7 — Local Economy and Government

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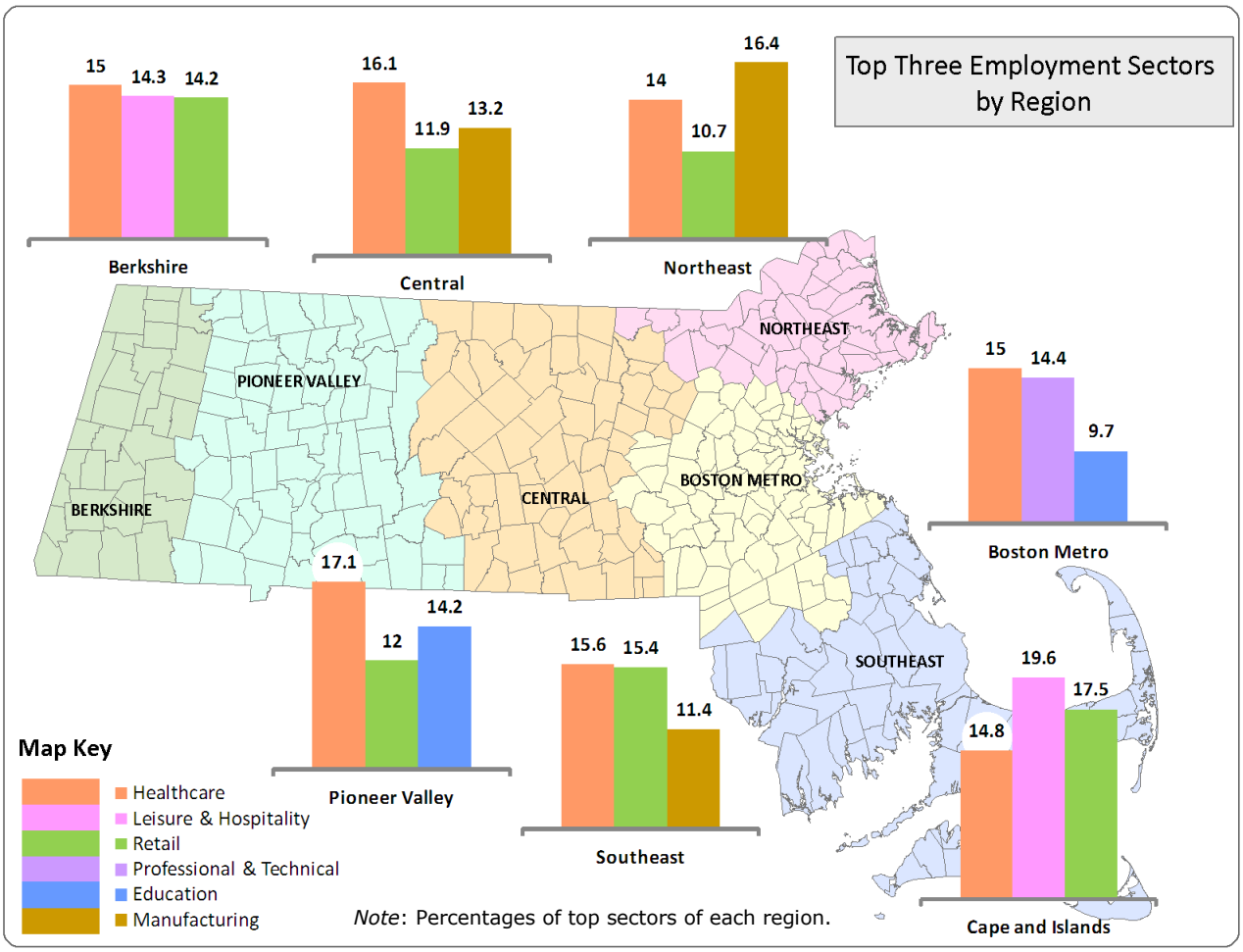
7 Local Economy and Government

Introduction

As climate change occurs, it will affect many of the features that make Massachusetts attractive—its cities and towns, job opportunities, historic sites and natural beauty. This chapter reviews how predicted climate change may affect key sectors of the Massachusetts economy and government. Some may be near-term impacts while others may create longer -range challenges. The sectors addressed in this chapter include weather-dependent industries such as agriculture, forestry, and fisheries; manufacturing such as computers, electronic equipment, fabricated metal, and machinery; and service industries such as real estate management, tourism and recreation, health care, and higher education. This chapter also provides an overview of the potential impacts on government and the services it provides, helping citizens to seek "safety, prosperity, and happiness" (Constitution of the Commonwealth of Massachusetts, 1780), and the importance of proper planning, development and siting in the land use section.

The Massachusetts Executive Office of Housing and Economic Development tracks economic activity in Massachusetts, dividing the Commonwealth into seven economic regions: Berkshire, Boston Metro, Cape and Islands, Central, Northeast, Pioneer Valley, and Southeast (See "Top Three Employment Sectors by Region" map below). In each of the seven regions, the health care industry is consistently among the top three employers. Retail ranks among the top three employers in six regions, manufacturing in three regions, and leisure and hospitality rank among top employers in two regions—the Cape and Islands, and the Berkshires.



Note: Percentages of top sectors of each region.

Education, among the top employers in Massachusetts, is concentrated in two regions, the Boston Metro and the Pioneer Valley (Nakajima, 2009).

Of the more than 6.4 million people living in Massachusetts, 5.18 million are considered to be of working age and 3.42 million are active in the workforce, either employed or seeking employment (Massachusetts Dept of Labor, 2009). The state ranks fifth in population density among the country's states and territories (U.S. Department of Commerce, 2000). In 2007, approximately 21.2 million travelers visited Massachusetts and spent over $15.1 billion (United States Travel Industry Association, 2008).

Overall Vulnerabilities

As discussed in Chapter 2, scientific research indicates that the state's climate will be warmer, the coastline will alter due to sea level rise, and fluctuations in weather extremes will bring more intense rain and ice storms, and greater heat intensity. Although all sectors will be affected by climate change, the impacts will be dependent on geography and the specific characteristic of a sector. For example, variable timing of precipitation events, as well as increased periods of heat and drought, are concerns for the agricultural sector and industrial processes that depend on water.

Should the water shortages predicted for the southwestern states intensify, Massachusetts may become an attractive place for water-dependent operations, including agriculture and manufacturing, resulting in an influx of new residents from the Southwest to New England—reversing a trend prevalent in the 1980s and 1990s. The business-as-usual scenario for 2035, as developed by NOAA, predicts that migration to the northern states will increase by 20 percent from 2020-2035 (NOAA, 2009). This will likely result in mounting pressure on water supply management strategies as the competition for water grows between human needs and ecosystem needs.

Economic Opportunities

Massachusetts is well poised to take advantage of the opportunities that climate change presents by developing new technologies for energy production and use, irrigation techniques, engineering design, and curriculum development. As an emerging economic sector, clean energy is expected to play an increasingly important role in the state's economic growth. In fact, according to a recent study (Clean Edge, Inc., 2010), Massachusetts has already become the leading state on the East Coast for clean energy innovation, investment, deployment, and jobs.

A Massachusetts Clean Energy Center survey of 471 local companies showed that more than 11,000 people were employed in clean energy at the end of 2010, up 65 percent since 2007. Some 3,500 people are employed in manufacturing of energy efficiency products, a growth of 20 percent since 2007, and the fastest growth (67 percent) is in energy storage. Employment in energy efficiency services has nearly doubled, from 1,000 in 2007 to 1,972 in 2010 in just the 69 firms surveyed, which represent only a fifth of energy efficiency services companies in the state. Jobs in solar manufacturing, installation, and services, meanwhile, have more than doubled during this same period.

