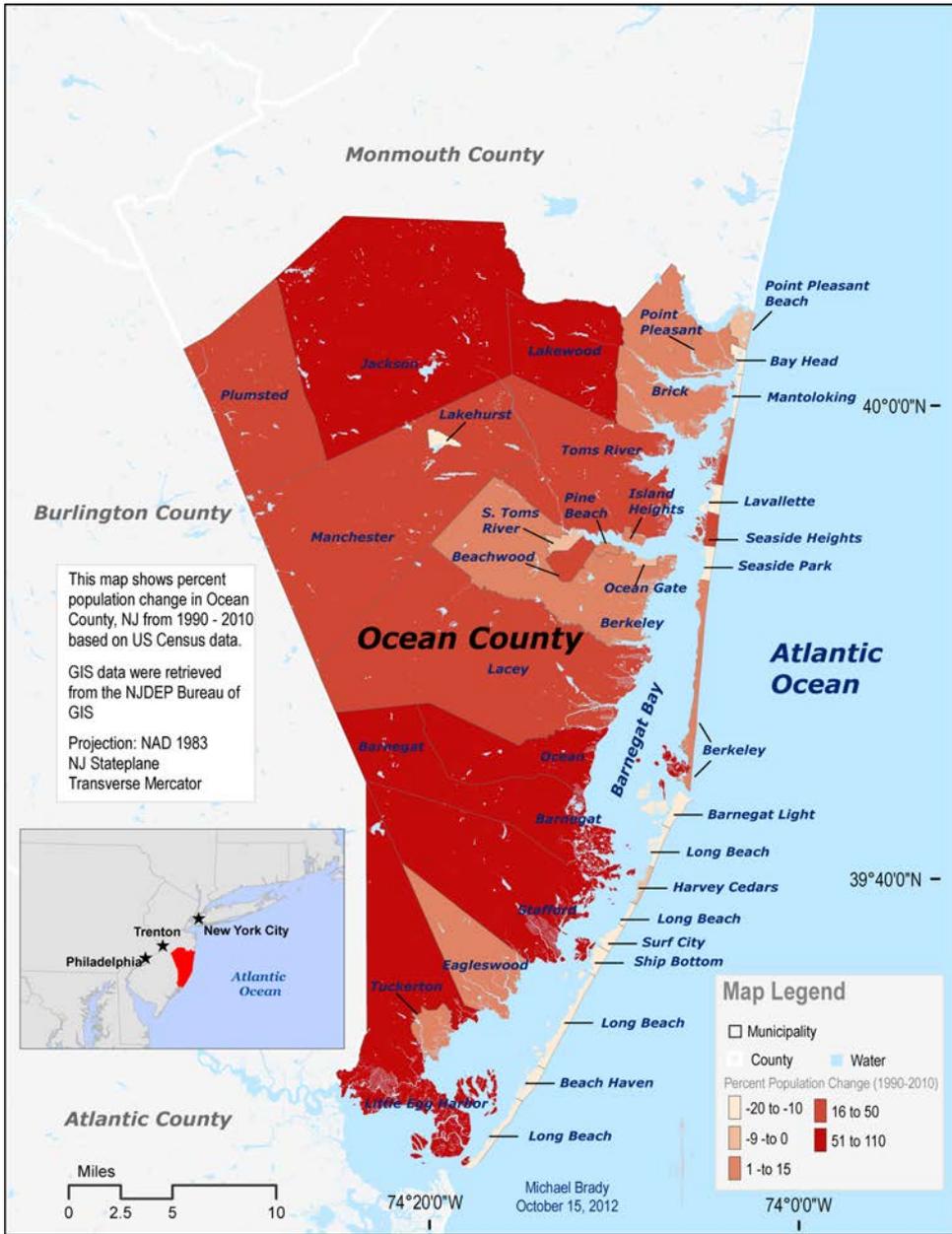


Figure 4. Percentage Population Change in Ocean County, 1990–2010. Data Source: US Census, Various Years

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senior citizens in the area (Figure 5). Whereas approximately 13 percent of the population in New Jersey is aged 65 and over, more than 21 percent of the population of Ocean County falls into this category. Several stakeholders commented on the displacement of fixed-income retirees from modest shore houses to make way for teardown redevelopment. Individuals who own shore homes but have a fixed income may be “pushed out” by rising property taxes which make it unaffordable for them to remain in a shore community that is undergoing re-development.

