MAGIC Climate Change Resiliency Plan

Pt. 2
Climate Change Response Strategies

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MITIGATION AND ADAPTATION STRATEGIES

Introduction

The MAGIC region will face new risks in the coming decades due to climate change. As described in the previous section, the 13 towns of the MAGIC will experience weather events and related impacts more frequently and more intensely than they have in the past. Flooding will occur more frequently only to be matched by longer periods of drought. Entire years will be warmer on average than previous years and extreme and prolonged heat may be a regular occurrence in summer months.

Climate change mitigation and adaptation strategies serve as the response to these new conditions that will confront the region. Mitigation strategies will seek minimize or eliminate the impacts of climate change on the MAGIC region and larger geographies. Adaptation strategies recognize that certain aspects of climate change are already set given past GHG emissions and that the future level of emission are uncertain, and seeks to strengthen the region's ability to adjust to the new conditions.

The mitigation and adaptation strategies are informed by four assumptions and approaches: 1) MAGIC has existing strengths, 2) mitigation, adaptation and emergency preparedness are interconnected, 3) apply a 'no regrets' approach, and 4) apply an "adaptive management" approach. These are described in greater detail here:

MAGIC has Existing Strengths.

The MAGIC region has strengths that inform a shared agenda for climate action by individual towns and by the region. As identified by the project working group, these strengths include:

1. **The region is proactive**. This propensity to act is demonstrated by MAGIC Climate Change project and other projects where towns in the region have adopted local policy changes to address changing conditions such as transportation and agriculture.
2. **The region is committed to conservation**. This is evident in town participation in the state's Green Communities program, development of multiuse rail trails, and the protection of undeveloped open spaces and wetlands.
3. **The region values its agriculture.** Several farms operate in the region, and there are efforts to preserve farmland and keep it active. Agriculture is important to the local economy and heritage, and it informs a regional identity.
4. **The region has a dynamic network** of non-profits and institutions, including a community college, vocational and tech schools, and conservation groups.
5. **The region supports collaboration.** In discussing and acting on current and future regional matters, there is a culture and practice of collaboration between elected officials, municipal staff, residents, community groups, and private sector representatives.

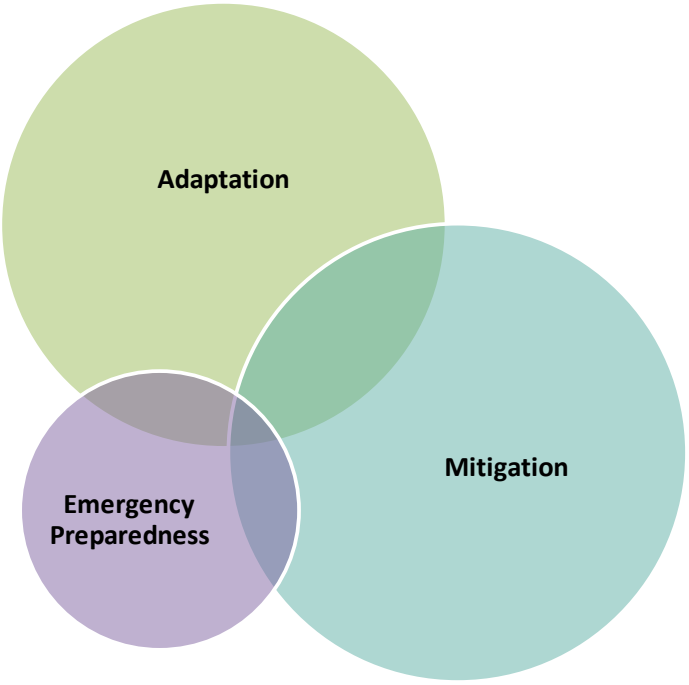
Maintaining these strengths as guideposts for action will be essential in an uncertain future. They will serve as reminders of existing adaptive capacities and provide direction regarding new capabilities that are needed to respond to a changing climate.

Mitigation, Adaptation, and Emergency Preparedness are Interconnected.

Responses to climate change include mitigation and adaptation strategies as well as support for emergency preparedness (Figure 1).[1] Of the three, emergency preparedness planning is generally in place already in each MAGIC municipality. However, emergency preparedness is a process that requires continuous updating and the strategies used are likely to change as a result of climate change.