In terms of future job potential, the clean energy sector will soon be the tenth largest employment group in the state. Renewable energy companies are the fastest growing firms in the state with an expected 30 percent job growth while energy efficiency firms are expected to grow by 25 percent, over three times greater than the next fastest

Wind Turbines at Ski Resorts: Energy Self-Sufficiency and Good Economic Sense

Ski resorts are constantly upgrading snowmaking capacity and efficiency in order to convert tremendous amounts of water into snow to supplement what nature provides. This effort is ongoing and will increase with predicted climate change of higher temperatures and reduced winter snow cover.

At Jiminy Peak in northwest Massachusetts, a 1.5 MW wind turbine installed in 2007 provides approximately 33 percent of the electrical demands of the resort annually. Winds blow strongest at the site during the winter when power needs are greatest for snowmaking, lifts, and night lighting. During these months, the turbine may provide as much as half of the electrical demand. Wind resource studies conducted by Jiminy Peak showed that the investment pay back was reachable within seven years and it would supply lower cost power for the long-term. The resort is currently investigating the installation of a second turbine.

Early in 2011, Berkshire East completed its wind energy project, making it the first ski resort in the world to be powered entirely by on-site wind generation.

December 2008 Ice Storm Affects Business

A dangerous combination of low pressure, moist air, and cold, powerful winds produced a violent ice storm over the Northeastern states in December 2008. Upstate New York, New Hampshire and northern Massachusetts were most severely affected. Thousands of local businesses were forced to close due to a lack of electricity, heat, sewage, and transportation of necessary supplies. Airports were closed and travel was shut down throughout New England. Delivery trucks could not reach their destinations, slowing commerce dramatically. The loss of sales in combination with property damage from falling branches and ice buildup caused small businesses to lose tens of millions of dollars.

emerging growth sector (Global Insight, Inc., 2007). The Advanced Biofuels Task Force estimated that development of non-food-crop-based alternatives to petroleum fuels could yield 2,500 permanent Massachusetts jobs within the industry by the year 2025, with another 3,700 jobs through indirect spending effects (Commonwealth of Massachusetts, 2008). Policies in the recently released Massachusetts Clean Energy and Climate Plan for 2020 (Commonwealth of Massachusetts, 2010) will help create 36,000 jobs in the State in 2020, including about 13,000 via transportation policies and 23,000 via policies to improve efficiency of energy use in buildings. The estimate for employment from in-state demand for renewable energy in Massachusetts in 2020 is 6,000 to 12,000 full-time jobs.

The potential integration of renewable energy and agriculture could result in the protection of farmland, while reducing or eliminating energy costs to farm operations and reducing the overall demand for fossil fuels. In agriculture, opportunities abound in the research and development of improved pest controls by private companies and academic research laboratories. The development of hybrid crops better able to withstand new pests emerging as a result of climate change could help increase crop resilience and protect farm income. Extended spring and summer growing seasons may improve crop yield and provide opportunities to expand crop varieties. They could also create an economic boon to warmer weather, tourist-based businesses.

In the health sector, climate change will affect human health worldwide. Massachusetts hospitals and universities could address these health effects in their research and teaching. In higher education, continuing research on climate change and adaptive strategies, improved engineering and design, and clean energy alternatives all provide additional opportunities for Massachusetts' economy.

Adaptation Strategies

In response to the vulnerabilities described above, the following pages outline key economy and government sectors and adaptation strategies that will continue to be evaluated and examined in response to potential climate change impacts.

Local Economy—Agriculture

Since colonial days, Massachusetts has maintained an agricultural economy through farming and forestry. Today, farming and agritourism remain central to the economy of many communities. While Massachusetts ranks 43rd among all U.S. states in agricultural production, it ranks 14th in net farm income per farm operation and fourth in net farm income per acre (USDA, 2007). Six of the state's counties are in the top two percent in the United States for direct sales to consumers.

There are approximately 6,000 farms in Massachusetts, with farmland covering approximately 14 percent of the land mass, or approximately 590,000 acres (USDA, www.agclassroom.org). Although many farms and much of the agricultural land base are devoted to major food crops such as apples, cranberries, vegetables, livestock and dairy products, greenhouse and nursery products such as flowers and ornamental plants are the leading sources of income for Massachusetts farmers. Specialty crops include apples, beans, butternut squash, cabbage, cranberries, corn, dairy products, potatoes, and pumpkins. Many of these are sold directly to consumers through farmers' markets, pick-your-own farms, agritourism, and farm stands.

Impacts and Vulnerabilities

Relatively small fluctuations in temperature, groundwater, seasons, and pest population dynamics can have dramatic short- and long-term effects on crops.

Increasing temperatures can extend growing seasons, bringing more income opportunities as well as increased operational expenses, including labor, irrigation, and other fixed costs. As higher temperatures and variable precipitation strain water resources, many agricultural enterprises may be challenged to reduce water use by altering irrigation practices. Irrigation demands, and their associated energy costs, may continue to rise as these climatic changes become less predictable. Agricultural water management will also be affected by potential competition from non-agricultural users such as expanding suburban development. With an increase in the potential for flood as well as drought,

increased capture and storage of water may be needed to provide a reliable and continuing source of water for irrigation-dependent crops.

Cranberries generate the largest gross revenue as an individual crop in the Massachusetts agricultural industry (USDA, 2007). With rising temperatures predicted, cranberry farmers are looking to bog management practices in New Jersey for lessons on maintaining successful operations in milder climates (Wick, 2009). With the cranberry production area primarily along the coasts, concerns are growing that sea level rise could cause saltwater intrusion into the groundwater and disrupt bog drainage in low slope streambeds.

Extreme and unpredictable weather patterns will also affect agritourism, a major growth sector. The number one impact on most Massachusetts retail farm sales is weekend weather because it affects the volume of customers coming both to the farm and to regional farmers markets. Climate change may also disrupt the balance between crop pests and diseases and the natural enemies or barriers that control them. Warmer climates enable more insect reproduction cycles in a season, resulting in potentially devastating effects such as the migration and spread of the Hemlock Woolly Adelgid into Massachusetts from neighboring states.

Lastly, a potential threat to Massachusetts agriculture is the sale of productive farmland for other development purposes. This is especially true in a climate change scenario where rising sea level can spur displaced populations from the New England coast and other "climate refugees" to migrate to undeveloped inland areas, such as agricultural lands.

Potential Strategies

General Agriculture Strategies

No Regrets Strategies

1. Assess vulnerable crops. Identify major crops and livestock likely to be affected by climate change, and practices that may mitigate these effects.
2. Establish technical assistance programs. Develop programs to keep the agricultural community informed about the impacts of climate change, how to adapt to the changing conditions, and alternative agricultural products.

Long-Term Strategies

1. Shift to alternate varieties or products. Evaluate means to alter farming practices and shift crop preferences to products better suited to greenhouse cultivation or new climate conditions.
2. Promote the concept of "Buy Local". Approximately 15 percent of the foods consumed in the state are Massachusetts grown. Increasing the consumption of locally grown products reduces the negative effects of shipping agricultural produce. For example, shortening the distance from production to consumption minimizes potential supply disruptions due to storm events, decreases shipping costs, and reduces greenhouse gas emissions from long-distance transportation.
3. Promote urban/community gardening efforts. Urban gardening may help to reduce the heat island effect in larger developed communities, increase consumption of locally grown products, and further reduce the negative effects of shipping agricultural produce.
4. Encourage expansion of improved storage facilities to hold and protect local produce during the growing season and after harvest.