Economic Stresses: The recession and slow pace of economic recovery was the most widely discussed economic stressor. Several stakeholders noted that the region’s dependence on construction and new housing development for economic growth leaves it especially prone to boom-and-bust cycles. Relative to new housing, demolition has offset up to a third of housing construction, though this trend does not imply that all demolition was conducted for the purposes of re-development. For the tourism sector, another of the region’s major industries, impacts of the recession have been mixed. A tourism stakeholder noticed that local visitors to the shore have actually increased. A fisheries and tourism stakeholder explained how people shift out of higher-cost purchases, creating more business for lower-cost alternatives. Creative solutions like package tourism and recruitment of new customers were cited by several. However, many noted that these were all short-term survival strategies, and that long-term planning for climate change or other considerations was a casualty of the downturn. Government budget cuts were mentioned by numerous respondents in the context of the recession. Budget cuts have or will affect vital services like beach replenishment, parks staffing, and emergency preparedness, with potential fallout for important economic sectors.

Environmental Stresses: Widespread development and rapid population growth were perceived as the major environmental stresses facing the region. Many of the more specific concerns identified by stakeholders were linked to these factors, including stress on water quality and quantity. The adverse impact of development was most often noted in connection to the ecological health of the Barnegat Bay. Development increases non-point-source pollution of the bay, such as pesticides and fertilizers from lawn run-off. It also blocks the retreat of marshes, which are important fish nurseries on the bay. Several respondents expressed concern that eelgrass die-off, which has already affected much of the bay, could intensify, destroying the fish stocks important to the bay’s economy. Many of those who cited these dangers also commented on the decline of shellfish such as oysters and surf clams, both of which were historically of vital economic importance. Stakeholders pointed out that a variety of industries that had been dependent on the bay