These three elements are also interconnected, as action in one dimension can help address the causes or outcomes that another is also trying to tackle. For example, mitigation activities address the causes of climate change (e.g., GHG emissions), and in reducing the magnitude of impacts, efforts may, in turn, affect what adaptation actions are needed or the extent that of emergency preparedness and planning activities are necessary. An instance of this would be clean energy investments that reduce GHG emissions through solar. If done under certain circumstances, the solar could be connected to a microgrid[2] that would enable a set of homes of a neighborhoods to maintain electricity during outages and reduce the demand on emergency responders and utility companies.

Figure 1. Conceptual Representation of the Interconnections of Mitigation, Adaptation, and Emergency Preparedness



Each dimension – adaptation, mitigation, and emergency preparedness - provide valuable perspectives and tools that are needed to holistically address the causes of and potential impacts.

[1] Emergency preparedness typically encompasses four sets of actions: preparation, response, recovery, and mitigation.

[2]Department of Energy, "How Microgrids Work", https://energy.gov/articles/how-microgrids-work, accessed April 5, 2017

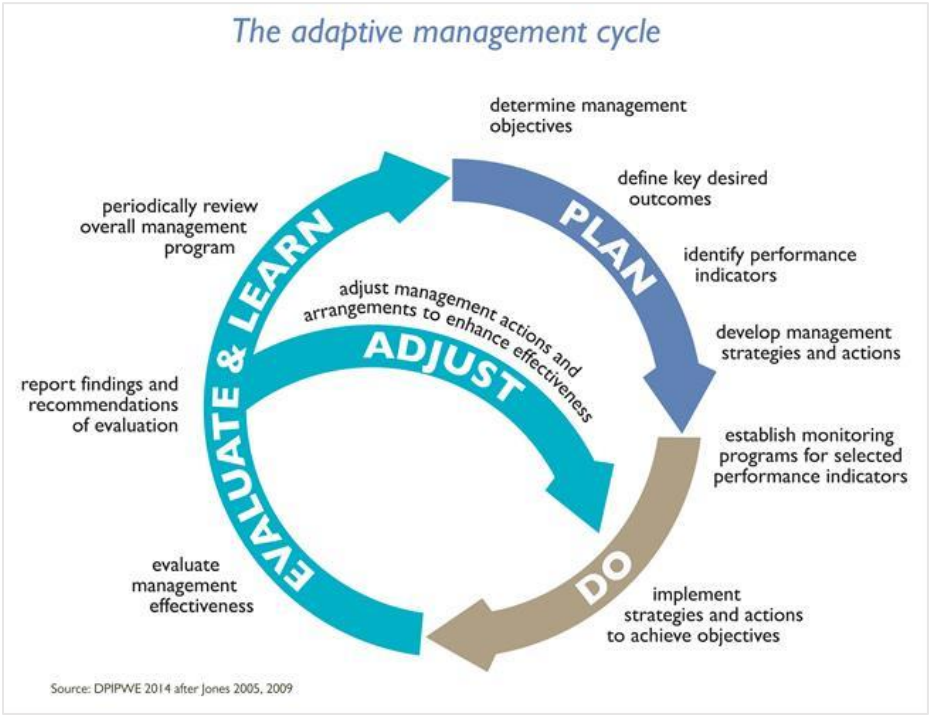
Use a "No Regrets" Approach

The strategies embrace a no regrets approach. They include action items that should be considered even in the absence of climate change and that are anticipated to generate economic, environmental, and social benefits. They include evidence-based and best practices for environmental protection, public health and safety, sustainable economic growth, and a reduction in disparities. An example is the use of green infrastructure and low impact development (LID) techniques that reduce stormwater runoff, provide additional green space, reduce cooling cost due to less impervious ground cover, and recharge water in the local ecosystem. This change would provide benefits to the region even if climate change was not occurring as it would expose more residents to green space, reduce demands on municipal stormwater drainage systems, and support the needs of local ecosystem.

Adopt an Adaptive Management Framework

The strategies embrace the concept of Adaptive Management. This concept is used to address issues that involve uncertainty. It relies on iterative processes that use continuous monitoring and assessment to understand what actions are working, which are not, and how these actions could potentially come into conflict with one another. It operates best when new information (e.g., projections, estimates, etc.) can be integrated quickly so that new approaches can be better evaluated and modified in order to maximize impact under changing climate conditions.

Figure 2. Adaptive Management Framework



Source: Parks and Wildlife Service, Tasmania

An adaptive management operating approach is likely to face many challenges in a municipal framework. The concept requires decision-making to be agile and capable of working quickly in the face of evolving information. Massachusetts town governments and residents frequently do not like, or cannot operate, in such a manner. Therefore, a general proposal is to identify how

adaptive management concepts can be tested and used to make enhancements in municipal decision-making in order to best address climate action.