Pest Control

1. Escalate pest monitoring efforts. Consider instituting monitoring and farmer education programs to identify and report harmful pests.
2. Conduct research and investigate use of pest controls for changing conditions. Integrated pest management, and the use of herbicides, fungicides, and insecticides will likely be needed to address pests not presently common in Massachusetts. Research by educational institutions and trade groups on organic strategies, as well as training in new pest controls may be needed to improve familiarity of best practices and alternative solutions to emerging pests.

Figure 8: ***Buy Local Groups*.**
Regional Buy Local Groups connect farmers to their surrounding communities and vice versa.
http://www.mass.gov/agr/massgrown/buy-locals.htm

Crops and Soils

No Regrets Strategies

Research soils, crop alterations. Enhance analysis of current soils and identify crops better able to accommodate shifting climate conditions.

Long-Term Strategies

Development of agricultural hybrids. Consider working to develop hardier hybrid crops to help protect crop resilience and, therefore, farm income. More attention may need to be paid to developing disease- and drought-resistant varieties. Research and development of hybrids can be ventures of private growers as well as educational institutions such as the University of Massachusetts Amherst. Private investors may fund research of commercially popular crops.

Agricultural Operations

No Regrets Strategy

Develop local alternative energy. Coordinate efforts between state agricultural and energy resources departments to enhance programs encouraging the development of local renewable energy on agricultural lands.

Long-Term Strategies

1. Adjust seasonal labor pools. Consider the need to shift from seasonal employment (college and high school students, migratory harvest workers) to alternate labor pools should longer warm seasons preclude labor pools dependent on academic calendars or shifting harvest seasons.
2. Expand crop planting to accommodate extended growing seasons, as feasible.

Water Use

No Regrets Strategies

Seek implementation of alternative irrigation practices and install water conservation practices to reduce vulnerability to water supply fluctuations. The U. S. Department of Agriculture's Natural Resources Conservation Services (NRCS) is a leader in helping Massachusetts irrigated farmland benefit from new lower water use technologies.

Long-Term Strategies

Increase use of storage. With the potential for extreme storm events and reduced summer precipitation, consider increased capture and storage of water to help increase crop reliability. Explore the option of providing farmers with financial incentives to invest in storage capacity.

Sea level rise impacts

Long-Term Strategies

Use improved LiDAR elevation data and information on sea level rise to guide cranberry growers who are considering relocation of vulnerable bogs.

Land Use Impacts on Agriculture

No Regrets Strategies

1. Continue efforts to minimize conversion of protected farmlands to non-agricultural uses.
2. Continue farm protection programs. Continue the Department of Agricultural Resources' Agricultural Preservation Restriction Program to preserve and protect farmland in collaboration with local land trusts and with matching funds from USDA (NRCS).

Local Economy—Forestry

More than 63 percent (nearly 3.3 million) of the state's total land area is forested (USDA, 2006). Timberland makes up 2.6 million acres much, of which is under private ownership (Butler, 2006). Concentrated in the central and western counties of Worcester, Berkshire, Franklin, Hampshire, and Hampden, Massachusetts timberland is capable of producing 20 cubic feet of wood per acre per year. In recent years, up to $845 million in economic activity has been generated annually from the Massachusetts forest products industry, which employs more than 24,000 workers. A total of 92 million board feet are harvested from Massachusetts forests each year, some of which are exported to other states. Massachusetts has 49 sawmills that produce approximately 49 million board feet of lumber each year (Reichel, 2009).

Most of the privately owned forests in Massachusetts are not managed for commodity use. It is estimated that Massachusetts forests support $15 billion in tourism annually. Forest-oriented wildlife recreation contributes about $1 billion to the state's economy, of which over a third is attributed to private forests. Active forest management helps to protect more than 350,000 acres of private forested open space, 50 percent more land than the state owns. If tree planting activities are increased to ameliorate the heat island effect in cities, mitigate urban

stormwater, and to sequester additional carbon, the increased need for saplings and trees will benefit the state's $2.6 billion nursery industry, the largest component of the Massachusetts agricultural sector (Riechel, 2009). Forests and trees, in addition to their ecological value, provide climate and nutrient regulation, soil retention, stormwater mitigation, heat island reduction in cities, and natural filtration of drinking water supplies.

Impacts and Vulnerabilities

Shorter and milder winters can disrupt seasonal schedules foresters rely upon to harvest timber and other forest products on tracts of land where frozen ground is preferable for operating harvesting equipment. Overall productivity may be reduced since operating harvesting equipment in mud is costlier. Warmer temperatures will also impact the time frame during which certain timber harvesting can be conducted—to take into account other ecological considerations such as wildlife species migration and nesting. Warmer temperatures can directly alter the value of forest products by causing an increase of stain in the wood from its sap. This stain, or discoloration, affects the grade of wood and may diminish its market value. More intense rainstorms will increase the costs of erosion control, requiring larger culverts on harvest sites.

Higher temperatures will disturb certain tree species, including spruce, hemlock and sugar maple, and alter the reproduction season of some rare species. Mortality may be much higher in young trees since they are less prone to survive heat and water stress, insect and fungal pests. Warming and the unpredictability of weather patterns may change the window during which certain timber harvesting can be conducted without harming rare species. Increased temperatures and the shorter duration of cold and chilling periods may increase invasive pests and plant diseases, such as the hemlock woolly adelgid (Adelges tsugae), which is far more virulent in southern forests (see case study in Chapter 4). Warmer weather may decrease the ability of certain species to survive and lead to an overall reduction in forest growth in this region. Many southern tree species (including species such as oak and hickory found in the upland central hardwoods forest, the predominant forest type in Massachusetts) could potentially move northward in a warming climate.

Although a relatively small industry in Massachusetts, sap collection for maple sugar products totals about 50,000 gallons with an approximate current value of $2 million. This significant niche industry relies on a sustained springtime freeze and thaw cycles. Such cycles are expected to become less common, and any sustained warming trend will be troubling for maple sugar producers.

Finally, increased temperatures and a longer growing season can increase aeroallergens, potentially affecting foresters with respiratory conditions and allergies.

Potential Strategies

No Regrets Strategies

1. Assess vulnerable species. Identify forest types likely to be vulnerable to climate change, and practices that may mitigate these effects.
2. Provide technical assistance. Provide foresters with information and support services about how climate change may disturb forests, and impart skills and strategies for keeping forests viable.
3. Enhance carbon sequestration. As forests are a very significant carbon sink in Massachusetts, explore strategies that maximize sequestration. Strengthen and develop markets and industries that use harvested wood in long-term products that store the carbon removed.

Short-Term Strategy

Reevaluate current harvest and natural regeneration practices. Research, educate, and develop incentives to encourage forestry practices that foster regeneration of vulnerable species (such as northern hardwoods) to perpetuate their many benefits. By regenerating species now, the growth of more mature trees will extend into periods when climate change impacts may increase in severity.

Local Economy—Fishing and Aquaculture

Massachusetts is one of the leading commercial fishing states in the U.S. In 2006, gross sales by the Massachusetts commercial fishing industry was $4.4 billion (U. S. Dept of Commerce, 2006), supporting 83,000 jobs in the state. This revenue includes not only products brought to the pier (landings) but also related sales and employment through processing and transport operations. The industry delivers a broad range of products including scallops, cod, flounder, haddock, lobster, goosefish, whiting, clams, crabs, hake, herring, pollock, squid, swordfish, and tuna.