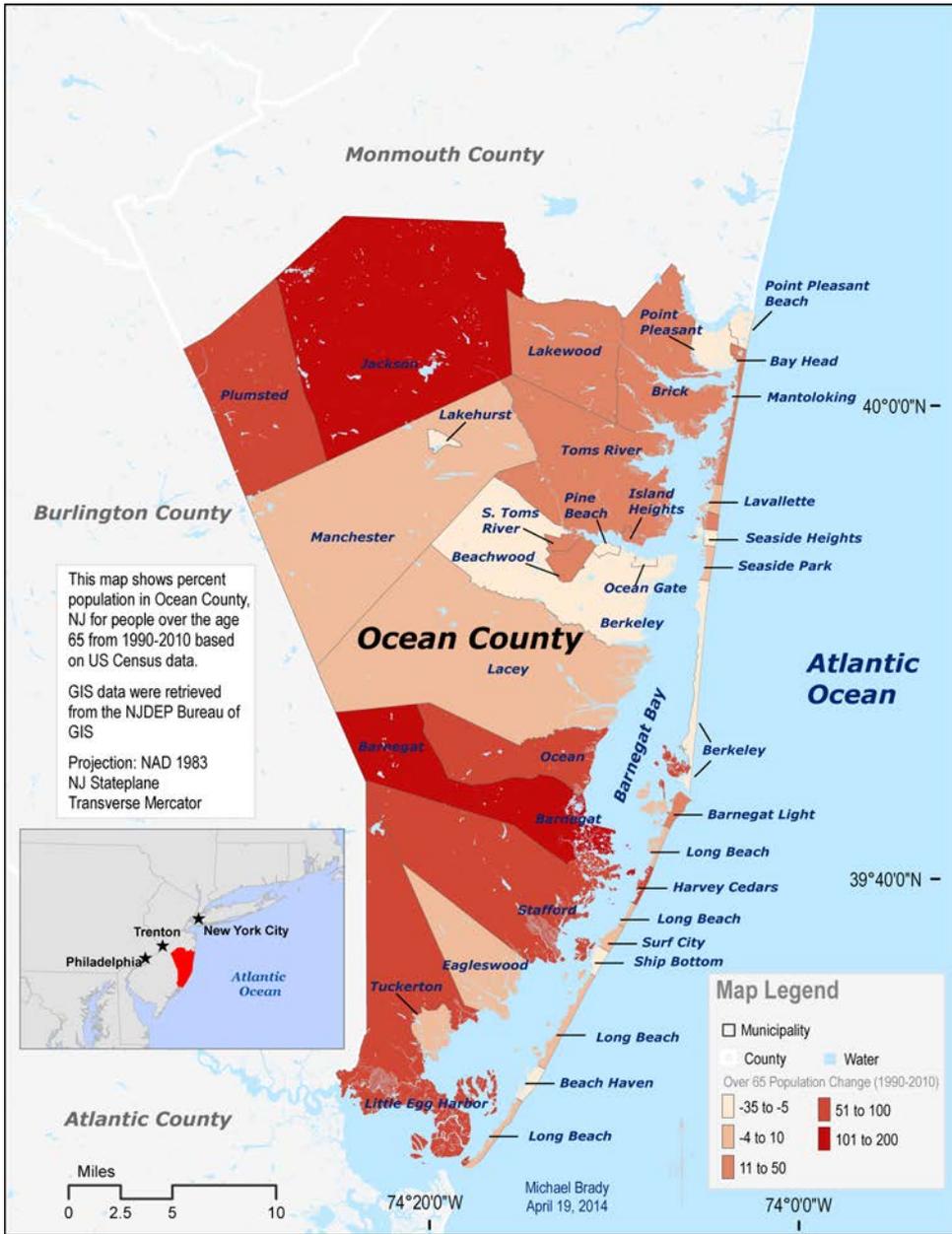


Figure 5. Percentage Change in Population over age 65, 1990–2010 Data Source: US Census, Various Years

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were declining, including boat-building and surf clam fishing. These sectors were all once more prominent in the region, and were perceived by some stakeholders to make the economy more diversified and resilient. The impact of shore armoring and jetty construction was also an issue of concern for stakeholders. Erosion can be exacerbated by shore armoring, which interferes with sediment transport. Altering sediment flows can also reduce marsh cover, as marshes need to be fed by sediment accumulation. Natural land managers were especially concerned about this impact. Stakeholders noted that the region depends on beaches for tourism and on a healthy bay for fisheries, and coastal engineering projects have mixed and sometimes unforeseen effects on them.

5. Pre-Sandy Stakeholder Perceptions of Assets, Activities and Population Vulnerabilities

Following the discussion of climatic and non-climatic stresses, stakeholders were asked to identify key assets and economic activities that might be vulnerable to harm as the result of climate extremes and climate change. We also asked stakeholders which types of occupations, and which social groups would be most affected by climate-related damage to assets and disruption of activities.

5.1. Assets at risk

Stakeholders discussed key assets at risk due to climate change and climate variability in terms of two major categories: natural features and the built environment. Stakeholder responses are summarized in Tables 4 and 5.

Natural Assets: The most frequently mentioned natural assets were the region's beaches. Beaches are understood to be a key draw for tourists and homeowners in the region, and they are vulnerable both to ongoing and gradual sea level rise and to severe coastal erosion from increased frequency and severity of storms. One stakeholder suggested that the value of waterfront homes, boardwalk businesses, and tourist visitation numbers would all tend to collapse in localities where the beach disappears. Other natural assets that were frequently mentioned include estuary and tidal marsh areas, which are vulnerable to saltwater intrusion. Within the Barnegat Bay region, there were 66,732 acres of freshwater wetlands and 21,449 acres of saltwater (tidal) wetlands as of 2007 ([Barnegat Bay Partnership 2011](#)). Drinking water was also cited as key asset that is vulnerable to saltwater intrusion. Well and aquifers are subject to saltwater intrusion due to a combination of lack of recharge and excessive use under drought conditions. A decline in forest health in the region was also noted. Stakeholders commented that saltwater intrusion is killing cedars, while drought and pinebark beetle infestation (favored by

Table 4. Natural Assets at Risk: Stakeholder Perceptions

Natural Asset	Extreme Events	Gradual Changes
Beaches	x	x
Fresh water		x
Estuary and tidal marshes		x
Forest species		x
Marine life		x
Forest habitat	x	x

Illustrative Stakeholder Quotes

When you don't have a beach to sit on, it doesn't attract many visitors. *Economic Development Stakeholder*

There's a period of time in between storms that the beach replenishes . . . If that starts getting less and less, . . . then you're going to have more beach destruction, more houses collapsing into the sea, just because you have more storms. *Fisheries Stakeholder*

You're going to have changes in freshwater inputs into the estuaries . . . if the freshwater inputs slow down, the salt concentration from the estuary will move further up the river, therefore increasing treatment costs and reducing the freshwater supply. *Conservation Stakeholder*