PRIORITIES IDENTIFIED FOR THE MAGIC REGION

Residents and stakeholders in MAGIC provided their feedback on what action strategies should be part of the Climate Resiliency Plan[3]. The strategies that received 50 percent or more of the responses were:

- Increase the number of **clean energy** projects (e.g., wind and solar energy, low or no emission transportation options, etc.)
- Protect and restore **natural resources** that protect properties from climate impacts (e.g., wetlands, forested and open spaces).
- Use **green infrastructure** (e.g., natural landscapes and stormwater management) to retain and absorb flood waters.
- Expand access to **public transportation** options and schedules, as a means to encourage less car use and reduce greenhouse gases
- **Regulation and zoning reform** that takes climate impacts into account (e.g., increased setback areas to protect wetlands).
- **Agricultural preservation** to ensure regional food security and protect open spaces.
- **State action and funding** for climate resiliency planning and project implementation.

Working Group members were also asked to identify their top strategies and sectors to be addressed. They reviewed an initial list of strategies, many of which are listed in the following section, and asked to identify those they would prioritize. In order, the top 10 strategies are:

- Continue Transition to Renewable and Resilient Energy Systems
- Emergency Preparedness
- Maintain and Protect Critical Infrastructure
- Water Infrastructure
- Transportation Infrastructure
- Agricultural Land Conservation and Farm Resilience
- Use Low Impact Development Techniques
- Institute Water Conservation Practices
- Develop Climate Resilient and Restorative Building Practices
- Identify a Municipal Climate Lead

[3] See *Adaptation Strategies Survey Results* in Appendix.

Starting Points for the Region

The overlap in priority strategies across groups indicate support for a set of actions that sustain or introduce climate change-related strategies in the MAGIC region. Therefore, we recommend that MAGIC and the individual towns take the following actions to advance climate action in the region:

Recommended Action	Desired Outcome
A. Designate Municipal Climate Leads and Establish a MAGIC Climate Sub-Committee	A network of municipal stewards that lead local climate resiliency efforts and hold towns responsible in their decision-making as it relates to local and regional action to prepare for climate change. In addition, a formal body, recognized by MAGIC, that acts as peer exchange network and an advisory group for regional advocacy on state and federal legislation that affect climate change resiliency.
B. Engage in Regional Green and Clean Infrastructure Planning	A 13-town action plan for preservation and protection of natural resources, with a specific focus on open space and water resources and clean energy infrastructure. The plan would serve as a recommended investment plan for land protection and clean energy investments at the local level in service of regional climate change resiliency.
C. Prioritize Active Transportation Investments	Adoption of standard active transportation policy and performance targets for the region that produce reduction in GHG emissions and increase redundancy of existing personal motor vehicle infrastructure.
D. Build and Bolster Community-Level Climate Resiliency	Residents, regardless of income, background, or ability, have the capacity to meet their needs and assist neighbors prior, during, and after climate change-induced weather events. Although this work with begin through community organizations, its purpose would be to enhance informal neighbor-to-neighbor social connections that can be activated in the event of anticipated climate change impacts.

Layering on New Strategies

The information above reflects municipal, resident, and stakeholder perspectives on where action should begin in response to the changing climate. The strategies presented in the following include more detail about the identified strategies as well as other options related to identified vulnerabilities. The purpose of the additional options is to identify actions that should also receive consideration and that provide alternatives should municipalities need to pivot from one strategy to another in response to evolving climate conditions.

GUIDE TO THE MITIGATION AND ADAPTATION STRATEGIES

The mitigation and adaptation strategies are based on recommendations from the State's Adaptation Plan, MAPC's Regional Climate Change Adaptation Strategy (RCCAS) and input provided to date from the Working Group and local stakeholders. The strategies address vulnerabilities assessed to date and are grouped into the following seven categories:

- Prepare Local Government and Monitor the Local Economy
- Monitor and apply Local Predictions for Climate Changes
- Protect Natural Resources and Maximize Use of Ecosystem Services
- Increase Use of Clean Energy and Green Building Measures
- Enforce and Enhance Regulatory Measures Affecting the Built Environment
- Maintain and Protect Critical Infrastructure
- Safeguard Health and Human Resources

Each strategy includes a background and describes the purpose of the strategy; information on the strategy's regional relevance, and practical actions for implementing the strategies. As climate planning continues in the MAGIC region, process and output indicators will be added to assist with monitoring and tracking progress on the action items over time.