The inland and shoreside industry is found mostly in New Bedford, Boston, Cape Ann, and Cape Cod, and produces hybrid striped bass, tilapia, trout, summer flounder, and other finfish. The marine aquaculture industry, found mostly on Cape Cod and the Islands, produces quahogs (hard-shell clams) and oysters, and small quantities of scallops, soft shell clams, and mussels.

Reported sales of marine shellfish topped $11.2 million in 2007. Altogether, inshore and intertidal shellfish such as soft shell clams, northern quahogs, blue mussels and oysters approximated 29 million pounds and exceeded $20 million (Murphy et al., 2009). In addition, the surf clam and quahog dredge fishing vessels landed $1.5 million and $1.4 million worth of surf clams and northern quahogs, respectively (Massachusetts Division of Marine Fisheries, 2008).

Total landings in 2008, not including dredge fisheries and large pelagic species (such as bluefin tuna), amounted to 530 million pounds, with a value of $383 million. Just over 10 million lbs of American lobster were landed in 2008 for a value of $44 million.

Of the New England states, Massachusetts enjoys the highest number of jobs sustained and total sales supported by recreational fishing, with over 6,080 jobs and $803 million in sales in 2006 (U. S. Department of Commerce, 2008). Recreational saltwater anglers took 4.5 million fishing trips and landed 15 million fish including striped bass, mackerel, summer flounder, cod, haddock, black sea bass, and scup. Saltwater anglers spend $800 million annually pursuing their sport, including $200 million from out-of-state participants. For freshwater fishing enthusiasts, more than 500 of Massachusetts' lakes, ponds, rivers and streams are stocked annually with trout, bass, herring, salmon and many other varieties.

Impacts and Vulnerabilities

As the ocean absorbs carbon dioxide, its pH level drops and it becomes more acidic. This could reduce calcification, a process by which sea creatures create their shells and exoskeletons (Green et al., 2009). These changes would affect mollusks, crustaceans, and some plankton species important to the ocean food chain and to human consumption, leading to a significant impact on the multi-million dollar clam, scallop, finfish, and lobster industries. The species distribution will likely change with warming ocean temperatures and this will alter the abundance and availability of those species vital to commerce and the marine ecosystem. Many commercial fishermen

and lobstermen may need to harvest from other waters or change their target of harvest (Jansen and Hesslein, 2004). A change in the target harvest may then require a change of gear, incurring a considerable expense.

A recorded warming trend in the coastal waters of Southern New England since 1999 has been cited as one reason for the lobster stock in Buzzard's Bay and Long Island Sound to seek deeper waters. As a result, southern New England and New York face a recommendation under consideration by the Atlantic States Marine Fisheries Commission for a substantial cut in landings to protect the remaining population, including a potential five-year ban on lobstering to help restore depleted stocks. Lobster experts have concluded that continued elevated temperatures in the nearshore southern New England and Mid-Atlantic waters will result in a near abandonment of these historically productive areas by lobsters, resulting in a stock that is far smaller than seen in the late 20th century (See http://www.asmfc.org/).

Shellfish aquaculture takes place mainly in the tidal margins. Farmed beds need shallow tidal effects. Some species, notably oysters, require a mix of salt and fresh water for their full life cycles. However, climate change can cause low-lying coastal zones to flood as the sea rises. The resulting new beach or tidal flat areas may not be suitable for aquaculture, or they may not be available at all as the presence of seawalls, roads and other structures may prevent the creation of new shallow water habitats. A shift in the low-lying coastal zones may also threaten the nursery and feeding habitat of other valued fish species. As a result, stocks of bluefish, tuna, cod, haddock, and sea bass typically available for commercial and recreational anglers may be diminished.

Although aquaculture harvesters will incur less gear damage with less ice, overall yield could be affected with changes in food availability and harmful algal blooms (HAB's) such as "red tide". In New England, red tide is the term used to describe a population explosion or bloom of the toxic phytoplankton Alexandrium fundyense. Red tide is an annual occurrence in the Gulf of Maine with distribution and concentration dominated by nutrient availability and weather patterns, both subject to climate change. Shellfish concentrate the toxin, creating a public health risk if consumed, forcing the closure of

productive shellfish areas and affecting harvesters and wholesale and retail shellfish sales.

For freshwater fishing, temperature changes may threaten these fish species, with warmer water temperatures resulting in a reduction of dissolved oxygen in surface waters, which can stress fish habitat (Jansen and Hesslein, 2004).

Potential Strategies

No Regrets Strategies

1. Assess vulnerable species. Identify species likely to be affected by climate change and practices that may mitigate these effects. This could be done by state and federal agencies, in collaboration with academic researchers and trade groups.
2. Provide technical assistance.
   a. Provide the fisheries and aquaculture sector with information about how each sector might be affected by climate change, and with skills and strategies for keeping fisheries and aquaculture viable pursuits; and
   b. Provide research assistance to the fishery industry to assist with changes in harvesting processes and targeted fish stocks.
3. Conduct research to predict which species of fish might thrive in a changed ocean environment.

Long-Term Strategy

Invest in good science to understand changes in fish abundance, ensuring that fisheries management evolves over time to address changing conditions.

Local Economy—Manufacturing (Computers, Electronic Equipment, Fabricated Metal, and Machinery)

Massachusetts is home to many manufacturing companies, employing approximately 9 percent of the state's workforce, or about 300,000 workers. The biggest sectors, comprising 85 percent of total manufacturing jobs, include computers and electronics, fabricated metal, food processing, machinery, chemical, printing, plastics and rubber, transportation equipment, paper, and electrical equipment. The remaining smaller sectors include textile mills, furniture, and petroleum and coal.

Ninety percent of Massachusetts' businesses have fewer than 100 employees and 85 percent are classified as small businesses with 20 employees or fewer. Small businesses employ more than one quarter of the statewide workforce. Although small businesses typically make decisions with a three- to five-year outlook, many employers make decisions that affect their businesses over a longer term on matters such as the selection of facility locations. Larger investor-owned businesses use longer-term time frames when making decisions related to market and product development, particularly research and development.

According to the 2008 Milken Institute State Technology and Science Index (DeVol et al., 2008), Massachusetts was ranked as the top science and technology economy in the U.S. Expanding research of new energy sciences, building design, and infrastructure engineering in Massachusetts will help the manufacturing industry develop an increased resilience to climate change.

Impacts and Vulnerability

Heavier, harsher storms causing floods will likely have an impact on buildings, energy delivery and transmission, and transportation systems. Manufacturing operations in low lying areas may be exposed to increased inundation. More frequent and extreme weather events may disrupt the supply chain of businesses dependent on raw materials for production. Similar impacts may affect product delivery as firms rely more on speedy transportation of goods rather than stockpiling of large inventories, and they may also affect workers' abilities to get to their job sites. Rising temperatures will increase the need for climate control in the workplace. If water availability is affected by an increased variability in precipitation, water-dependent manufacturing industries will likely be strained.

Potential Strategies

No Regrets Strategies

1. Protect water as an asset.
   a. Continue to use market-based solutions to preserve water resources and conserve water;
   b. Encourage water storage, taking advantage of high rain periods to offset drought periods;
   c. Expand/promote opportunities for water recycling, including grey water;
   d. Explore opportunities to coordinate water treatment and energy generation. Locating power plants adjacent to wastewater treatment facilities could partially displace freshwater needs for cooling purposes; and

e. Seek to reduce water use in energy production by considering alternative technologies, since peak water use in energy production often coincides with periods of high heat and low water availability.