You're changing . . . ecosystems, and an area that was not flooded before, it is brackish water or salt water. We're starting to see some areas of the county where you're starting to see some tree die-back right along the edge of the marsh. *Economic Development Stakeholder*

warming winters) are stressing trees in the watershed. Stakeholders involved in fisheries also noted shifts in marine ecosystems, leading to the decline of some economically important species, notably surfclams (historically New Jersey's highest revenue-generating seafood product but now decimated by a steep decline in landings), as well as crabs and bluefish. While some of the species arriving from the South have economic value, local fishermen, boats, and markets are not yet set up to capitalize on them.

Built Assets: Among built assets, the transportation sector, including roads, bridges, and mass transit, topped the list of stakeholder concerns. Stakeholders noted that damage to transportation routes interrupts the flow of vacationers, and repair work extends the interruption. Stakeholders pointed out that some barrier island communities have only one approach and could therefore become entirely cut off during a storm event. This poses a dangerous obstacle to evacuation efforts and can do significant damage to tourism-based businesses. Stakeholders also noted that approaches to bridges and causeways are particularly prone to flooding, as are older municipal or county-owned roads, which typically have not been upgraded to meet demands associated with higher local and seasonal populations. Sea level rise and more frequent and severe storms also threaten waterfront housing, much of which is comprised of high value second homes and investment

Table 5. Built Assets at Risk: Stakeholder Perceptions

Built Asset	Extreme Events	Gradual Changes
Roads, bridges, mass transit	x	x
Waterfront property	x	x
Recreational infrastructure	x	x
Property located in flood prone inland areas	x	
Municipal facilities	x	

Illustrative Stakeholder Quotes

The stuff that is closest to the coast, which may not have been in a flood area before but is starting to transition to a flood area. . . .When we’re thinking regionally about our assets, we’re thinking about roads and bridges, and those are of course essential for evacuation. . . . Areas that are vulnerable, areas that may now be vulnerable that weren’t vulnerable before. *Economic Development Stakeholder*

The bridges and causeways themselves are not the [main] problem, it’s the approaches, you know. When you come down off the bridge, it always floods. So, you’re not going to get people out, even though the bridge is high. *Real Estate Stakeholder*

My big concern has always been on the oceanfront, where we’ve seen enough storms, we’ve done enough post-storm surveys, we know the damage that has happened, will continue to happen. *Real Estate Stakeholder*

If you think about people, much of the housing stock [that] is built on barrier islands, in particular Long Beach Island, those kind of places, are second homes and are investment properties. . . . I don’t know what happens when those houses start going under water or get destroyed. *Conservation Stakeholder*

. . . The police department, the fire department, the garage that houses the local ambulances. Normally towns utilize property that is not as favorable to somebody putting a house on, so it’s usually low-lying. *Emergency Manager*

properties. Threats to recreational infrastructure, such as boardwalks and marinas, were often mentioned. Stakeholders pointed out that homes situated in low lying areas, including some that never previously flooded, will “find the bay in their basement” with greater frequency.

5.2. Economic activities at risk

Many of the assets described in the previous section are pillars that support key economic activities in the region. Table 6 summarizes stakeholder responses to our questions about economic activities at risk. In addition to climatic stresses, stakeholders also emphasized the impacts of non-climatic stresses. Economic stresses were seen as important for all activities, while demographic and environmental stresses were cited in a number of cases.

Tourism was the sector most frequently cited as vulnerable to the impacts of climate change, particularly increased frequency of extreme events. Stakeholders

Table 6. Activities at Risk: Stakeholder Perceptions

Activity	Climatic Stresses		Non-Climatic Stresses		
	Extreme Events	Gradual Changes	Demographic	Economic	Environmental
Tourism	x	x	x	x	x
Commercial fishing		x		x	x
Recreational fishing		x		x	x
Wildlife and parks	x	x	x	x	x
Construction real estate		x		x	
Insurance	x	x		x	
Agricultural production	x	x			x

Illustrative Stakeholder Quotes

The reality . . . is we are so dependent on weather . . . I don't care how great the boardwalk experience is — if it's raining, or there's a nor'easter or there's a snowstorm, or if the weather is not good, people are not coming to the beach . . . The weather is the number one contributor . . . in the success of our business. *Tourism Stakeholder*