1 Prepare the Local Government and Monitor the Local Economy

1.1 Designate a Municipal Climate Lead

A single climate change preparedness "point person" can ensure that there is consistent management, monitoring, and oversight of a municipality's climate preparedness efforts. This climate lead can be an existing municipal staff member or if resources allow, a new position that employs a staff person who has expertise in climate change planning and implementation. Alternatively, a volunteer member on a municipal board or committee could take on this role due to their experience and capacity, especially in light on limited or no resources.

In addition to facilitating municipal climate change work, the Climate Lead would direct a communications program about climate change with residents, businesses, and property owner as the main audiences. The program's purpose would be to disseminate information about municipal climate resiliency work and new findings relative to local decision-making and empower communities within the town to take action.

Regional Applicability

The MAGIC Climate Change Working group reflects the willingness of towns to send representatives on their behalf to participate in climate change planning. Some of the working group members are municipal staff and others are volunteers who generously offer their time to participate. There is the opportunity for these individuals to transition to the role of a local climate lead or to influence their municipality to identify a lead who will advance the strategies.

Actions

- Review existing committees, such as municipal energy committees, as well as municipal staff to determine a potential Climate Lead responsible for coordinating climate resiliency efforts.
- Designate or appoint a municipal-level climate change coordinator that has a defined set of responsibilities. These could include:
  - Update information related to climate predictions, projected impacts, vulnerabilities and progress on advance adaptation and mitigation strategies;
  - Organize and set meetings across departments that will provide climate-related updates and serve to advance adaptation and mitigation strategies;
  - Access to and relationship with the municipal leadership to be able to advise on implementation plans and budgeting resources for actions that increase local and regional resiliency;
  - Ability to understand and communicate about climate adaptation and community vulnerabilities to a municipal and community audiences;
  - Report periodically to the Select Board (suggested: every 6 months).
- Develop local or regional task forces or committees comprised of key municipal officials and local stakeholders to address climate preparedness.
- Use existing resources that provide guidance on how municipalities can work within existing programs when planning for climate change (e.g., *Preparing for Climate Change: A Guidebook for Local, Regional, and State Government*, developed by King County, Washington).

1.2 Fund municipal climate resiliency efforts

One of the biggest challenges that towns in the region will face is the availability of resources to advance adaptation and mitigation strategies, especially those requiring new operating or capital expenditures. Municipalities should explore how to incorporate changes as part of ongoing activities like roadway reconstruction project and identify innovative ways to finance approaches that reduce the risks from climate change.

An example of innovative funding approach is to have a distinct budget for climate change adaption and mitigation channeled through a third party agency. Another approach would be to target CPA dollars towards open space and affordable housing projects that offer climate change adaptation co-benefits (e.g., green infrastructure in the form of parks, energy efficient housing units, etc.)

Another source is state-wide and national grant initiatives. Massachusetts' Office of Environment and Energy has demonstrated a strong commitment to Climate Change, dedicating $50 million in grant funding[4] to promote comprehensive climate change preparedness initiatives across the Commonwealth. This grant will be administered by the Department of Energy Resources (DOER).

Regional Applicability

At a minimum, the towns and residents in MAGIC are making an investment in climate change planning through in-kind and volunteer time. Likely they are also making such investments in the municipal actions that serve to as adaptive capacities such as open space planning and water resource protections. It will be important to capture these investments as a way to assess past progress and identify where additional resources, if any, can be directed to help other strategies get implemented. This will require more coordination with town leadership and communicate strategically with residents to inform decision-making at town meetings.

Actions

- Document current actions that demonstrate operational and capital investments that address climate change and increase resiliency.
- Review upcoming investments such as capital projects and planning and design projects for opportunities to integrate climate mitigation and adaptation strategies.
- Initiate local discussions about how and where to make changes in the municipal budget for climate mitigation and adaptation strategy implementation.
- Identify potential sources of outside funding to support climate mitigation and adaptation strategies, such as the proposed program that is part of Executive Order 569 that was signed by Governor Baker.[5]

[4] http://www.mass.gov/governor/pressoffice/pressreleases/2014/0114-climate-change-preparedness-investment.html
[5] http://www.mass.gov/eea/docs/executive-order-climate-change-strategy.pdf

1.3 Promote economic resiliency

Local small business owners are less likely to have the resources to prepare for and rebound from adverse climate events. Government can provide financial assistance and information and work to protect critical assets that businesses rely on. Financial assistance could be in the form of technical assistance, grants, or low interest loans for retrofitting buildings. Municipalities should collaborate with the private sector on identifying and protecting assets subject to climate change impacts and important for business operations such as critical infrastructure (energy, communications), transportation networks, public safety facilities, and cultural assets.