2. Encourage or incentivize conversion to more energy-efficient processes or local renewable energy sources to alleviate dependence on the grid and to protect from power disruptions that can occur during extreme weather events.
3. Support improvements to on-site stormwater management to mitigate heavier rains, especially at facilities in low lying areas.

Short-Term Strategy

Examine advantages of increasing inventory supplies and identify alternative materials and inventory suppliers to avoid delivery interruptions.

Long-Term Strategies

1. Encourage businesses to incorporate climate change impacts, particularly as data are refined to a sub-state level, into risk assessments and risk minimization strategies.
2. Consider long-term location alternatives that avoid or address the impacts of climate change.
3. Support building design modifications, such as electrical and HVAC systems, that withstand more frequent flooding and heat waves.
4. Consider altering operation schedules to cooler times of day.
5. Investigate alternate transportation routes, energy supplies, and communication systems for suppliers, customers, and workers to respond to evolving climate change impacts.
6. Establish partnerships with industry and government to facilitate technical assistance to businesses that are adapting to climate change.

Local Economy—Service Industries

This sector includes the insurance, financial services, real estate management, health care, higher education, and tourism and recreation sectors.

Health care and social services are the largest employers, with over 470,000 jobs provided statewide, contributing in excess of $30 billion toward the state's gross domestic product (GDP) annually. Massachusetts is renowned worldwide for quality health care and attracts an equally global clientele, with two hospitals ranking in the top ten facilities in the nation (Comarow, 2009). A number of hospitals statewide have been designated sole community provider status, offering area residents ready access to many state and federal health programs.

Approximately 200,000 employees in the insurance and financial management industries generate more than $33 billion annually for Massachusetts' GDP. At $47.1 billion, real estate management generates the most toward the GDP of any economic sector in Massachusetts and provides jobs for approximately 446,000 people.

Massachusetts is also known for the quality and variety of its educational institutions, attracting students throughout the year, creating approximately 310,000 jobs, and producing just over $8 billion in GDP.

Massachusetts is home to 20 national parks and historic sites; over 450,000 acres of state-owned forests, parks, greenways, historic sites, lakes, ponds, and reservoirs; and innumerable local parks and recreational venues, scenic seashores, harbor islands, riverfront areas, convention centers and resorts. Tourism is a significant economic driver that generated over $15 billion in direct spending in Massachusetts in 2007 (United States Travel Industry Association, 2008). Massachusetts residents account for one-third of the visits calculated in tourism industry reports, while travelers from out-of-state offer a larger overall contribution to the state's economic health, visiting longer and spending more. The state is a destination for domestic and international travelers throughout the year.

Impacts and Vulnerabilities

Due to the impacts of climate change, buildings in low-lying and flood-prone areas will become more vulnerable to flooding, and facilities may need increased cooling systems. The insurance industry's income is also dependent on sales and activities in other parts of the country, and not solely on Massachusetts, so climate change impacts in distant areas can have an economic impact on insurance companies headquartered in Massachusetts. Damage resulting from more extreme storm events will initially be borne by the insurance industry, but will ultimately be passed on to policy holders. Insurance payments could increase for flooded property, damaged crops, livestock, spoiled perishable food due to electricity outages, and heat wave-related health insurance losses.

Those working outdoors, in sectors such as construction, public works, and parks, may see a reduction in productivity during high heat days. Increases in overall summer temperatures and frequency of heat waves are expected to reduce or slow construction projects due to health and safety concerns for workers.

The SEC and Climate Change

According to the Securities and Exchange Commission's (SEC) interpretative guidance, companies should evaluate, for disclosure purposes, the actual and potential material impacts of environmental matters, including the physical impacts of climate change on their businesses.

Oceanfront and riverbank resorts may face inundation from rising seas and flooding. Changes in global ocean currents may contribute to stronger hurricanes, putting additional pressure on Massachusetts coastal areas, especially Cape Cod. Real estate values in low-lying areas may drop as the risk of flooding and associated insurance premiums increase. Insurance firms will likely seek higher premiums. The insurance industry can play a particularly critical role in providing disincentives to build or remain in high risk areas, such as coastlines that experience increased storm surges and sea level rise.

Others firms may leave the market, seeking better returns elsewhere. With the Security and Exchange Commission's rules requiring a company to identify the impact of climate change on business or legal developments, insurance companies are likely to pay particular attention to the level of impact risk in both their coverage and investment portfolios.

Should storm events increase, political pressure may mount to encourage additional public financing of these risks in an effort to keep insurance costs low, through government programs such as the National Flood Insurance Program (NFIP). These programs work to reduce flood damage through hazard identification and mapping, effective community floodplain management, and insurance protection for property owners through subsidized insurance premiums (Federal Emergency Management Agency). The result could be taxpayer funds expended to underwrite risky investments and activities in vulnerable areas and indirectly encourage development in flood prone areas.

In Massachusetts, the Fair Access to Insurance Requirements (FAIR) Plan provides insurance to property owners the private market does not cover. Funded by the 400 property and casualty insurance companies operating in Massachusetts, FAIR provides a safety-net of coverage and has become the leading underwriter on Cape Cod, with over 23 percent of the market. Increasing risk in coastal and inland low-lying areas from more frequent and harsher storm events may not only lead to diminishing coverage by traditional insurance companies, but also a burden on FAIR and NFIP beyond their capacity to provide adequate coverage or to remain solvent in the face of a catastrophic event.

The health care industry is likely to see an influx of patients as well as impacts on operations (e.g., increased flooding risks or increased demand for interior cooling). Massachusetts will continue to be a destination for patients, making overall capacity a potential issue. However, beyond the capacity of the health care infrastructure, additional strain will be placed upon health care insurers. Should reliance upon health care facilities rise due to increases in vector borne and other diseases, the pressure on health care costs may further complicate cost containment measures and put even more pressure on insurance premiums. As many of Massachusetts' hospitals and universities promote research and teaching, they are poised to take on research and treatment of climate-related health impacts.

The tourist industry will potentially face a decline in water availability. Many hotels have already adopted conservation measures to reduce water use and associated costs.

The need to seek relief from heat may increase popularity of recreational activities, such as beach and waterfront activities. Climate change may result in a longer warm weather tourist season, but the associated increases in operation budgets will have to be sufficient to make the extended season economically viable. With a longer tourism season, employers may need to shift from their traditional seasonal labor pool comprising students and migratory workers to more permanent employees.

Warmer temperatures may limit traditional outdoor winter activities such as skiing, snowmobiling, and ice fishing. Less ice cover on lakes reduces the number of days available for ice fishing and increases the risk of accidents. To maintain a full ski and snowboard season, ski areas will need to increase snowmaking operations, thus increasing their operational costs and requiring more demand on water and power. While the fall foliage season attracts many visitors, rising temperatures will also put the colorful sugar maple at risk (Case, 2005).