The tourist industry remains very important . . . and most of those facilities are on the water, so they are threatened by sea level rise or increase in storms. All of them are threatened, whether they are restaurants or amusements or other things people want to avail themselves of. *Economic Development Stakeholder*

the day after the storm, we made it very clear that the beach is open . . . The (media) . . . were giving out information that wasn't quite correct. Yes, we lost a section . . . in Spring Lake and in Belmar, but the reality is that we have 132 miles of beaches. And yes, maybe five miles of them got damaged. *Tourism Stakeholder*

A big part of the state's economy . . . is related to tourism from the Shore . . . All that . . . is based upon the environmental quality of the shore. *Conservation Stakeholder*

Fisheries are already pretty strained, stretched. The surfclam industry is the biggest sector of the fisheries in New Jersey, commercial fisheries . . . So to the extent that they have to go further to sea, further north, not only do they have increased costs, but they have more competition. *Conservation Stakeholder*

I mean, in order to have fishing, you got to have fish. And you [have to have species of] fish that people want to take home to catch . . . I don't know what you're going to do with an industry like [recreational fishing]. *Fisheries Stakeholder*

noted that the beach-going season runs only three to four months a year with peak visitation on weekends, so even a few additional days of disruption by rain or storm can mean the loss of a high proportion of revenue. A late summer disruption can effectively cut short the season, as was the case when Hurricane Irene in late August of 2011. Although the most severe damage from Irene occurred in the northern part of the state, stakeholders thought that the timing of the storm during the last weekend in August led many to conclude that “summer’s over” and substantially reduced the number of visitors to the region during the all-important Labor Day weekend.

Stakeholders noted that even those who were not dealing with flood damage did not return for Labor Day. Several estimated that the storm cost “10 percent of the season’s business.” Economic disruption from extreme events can also be affected by media coverage. One stakeholder pointed out that managing the media perception of the damage was critical. The stakeholder noted that the media tends to direct attention to areas where there is storm damage which sometimes leads to a perception that damage is much more extensive than it is in reality.

In addition to threats associated with more frequent extreme storm events, several stakeholders also pointed out that tourism to the region generally is affected by its overall environmental quality, which is strained by climate-change-compounded effects. Diverse types of businesses are dependent on or strongly linked to tourism. Hence, the array of businesses vulnerable to both climate and environmental risks includes not only hotels, restaurants, and boardwalk operators, but also marinas, boating and bait-and-tackle shops, convenience stores, auto dealers, fly-by advertisers, and even, as one stakeholder pointed out, accountants and all those providing services to tourism businesses. Also significantly driven by the tourism market is construction and real estate. The value of commercial, investment, and second-home properties rises and falls with tourist demand for their use, among other related factors.

After tourism, fishing was the sector that was most frequently described as climate-vulnerable. Both commercial and recreational fisheries are already under pressure (in “collapse” according to one stakeholder) from economic factors that are exacerbated by environmental stresses and climate change. One stakeholder pointed out that, although sea scallops, the main generators of economic value for Ocean County fisheries, have so far thrived, sea scallops eventually can be even more affected by climate change than finfish because it’s harder for them to migrate to cooler waters. Stakeholders explained that rising water temperatures were causing a northward shift of economically important fish such as bluefish and bluefin tuna and contributing to declines in populations of clams and oysters “with nowhere to go.” At the same time, degradation of saltmarsh nurseries and other forms of environmental change are stressing populations of numerous species. Although fishing days on the water are weather-constrained for commercial boats, they can be back in business immediately after a storm passes. However, fishermen and the fish processing and marketing operations are vulnerable to power disruptions and any conditions that might keep their customers away. Thus, the fishing boats were back in the water the day after Irene, but business was still hurt by the drop in demand for seafood due to a dearth of customers at local restaurants.

Recreational fishing is also affected by changes in fish populations. When fish populations decline, or are perceived to decline, regulators increase size limits and

decrease quotas for popular sport-fishing species, which amplifies the impact of the actual scarcity by discouraging participation. This was among the factors that stakeholders cited as depressing participation in recreational fisheries and thus the revenues of the mostly small businesses involved — charters, party boats, fishing supply stores. Other recreational activities that are likely to be affected by climate change included visits to observe migratory birds and visits to state, county and local parks. Birding activities are especially threatened as a result of loss of natural habitat for migratory birds, particularly estuaries. Regarding park visitation, numbers of visitors largely depend on weather conditions. One park manager noted that visitation rates, particularly for beach locations, are positively affected by warmer weather, but that parks currently have insufficient funds to accommodate larger crowds on very hot days.