Regional Applicability

Small business make up a majority of the businesses in the region. Often these businesses, and their owners, are focused on short-term action and long-term business planning. They are likely not paying much attention to potential climate change effects. Awareness of climate change impacts can be increased through outreach via Economic Development Corporations and business associations.

MAGIC is home to a limited number of health care facilities, and health care demand at these facilities may increase with climate change and demographic shifts. Municipalities, HMCCs and similar coalitions can engage healthcare institutions on assessing and addressing their climate risks.

Actions

- Require key systems (electrical, HVAC, communications) in new buildings or renovations to be located on floors above flood zone levels to avoid internal service outages.
- Work with local business and trade organizations to identify funding sources to assist property owners with flood and storm proofing critical systems.
- To increase resiliency, health care institutions should conduct Climate Risk Assessments that identify anticipated extreme weather risks and determine an emergency plan. An assessment can identify opportunities for reducing energy consumption; producing energy on site through combined heat and power systems, or solar or wind power; reducing potable water use; and developing independent sewage systems. Where a surge in demand for services is anticipated, health care facilities can stockpile medical supplies and food to enable serving more patients for a longer period, and they can support planning for critical programs and services to be located in low risk areas within health care facilities.
- Encourage and increase participation in state workplace safety programs in order to reduce existing and potential future workplace climate change related vulnerabilities. An example is the Massachusetts' Department of Labor's (MDOL) On-Site Consultation Program which is free and assists private-sector employers in increasing safety, reducing health hazards, and training employers and employees to encourage compliance with OSHA regulations.[6]
- Promote awareness and use of educational materials that address workplace safety issues, especially those that may become of more concern due to climate change. Examples include the Federal Centers for Disease Control and Prevention (CDC) National Institute for Occupational Safety and Health (NIOSH) 2-page Spanish and English "FastFact" fact sheets on Heat stress, Sun Exposure, and Ticks and Mosquitoes.

[6] http://www.mass.gov/lwd/labor-standards/massachusetts-workplace-safety-and-health-program/wshp-brochure-web.pdf

1.4 Emergency preparedness

Local governments and municipalities will need to provide emergency and disaster response when actual weather events associated with climate change occur. Hurricane Sandy was a grim reminder of the important role that municipalities in the MAPC region need to fill in order to ensure that communities are prepared and can respond to weather emergencies.

One of the key goals of emergency planning, as described in the UNISDR *Making Cities Resilient Report*[7], is to ensure that in the event of any emergency, institutions, organizations, schools and the general public have the knowledge and capabilities to be able to reach a place of safety. Municipalities will need to install early warning systems to ensure that communications are critically conveyed. This has historically been done through loud speakers and broadcast warnings on local radio stations, although more cities are taking advantage of mobile device penetration and utilizing services such as SMS and Twitter to disseminate hazard warnings effectively.

In the event of an emergency, first responders such as police, fire, and ambulances can very easily face a situation where their local capacity is exceeded. As identified in the Massachusetts' *Climate Change Adaptation Report*[8], support is consequently requested and provided by the next higher level of government.

Regional Applicability

The towns in MAGIC already have a number of avenues for communicating with emergency preparedness partners about potential climate change impacts. Similarly, community partners have these and other relationships, such as volunteer corps, that can be leveraged to communicate about what impacts are expected and determine what response strategies may work best.

Actions

- Ensure towns offer local emergency notification systems and are enrolled in local and state sponsored emergency notification systems. Develop supporting communication plans for use of social media (e.g., Facebook, twitter) to compliment emergency notification system and increase exposure to emergency notices.
- Consider key audiences and communication channels, taking advantage of existing communication pieces from the town (e.g., newsletter, local access television, reverse 911, etc.). Use existing resources such as the George Mason Center for Climate Change Communication and the Yale Program on Climate Change Communication[9]Municipal Budget and Resources Allocation.
- Review and, as needed, update existing emergency preparedness capacities through activities such as regular training and exercise opportunities, reviewing and refreshing equipment at cache sites, and planning collaboratively with regional and state partners.
- Review and update local Comprehensive Emergency Management Plan (CEMP) to account for how emergency situations and response activities could be affected as a result of climate change impacts (e.g., flood roadways, heat island effects, etc.). In particular, review the number of people and that can be accommodate at shelters and the duration that the shelter

[7] https://www.unisdr.org/we/inform/publications/28240.
[8] http://www.mass.gov/eea/waste-mgnt-recycling/air-quality/green-house-gas-and-climate-change/climate-change-adaptation/climate-change-adaptation-report.html.
[9] https://www.climatechangecommunication.org/. and http://climatecommunication.yale.edu/.

can be in operation. This will help address immediate area population needs as well as the potential sheltering needs of residents evacuated from coastal areas.