Potential Strategies

No Regrets Strategies

1. Improve elevation data. To better predict and delineate areas of risk, use elevation assessment tools such as LiDAR to help inform decisions on siting.
2. Provide outreach and educate public and private employers about Occupational Safety and Health Administration requirements regarding employee protections in times of high heat.
3. Increase emergency preparedness for cold weather accidents.
4. Evaluate the impacts of the true cost of risk over time, and consider revising mortgage banking formulas to better reflect the risk. The mortgage qualification process currently takes only the first year of insurance premium into account, rather than the likely rise in a premium due to an increasing risk scenario over time. Alternate pricing strategies, such as a three-year rolling average of insurance costs to forecast future premiums, may produce better lending evaluation criteria when reviewing mortgage applications for both commercial and residential borrowers.

Short-Term Strategies

1. Continue to promote and enhance water conservation efforts to reduce occurrences of water shortages.
2. Increase and expand the focus on emergency preparedness, particularly in areas predicted to experience the greatest impacts.
3. Assess the ability to address health care capacity needs in potential areas of flooding, extreme heat, or poor air quality. Establish alternatives to avert temporarily overwhelming local health care facilities.

Long-Term Strategies

1. Improve science and research on prevention and cures of vector borne diseases that are predicted to increase with climate change (See Chapter 5 on Health and Human Welfare for more information).
2. To address potential changes in seasonal labor pools due to longer warm weather climate,
   a. develop new labor pools for tourist attractions through broadened training opportunities and outreach; and
   b. consider altering staff deployment and staff funding to tourist sites of consistent high use.
3. Encourage employers of outdoor workers to shift work schedules to cooler times of day whenever possible, including possibly extending break periods at midday to avoid times of highest heat.
4. Evaluate benefits and consequences of altering snowmaking strategies at enterprises dependent on snow cover, by making more snow during colder weather and stockpiling snow for later use.
5. Reevaluate the Federal Emergency Management Agency's (FEMA) role in providing insurance in vulnerable areas to improve alignment of potential risks of development with climate change impacts.

Local Economy—Cultural Resources

Massachusetts cultural resources are an important part of the state's, New England's and the nation's unique cultural heritage. A variety of cultural repositories exist across the state, such as

- libraries, archives, historical societies, museums, and city and town halls, which house culturally significant objects such as literary collections, special and rare collections, manuscripts, historical archives, municipal records, and artifacts;
- historic sites or areas, such as Local, State, and National Historic Districts and archaeological sites yet to be studied;
- ethnographic resources, areas and objects with unique cultural meaning for specific ethnicities or population groups, such as Native American Sacred Grounds; and
- public recreational areas such as parks and beaches, which may also contain outdoor sculptures as well as historic artifacts.

Existing Resources

These resources are managed by a variety of governmental, private, and nonprofit organizations, such as the Board of Library Commissioners, the Massachusetts Archives, the Massachusetts Historical Commission, the Department of Conservation and Recreation, municipal governments, historical societies, museums, private boards, Native American Tribes, and other ethnic groups.

Impacts and Vulnerabilities

Many cultural resources are vulnerable to climate change because of their location and fragility. There are many specific climate change impacts on these resources:

- Sea level rise may flood sites in coastal floodplains;
- Rising temperatures may make it too hot to visit sites without climate control capabilities;
- Rising humidity may damage archives and library, museum, historical society, and

municipal collections and place increased burden on climate control systems;

- Increased precipitation and floods may completely inundate sites or damage the structural integrity of historic buildings, archives, libraries, museums, and historical society collections;
- Increased extreme weather events may damage fragile historic buildings, archaeologically and ethnographically significant sites, libraries, museums, archives and their contents;
- Changing growing seasons and rising ocean temperatures may affect culturally significant species—such as lobsters, cod, blueberries, cranberries, and sugar maples; and
- Ocean acidification may damage underwater archaeological sites along the continental shelf, including shipwrecks and Native American sites.

Potential Strategies

No Regrets Strategies

1. Structural reinforcement. Consider improvements to the structural stability, water drainage systems, and weatherproofing of culturally significant sites as part of capital improvement projects.
2. Incorporate climate change vulnerabilities and adaptation strategies into the decision-making process related to maintenance, structural reinforcement, studies and funding, relocation of threatened objects, and landscaping of cultural sites.
3. Investigate installation of year-round climate control capabilities, including natural site climate control capabilities such as tree cover and vegetation, and re-examine the thermal properties of buildings to increase resilience and reduce greenhouse gas production.
4. Prepare historic landscapes for drought by planting drought-resistant native plants to reduce water needs.
5. Cultural resource property managers may coordinate among themselves and with emergency management organizations such as Massachusetts Emergency Management Agency (MEMA), FEMA, and COSTEP-Massachusetts (Coordinated Statewide Emergency Preparedness) to assess resource vulnerability and develop plans for resilience.

Short-Term Strategies

1. Prioritize sites for study. Identify and focus research efforts on historical, archaeological, and ethnographically significant sites that are most vulnerable to sea level rise and climate change.
2. Maintain and develop emergency management plans in conjunction with MEMA and FEMA. Re-examine and strengthen existing or create new emergency management plans for cultural resources based on identified new potential impacts.

Long-Term Strategies

1. Consider enhancing monitoring and record-keeping of the type and extent of existing vegetation at cultural resource sites to monitor any effects of climate change.
2. Investigate developing and implementing a plan to digitally record as many artifacts, collections, and sites as possible, prioritizing by level of risk to damage or destruction.

Government

Government at local, state, and federal levels face many of the same challenges as other sectors, such as facility siting, energy use for worker comfort, health risks to employees, sea water infiltration into groundwater supplies, and transportation mobility issues. Collaboration between government, education, and business is vital to effective climate change adaptation.

General Impacts and Vulnerabilities

Harsher weather events can include flooding from rains or coastal storms, extended heat periods, and saltwater infiltration of water supplies. As greater exposure to such vulnerabilities is likely to increase, emergency preparedness will take on added importance.

Structures such as buildings, roads, bridges, and dams that exist along rivers, the seashore, and in other vulnerable areas are more likely to be impacted from sea level rise and storms. Low income and vulnerable populations will disproportionately suffer the effects of extreme events, be least-equipped to adapt, and likely rely more heavily on government for support and relief. Of great risk to local government is its fiscal vulnerability, as damage to private property due to climate extremes may result in a reduction of the municipal tax base, while at the same time call for an increase in services for vulnerable populations, emergency response, and public and private infrastructure maintenance upgrades or replacement.

Government often provides a vision and planning effort that precedes action (Heilbroner, 1992). The need to be ready for an uncertain future requires leadership and decision-making about infrastructure, land, emergency response procedures, and many other components of modern social interaction.

Government, however, cannot provide such leadership in a vacuum. By enhancing existing alliances with trade associations, the insurance industry, worker unions, and institutes of higher education, government can foster improved climate change readiness in its own service to constituents as well as to each economic sector.

Potential Strategies

No Regrets Strategies

1. Consider vulnerable populations during emergency planning efforts, including potential relocation options. This may include the following strategies:
   a. In the wake of extreme weather events, assist employees with alternate transportation to job sites;
   b. During temperature swings, plan to accommodate an increased demand for health and safety services; and
   c. Encourage good neighbor advisories and institute cooling centers during heat waves.
2. Continue, and enhance as necessary, maintenance efforts on roadways and bridges to avoid washouts and increase vegetation along roadways and bridge embankments to hold soils on sloping areas.