5.3. Groups vulnerable to asset damage and activity disruption

Physical, economic and social factors that influence the relative vulnerability of individuals to climate risks are well documented in the scientific literature and include, for example, residential location in a floodplain or near a coast, low income levels, and presence of health impairments or other conditions (e.g., non-native English speaker). Our questions focused on identification of economically vulnerable groups and particularly those vulnerable to the specified effects of damage to assets and activities.

The most frequently mentioned group was small business owners (Table 7). Small businesses were regarded as highly vulnerable to physical damage as the result of climate change because they cannot afford to make repairs in situations where they are not insured or are under-insured, nor can they afford to put in storm protections such as bulkheads. Stakeholders noted that ‘mom and pops’ that are either directly or indirectly tourist dependent could lose a significant percentage of their summer revenues to closures for storm events, even when those events do not cause significant direct physical damage. Without the access to savings or credit to diversify their operations or to get through lean periods, smaller businesses may not be able to weather the storms of change. While seen as more resilient than those in tourism, smaller businesses engaged in commercial fishing are similarly more at risk than larger, better capitalized and more sophisticated operations. Different species of catch require different techniques, equipment and skillsets, and some operators will have more adaptive acumen and resources. Baymen (a term describing fishermen with deep local roots) were described by one stakeholder as “at the top of the list” of the “heavily affected.” Another described their present “culture [as] a mere shadow of what it used to be.”

Table 7. Vulnerable Groups: Stakeholder Perceptions

Groups	Climatic Stresses		Non-Climatic Stresses		
	Extreme Events	Gradual Changes	Demo Graphic	Economic	Environmental
Small business owners and employees	x	x		x	x
Commercial fishermen		x		x	x
Municipalities	x	x	x	x	
Low-income residents and property owners	x	x		x	
Users of public amenities		x		x	x
Farmers	x	x		x	x

Illustrative Stakeholder Quotes

Small businesses in particular. Their lifeblood may be where they are. The bulk of their business is three or four months out of the year. If they're starting to get a lot of damage, it could drive them out of business . . . The larger ones may be able to do more bulkheading to give them more protection. *Economic Development Stakeholder*

Independent properties . . . are more at risk because they don't have the capital behind them, as a large chain hotel, . . . if you have to physically put the money up before you can get reimbursed, that's the issue. So the smaller people don't have the ability to do that. *Tourism Stakeholder*

Local government — which is barely hanging on now — will be among the most adversely affected. When individuals are hit, they'll appeal to local government . . . they'll be dealing with tax appeals, evacuation . . . and more demand on local services. *Conservation Stakeholder*

The most vulnerable? Definitely that would include individual homeowners, especially the low income. The wealthy will just put up sea walls. *Conservation Stakeholder*

. . . the small businesses that support recreational fishing, whether they're the boat guides, or the guys that run the head boats out of Highlands, or the bait shops, the tackle shops. Those are all very, very small businesses that don't have a lot of resiliency themselves, to use a climate-change-related term. *Conservation Stakeholder*

The attendance (to parks) goes up during hard times. It's a relatively inexpensive place to go on vacation. . . (seniors) are heavy users of the parks and programs. We also have school groups, but there are fewer of them because of cuts to busing budgets. *Natural Lands Manager*

Stakeholders also highlighted a number of other at risk groups. Already battered by the recession, local governments and those who rely on them were thought to be among the most vulnerable. Under a future scenario of sea level rise coupled with increasingly frequent and severe storms, municipalities will be simultaneously stressed by losses to their tax-base, damage to facilities, and increased service demands. Also among the vulnerable groups identified were individual homeowners, especially those with low incomes and/or limited insurance coverage and resources for repairs. Stakeholders noted that low-income or fixed-income, elderly property owners are already experiencing property-related economic pressure because of rising property taxes that typically accompany re-development in shore

communities. Users of county and state parks were another group that was noted as vulnerable in light of the potential for damage to natural assets from sea level rise and storms. While users span the demographic and income spectrum, particularly vulnerable users include those with fewer assets to put towards seeking out alternative activities which may require more costly, longer-distance travel. Populations identified include lower income residents, elderly and other residents with fixed incomes, and school groups. In discussing impacts on park users, several stakeholders pointed out the voluntary contributions of area seniors to maintaining area parks and noted that these contributions were vital in light of budget cuts. Equally at the mercy of weather, farmers in the region were also cited among the most vulnerable. Stakeholders noted climate instability can bring both drought and excessive rain in one year and crop failure could wipe out smaller and more marginal farmers.