Short-Term Strategies

1. Continue sponsoring climate change data collection and research as budgetary constraints allow.
2. Research and develop new products and engineering strategies to build climate change resilience.
3. Evaluate and implement changes in procurement, grant criteria, engineering standards, building codes, and zoning, as precautionary measures to reduce vulnerability to climate change impacts.
4. Collaborate with trade associations and the insurance industry to develop specification improvements that ensure building and infrastructure designs are more resilient to climate change. Examine development of a building-and-design education curriculum that incorporates planning for climate change.
5. Consider possibly amending Chapter 41, Section 81D of the Massachusetts General Laws to require inclusion of a climate change impact assessment and establishment of mitigation strategies in community master (comprehensive) plans.
6. Incorporate evaluation of climate change impacts into Massachusetts Environmental Policy Act (MEPA) (required by the Massachusetts Global Warming Protection Act of 2008) and other permitting processes, as these could facilitate consideration of climate change impacts in the development/redevelopment process.

Long-Term Strategy

Target infrastructure funding to assist in redirecting development toward less vulnerable areas.

Government—Enhance Emergency Preparedness

Emergency preparedness resources have evolved over time based on the demands of past emergencies and storm events. The scope, magnitude, and frequency of historic emergencies have served as the basis for the design and development of our current emergency preparedness infrastructure. As noted, storm-related emergency situations are expected to become more frequent and intense, and, with changes such as sea level rise, many areas that previously escaped storm impacts will now be vulnerable.

For the purposes of this assessment, the public safety sector has been viewed through the lens of emergency management. Emergency management is divided into four phases: preparedness, response, recovery, and mitigation.

Existing Resources

The overall emergency management strategy involves all levels of government, with an overarching concept of one level of government supporting another, e.g., federal government supporting the states, and states supporting regional and local entities. Typically, when the emergency management capacity of a lower level of government is exceeded, support is requested and provided by the next higher level of government. This planning and implementation model has generally worked well and has been enhanced with the requirements established by the National Incident Management System.

Impacts and Vulnerabilities

Since September 11, 2001 and the major storm events that hit the Gulf Coast region in the last decade, emergency management professionals have recognized how easily and quickly response and recovery capacity can be exceeded at all levels of government. These lessons can serve as the starting point for enhancing future emergency management capabilities in order to respond to the increased frequency and intensity of extreme weather events expected from climate change.

Potential Strategies

1. Update MEMA databases and maps. During emergency response and recovery phases, MEMA serves as the state's emergency operations center (SEOC). The SEOC is the focal point for all agencies and organizations that provide response and recovery activities, as well as the information source for the Governor's Office during emergency situations. Recent storm events and exercises have revealed areas in mapping and information systems that need to be updated and enhanced. As these efforts move forward, the potential impacts from climate change should be factored into the scopes of work for enhancing these systems, which will include getting support from state agencies such as the Massachusetts Department of Transportation (MassDOT) and DEP.
2. Update the State Risk Assessment Inventory. Based on predicted increases in areas subject to flooding and coastal storm flowage (e.g., expanded "A" and "V" zones), the State Risk Assessment Inventory should include an accurate list of at-risk government facilities and resources.
3. Update the State Comprehensive Emergency Management Plan to recognize the potential for climate change to influence the severity and frequency of a range of natural and technological hazards (flood, severe weather, drought, water contamination, etc.). Update and revise hazard-specific annexes and plans, referencing mapping and technical data with regard to climate change research.
4. Expand the scope of the State Hazard Mitigation Plan. This plan is routinely updated and submitted to the federal government to support funding requests for various mitigation projects that enhance the preparedness of government/public facilities to withstand future storm events and reduce damage potential based on historic experiences. Future plans should consider factoring in expected vulnerabilities from climate change impacts. This may require federal approval to allow flexibility in Hazard Mitigation programs, since federal requirements are prescriptive and could limit hazard mitigation projects designed to address climate change impacts.
5. Design and implement coordinated education and outreach efforts to increase awareness of the cost savings and public safety benefits of hazard mitigation, enhanced preparedness planning, and other projects that will assist communities and state agencies with climate change adaptation. Assistance programs to help municipalities develop debris management plans comprise one of several areas where local officials need both education and technical assistance.
6. Continue assessment of emergency responses. Since extreme weather events are predicted to occur more frequently, it is important to ensure that various sectors (such as the energy sector) have the capacity to respond to these events. Emergency management plans should be updated to account for predicted climate change and impact on delivery systems should be evaluated. Maintaining a database of available equipment parts to facilitate sharing during an emergency, and increasing replacement budgets and material stock should be considered.
7. Increase capacity to address emergencies by facilitating greater cooperation and sharing of resources and expertise with the business community, forestry sector, and the tourism industry at a regional scale.
8. Continue assessment of emergency equipment, supplies, and evacuation facilities.
9. Practice the execution of communities' emergency action plans, involving local non-governmental organizations for support, staffing, and building constituent support.
10. Establish support mechanisms to ensure overall preparedness to meet increased demand on local public works and emergency response staffs due to more extreme weather events.

Government—Improve Planning and Land Use Practices

Difficult societal decisions lie ahead regarding options and alternatives for reducing risk to public infrastructure, private property, natural resources, and human safety and welfare. Public discussions and deliberations can be initiated now to develop criteria, set priorities, and establish or modify policies to determine where protection should be advanced and where managed retreat may be more prudent. Future risk and costs can be minimized for new development and redevelopment through the careful siting and inclusion of design standards that account for higher sea levels and more intense

storms and precipitation events.

Numerous planning and land use tools will be critical to addressing climate change. These tools should be used to engage the public, analyze and present data to guide policy making, and inform conservation and development plans. New or revised policies and regulations can assist in guiding infrastructure or other investments to desirable outcomes given anticipated climate change impacts. The intent of this section is to synthesize and summarize means of employing land use tools and techniques to address the many challenges of adapting to a changing climate. Strategies have been divided into three sections: those that a.) apply predominantly to new development, b.) address existing development, and c.) concern planning regulations and assistance. These strategies will continue to be investigated for feasibility.

Potential Strategies

New Development Strategies

1. Consider sizing infrastructure (such as pipes, culverts, rain gardens) to handle predicted storm events. Consider modifying existing standards within the Massachusetts Stormwater Handbook to better handle stormwater volumes reasonably expected as the climate changes with an emphasis on green infrastructure.
2. Seek to ensure that state investments in infrastructure and development projects (direct or indirect via grants, loans, tax incentives or other funding mechanisms) reflect potential climate change impacts, especially future risk projections. Consider incorporating future risk projections into program-level project selection criteria and in capital budget review by the Executive Office of Administration and Finance in order to properly assess impacts.
3. Examine utilization of state statutes and regulations to ensure that new buildings are sited and built in a manner that reduces their vulnerabilities to impacts of climate change, especially those in inland and coastal floodplains and other current and future threatened areas. Consider applying one or more of the following land use tools.
   a. Provide incentives and tools including funding, a robust technical assistance program, and complementary state policies to aid in the implementation of "no adverse impact" policies.
   b. Guide development of structures and infrastructure to areas unlikely to be eroded or flooded by more intense and frequent storms and/or predicted sea level rise.
   c. Apply a "no adverse impact" approach (see case study on StormSmart Coasts in Chapter 8) via statewide regulation.
   d. Explore mechanisms that proactively address migrating wetlands. Consider utilizing "rolling regulations" that facilitate wetlands or beaches to migrate inland as sea level rises. Rolling regulations provide an alternative to prohibiting all development in coastal areas, preclude coastal armoring, and facilitate sediment transfer.
4. Site and design development to preserve/restore natural hydrology. Facilitate restoration or creation of flood storage where feasible.
   a. Investigate applicability of low impact development (LID) strategies via potential state stormwater regulations;

   b. Provide incentives and tools including funding, technical assistance, and complementary state policies to aid in the implementation of LID site design and stormwater management regulations;
   c. Develop regulations and incentives to encourage development projects to restore or create flood storage;
   d. Develop incentives for landowners to return impervious surface to permeable surface, especially once the impervious surfaces are no longer needed (for example, parking for an abandoned mall); and
   e. Consider establishing a public revolving loan fund or tax credits to support and encourage retrofitting—brownfield cleanup fund may be a model.

Land uses that absorb more water

A school in Manchester, Massachusetts invested $1.2 million on artificial turf for its athletic fields. After receiving four inches over rain during 12 hours on a Thursday evening and Friday morning, the newly constructed rubber turf field was dry enough to play on Saturday. The field substance used allows water to absorb into the ground rather than running off as stormwater. The field's design helps to recharge groundwater naturally while keeping the field dry and ready to use. With an increasing number of high-intensity storms anticipated with climate change, investments that increase pervious surfaces could have the dual benefit of reducing flooding and replenishing aquifers.

Existing Development Strategies

1. Explore options for ensuring that, as sea level rises, vulnerable buildings and infrastructure are structurally prepared for storm events. Means to achieve these goals may include enhancement of the building code to the extent feasible. "Index" the code to scientifically-derived standards, consider applying flood hazard area regulations to "A" zones, and consider updating policies/ regulations/safety standards applicable to vulnerable structures not covered by the building code.
2. Evaluate the potential benefits of classifying coastal areas by "tier" based on degree of risk, extent of existing development and corresponding investment, sensitivity of natural resources, and other factors. Indicate for each tier the degree to which areas so designated could be addressed, including options such as:
   a. Protect from sea level rise, in which:
      i. coastal armoring/shoreline stabilization will be allowed in the form of traditional "hard" engineered barriers (with careful consideration of their impact on surrounding property and habitats); physical barriers where appropriate and feasible, particularly in areas where land and existing development is too important to lose (for example, the hurricane barrier in New Bedford); or "soft" measures—landscape flood mitigation such as extensive LID and preservation or creation of wetlands or coastal dunes to mitigate storms impacts;
      ii. infill development will be permitted;
      iii. structures/infrastructure will be rebuilt if damaged; and
      iv. flood resistant building and infrastructure measures will be employed.
   b. Left for "nature to run its course," in which:
      i. coastal armoring/shoreline stabilization is strictly limited or not allowed;
      ii. new buildings and infrastructure are limited or not allowed;
      iii. managed retreat and relocation policies/ programs are pursued;
      iv. buildings are to be removed if threatened or "substantially" (for example, 50 percent) damaged;
      v. expansion of existing development is tightly constrained; and
      vi. existing infrastructure is maintained, but not repaired/replaced if substantially damaged.
3. Develop and implement a protocol for each proposed tier that applies appropriate state and local planning, regulatory, infrastructure, investment, and other tools. Begin with a factual inventory that characterizes coastal locations by degree of risk, existing extent of development, environmental sensitivity, and other factors. Then

Figure 9: ***WasteWater Treatment Plant in Hull, MA: Simulated flooding around a critical facility from base flood plus 3.3 feet of sea level rise.***
Base flood (i.e., a 100-year flood) elevations taken from FEMA Preliminary Digital Flood Insurance Rate Map for Plymouth County (11-7-2008). Labels represent flood water depths measured from building foundation at ground level.
Source: http://www.mass.gov/czm/stormsmart/resources/hull_inundation_report.pdf

Massachusetts precedence for 'no-build' in dangerous coastal areas

When a landowner sued the town of Chatham for its refusal to permit construction of a new home in the town's mapped floodplain, Chatham defended its floodplain zoning bylaw intended to protect local people, property and resources. In 2005, the Massachusetts Supreme Judicial Court issued a landmark ruling that upheld the bylaw, citing reasonable public interest, stating that its enforcement was not tantamount to a taking and did not require direct compensation from the town. Further, the land retained more than a token value. Even though residential units could not be built on the land, various other uses including fishing and agricultural uses were allowed on the site. The town's right to enact regulations that ensure the safety of its citizens in the face of a hazardous landscape was upheld.

utilize this information as the basis to:

a. Engage in a classic planning exercise to engage stakeholders and produce a plan that designates tiers and selects appropriate land use outcomes for each tier. Implement the resulting plan through statute, regulations, policies, and programs as appropriate;

b. Perform a scenario-based risk assessment in which the probable impact of various adaptation actions are determined for various climate change and socio-economic scenarios. For each location, the most robust adaptation option will generally be the one that performs best in the majority of scenarios. As part of the analysis, gather stakeholder input on costs of various socio-economic scenarios and acceptable degree of risk; and

c. Undertake some other process to produce a plan that addresses coastal impacts of climate change.

Planning, Regulation, and Assistance Strategies

1. Consider assigning an agency the responsibility to gather and provide data, offer policy guidance, facilitate inter-agency coordination, and otherwise serve as an information provider on climate change and adaptation strategies in order to coordinate actions and guide plans, regulations, and investments.
2. Promote state, local, and other land conservation and development plans that reflect future climate change risk projections and that post-storm emergency response and decision-making plans are in place. Investigate the Statewide Hazard Mitigation Plan and local mitigation plans prepared for MEMA/FEMA to determine if emergency planning is adequately addressed and respond as needed. Assist regional planning agencies in the production of regional climate action plans that comprehensively assess risks, costs, and potential solutions for adapting to climate change. Work with and provide incentives for municipalities to integrate the appropriate regional climate action plan into master, open space, and other local plans in order to ensure that they address climate change preparedness, resiliency, and adaptation over a long-term horizon.
3. Incorporate evaluation of climate change impacts in MEPA and environmental permitting processes. Review (and revise accordingly) state permitting procedures and regulations for ways to consider climate change concerns such as requiring alternatives and impact analyses for development of current and future threatened properties.
4. Use climate change impacts information to help identify high-value land acquisition:
   a. preserving large unfragmented blocks of open space and connecting corridors to allow species to migrate with their habitat;
   b. protecting unregulated but vulnerable areas for conservation uses;
   c. conserving parcels just inland to allow coastal ecosystems to retreat as seas rise; and
   d. preserve agricultural soils and lands, especially near urban markets.
5. Investigate opportunities where local regulations (general, environmental, zoning, etc.) can minimize the impact of climate change. Provide robust financial and technical assistance and enhanced planning and land use tools in order to encourage and assist communities in the potential use of local regulations to, among other things:
   a. preserve large unfragmented open spaces and connecting corridors;
   b. consider potential future floodplain expansion in land use planning and direct growth away from floodplains and other vulnerable areas—this may include the use of some form of overlay zoning (either through the potential hybrid of existing floodplain designations or expansion of regulated flood zones to encompass the 500-year flood zone) to preserve high water "climate impact zones";
   c. concentrate development on portions of a parcel that are least vulnerable; and
   d. transfer development rights from areas at risk and properties that have been damaged by storms.
6. Investigate opportunities where local land use regulations and building codes can address the "heat island" effect. Encourage the implementation of local land use regulations (zoning, subdivision, etc.) and the adoption of state building code provisions that address heat concentration including:
   a. land use regulations governing impervious surface, tree, shading, street/building orientation, etc.;
   b. building code provisions on roofing materials, insulation, fenestration, etc.; and
   c. incentivizing white, if not green, roofs.

 The symbol signifies adaptation strategies that are also climate change mitigation actions.

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