6. Post-Sandy Learning Opportunities

The results of the stakeholder interviews provide a detailed vulnerability portrait of the region just before it was hit by a devastating coastal storm event. When the study findings were presented to stakeholders several months after Sandy, stakeholders generally concurred with the study assessment of key vulnerabilities and commented on the fact that the interviews had anticipated much of the damage wrought by Sandy, particularly the impacts on beaches, boardwalks, waterfront properties, transportation infrastructure, the tourism sector, small businesses and lower income households. However, much of the discussion at meeting centered on emergent vulnerabilities that the study had missed and on learning opportunities in the post-Sandy context.

6.1. Emergent vulnerabilities

The discussion at the meeting focused on a number of areas of unexpected vulnerabilities that emerged from Sandy, including vulnerability of energy and water supply infrastructure, shore-based recreational fishing, and middle-income homeowners. Stakeholders also noted that the policy environment after Sandy had become much more uncertain with respect to floodplain extents, rebuilding requirements, and availability of flood insurance.

Energy and Water Infrastructure: Damage to the region's energy and water infrastructure as the result of Sandy was widespread and long-lasting. Particularly hard hit were the barrier peninsula and island, where the total destruction of gas, electric, and water lines in some areas resulted in outages that lasted weeks or months. Stakeholders commented that, while they expected some outages, the magnitude of infrastructure damage, particularly to the power grid, was unexpected

and that they were taken by surprise. Stakeholders also noted that emergency power backup plans failed because they did not anticipate long-term outages (e.g., battery back-up systems failed because they were designed to last for 24 to 48 hours maximum). Stakeholders commented on the unexpected disruption of “normal” life as a result of energy sector damage and noted that there has been a surge in demand for back-up generators for Ocean County homes and businesses. Stakeholders noted that the vulnerability of energy and water systems was a critical concern for the economy of the region.

Shore-based Recreational Fishing: Sandy also did significant damage to the shore-based recreational fishing sector. Stakeholders noted that the small businesses that support bay and surf related fishing activities (e.g., tackle shops, gas stations, food services) were particularly hard-hit because of damage to shore access points, piers and other shore infrastructure, and closure of beaches. Stakeholders also noted differences in vulnerability between those business that are oriented toward ocean fishing such as charter or party boats versus those that serve bay and surf activities. While both are vulnerable to business interruption from extreme events, bay and surf businesses were noted as especially vulnerable to long-term interruption as the result of both damage to infrastructure and beach closure.

Middle Income Homeowners: A third unanticipated vulnerability was among middle-income homeowners in both inland and shorefront communities. While the stakeholder interview results emphasized the vulnerability of elderly and lower-income homeowners, stakeholders at the meeting expressed the need for additional attention to the vulnerability of middle-income homeowners. Stakeholders noted that many middle-income homeowners were finding that they did not have sufficient insurance coverage and lacked personal financial assets needed to rebuild after Sandy.

Policy Uncertainty: A final type of emergent vulnerability concerns the shifting policy environment after Sandy. Rebuilding costs for many homeowners were higher than expected because of recent changes in state-level elevation requirements for new ocean-front construction and anticipated changes in Federal Emergency Management Agency (FEMA) Base Flood Elevation Maps (BFEs), which dictate eligibility and costs for federal flood insurance. Expected increases in federal flood insurance rates and possible changes in insurance availability were also noted as a source of uncertainty for homeowners in the region.

6.2. Opportunities for post-disaster learning

The post-Sandy meeting not only revealed what the initial assessment had missed but also showed how the initial assessment had served to create buy-in and

learning opportunities in the past Sandy context. Consideration of the results of their “own” baseline assessment allowed stakeholders to reflect on how their perceptions of the region’s vulnerabilities had evolved as the result of their experience with Sandy. Stakeholders discussed the emergent vulnerabilities as “surprising and unexpected,” and also commented on how their thinking about the region’s risk profile was affected by Sandy. One noteworthy example is the case of inland flooding. While post-Sandy perceptions of climate change risks in the region have been largely focused on coastal flooding risks, pre-Sandy interviews expressed major concern over inland flooding of the sort that had occurred during Hurricane Irene in 2011. Stakeholders commented how the different storms affected their risk perceptions and noted that efforts to build resilience in the region cannot solely be directed at preparing for the next Sandy or the next Irene, but also need to take into account the wide-array of climatic and other stresses that the region faces, including the possibility of unexpected events. Concerning future learning, stakeholders at the meeting expressed the need for more information about approaches to addressing climate risks being used in other regions that may be applicable to coastal New Jersey.

The stakeholder-based assessment also helped to set the stage for continuing efforts and activities intended to build regional resilience. These efforts include development of a follow-up survey to identify information and training needs, which was administered to a larger set of coastal stakeholders in summer 2013 ([New Jersey Climate Adaptation Alliance 2013](#)), development of quantitative estimates of property and tax base exposure to sea level rise and storm surge for communities in Ocean County, technical training on climate risk assessment and resilience planning with municipal officials in those communities ([JCNER 2014](#)), refinement of a web-GIS sea level rise mapper ([Lathrop et al. 2014](#)), and further investigation of options and barriers to regional resilience.

7. Conclusion

This study utilized a co-production approach to the assessment of key economic vulnerabilities to climate change in coastal New Jersey. Our work with stakeholders tapped into a wealth of local knowledge about climatic, demographic, economic and environmental stresses that the region is facing, and demonstrated that economic vulnerability in the region encompasses a wide array of natural and built assets, economic activities and population groups. Engagement with stakeholders also created buy-in to the vulnerability assessment process, which, in turn, facilitated opportunities for learning in the post-Sandy context. The study results reinforce the value of co-design and co-production of vulnerability information and

suggest that this type of approach will be critical for future efforts to identify feasible adaptation strategies and to build regional climate resilience.

Our discussions with stakeholders also revealed a number of gaps in knowledge regarding how specific types of climatic risks may affect assets, activities and vulnerable groups, as well as the types of adaptation strategies that might be feasible. These discussions suggested that the following topics would be fruitful areas for further research and analysis:

- (1) *Assets and activities at risk.* There is a need for analysis of how specific types of climatic risks such as sea level rise and extreme precipitation events will affect natural and built assets. There is a particular need for detailed documentation and assessment of natural assets, private property, public infrastructure and utilities that are at risk in the region.
- (2) *Community-level risks and vulnerability.* Investigation of risks, vulnerabilities, and their variation across the many different types of communities is also needed. Inland and bayfront communities, for example, face different types of climate hazards in comparison to oceanfront communities. Moreover, vulnerability and resilience also vary within communities along multiple lines, such as age, class and immigration status. In-depth information about the nature and variation of risks and vulnerabilities among and within communities will be crucial to informing effective and equitable social policies to reduce vulnerability and build resilience.
- (3) *Adaptation options and financing.* Recent evidence and projections establish with high likelihood that the region will need to adapt to novel and unprecedented types of change in the future. Additional research would help to identify new types of options for adaptation to respond to climate change, including approaches that are being used in other regions that may be applicable to Ocean County and the Barnegat Bay. Many stakeholders also voiced concern about the costs of adaptation to local businesses and communities, particularly during the present era of slow economic growth, suggesting the value of additional investigation into the costs, financing and feasibility of specific types of adaptation.

As stakeholder-based work proceeds in this region and elsewhere, it will be especially important to ensure that stakeholder participants represent a broad-cross section of public and private interests (Lane *et al.* 2011; Whatmore and Landström 2011; Wagner *et al.* 2014). Given this region's reliance on tourism and recreational activities, which are largely supported by individuals living in other areas, expansion of stakeholder participants to include individuals from "away" may provide valuable insights into outside perceptions of regional vulnerabilities and

strategies to enhance resilience. These industries also employ large numbers of low-wage, service sector workers, many of whom experienced severe financial distress as the result of Hurricane Sandy. Also hard hit were the vulnerable groups identified by stakeholders in this research, such as low-income residents and property owners, commercial fishermen, and municipal governments. Expansion of the stakeholder participants to include these and other groups affected by Sandy in diverse ways will broaden the relevance of future vulnerability assessments. Within coastal New Jersey, Sandy has created many new openings and opportunities for further collaboration on rebuilding, resilience, and future preparedness. Engagement with a wide array of stakeholders will be critical to the success of these efforts.

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