- Promote the use of micro-grids and renewable energy at vital service stations such as hospitals and public safety buildings.
- Promote the use of solar energy at pump stations for emergency service vehicles.

1.5 Advocate for climate policy in the Commonwealth and the U.S.

Federal and state actions impact climate change planning and the allocation of resources to implement climate change mitigation and adaptation measures. Decisions made in federal and state government significantly influence the degree to which municipal governments are able to proactively address climate change and promote local resiliency.

Massachusetts has been a leader in progressive climate change legislation and has committed to prioritizing climate change resiliency going forward. However, the state and country face major obstructions to maintaining these efforts, as the current trends in the Federal Administration indicate a disregard for evidence of climate changes and for participation in national and international commitments to addressing climate change. With the rescission of Federal support, funding, research, data, and other resources to increase climate change, resiliency is under threat.

MAGIC is uniquely positioned for collective advocacy to prevent, and even reverse, these changes. Its regional climate resiliency planning is a model, having engaged the largest group of contiguous municipalities in Massachusetts to-date, and the region has a history of collaboration, engagement, and advocacy capacity.

Regional Applicability

The MAGIC region has formal relationships, like those through the MAGIC Subregional Council, as well as organized constituencies such as watershed groups and climate action networks that are well positioned to call for changes that would assist municipalities in responding to climate change. MAGIC can draw attention to municipal needs on behalf of the interests of inland communities as well as coastal communities in Massachusetts. In particular, MAGIC can push for actions that will help municipalities that rely on vehicular travel so that they have the information and capacities needed to serve residents who may be isolated if local roadways become inoperable due to flooding or other extreme weather conditions.

Actions

- Convene representatives from the 13-town MAGIC group in order to review potential state legislative action that would support climate change mitigation and adaptation action by municipalities. The group should look to identify up to two priorities that would benefit MAGIC municipalities and other Massachusetts inland communities, as well as coastal communities. MAGIC can be a leading voice for their region and for those cities and towns who do not currently have the capacity for collective advocacy.
- Collaborate and coordinate with regional, statewide, and multi-state coalitions to prioritize, shape, and support federal legislation that addresses climate change. Potential collaborating entities could include the Metro Mayors' Coalition and The Southeast Florida Regional Climate Change Compact that are advancing conversations for multi-state advocacy.
- Advocate for state investment to make necessary upgrades to state-owned and –operated infrastructure critical to local operations, in order to make Massachusetts and its communities more resilient to climate change.

1.6 Disseminate municipally-tested and proven best practices for climate resiliency

Climate change adaptation is best served by practice, not plans. It is activity similar to how a rowing team may improve the coordination of their strokes and the speed of their boat. Improvement occurs as teammates share observations and apply changes to see if, and how, they work. Climate change resiliency for municipalities will benefit from a comparable approach: apply climate responsive actions now so that they can be tested and what is learned can be shared and used for improvement.

MAGIC is at the leading edge of climate resiliency planning, especially at a multi-municipal scale. The region is in a unique position to model climate resiliency and share what it finds with others in the Commonwealth and even beyond. In one aspect, the towns can model local action on certain issues – like clean energy investments or water resources management – and assess how the work has succeeded or faced challenges. In another aspect, MAGIC can be regional laboratory where successful practices and lessons learned are regularly shared at subregional meetings or climate change conventions. In both cases, this information can be disseminated across the state for others to use and for MAGIC member municipalities to receive peer guidance on future actions.

Regional Applicability

MAGIC has regularly tackled issues regionally and is a leader in municipal practices. Examples of other regional work include the MAGIC Comprehensive Agricultural Planning Program and MAGIC Suburban Mobility Transit Study, and the towns in MAGIC have lead the way on local practices in clean energy, affordable housing, and historical protection. This work has served as models for other municipalities in the MAPC region as well as the state.

Climate change resiliency continues this trend and expands on it. As one of, if not the first, multi-municipal climate change planning projects, MAGIC is leading the way on climate change in the state. As a first mover, MAGIC can model what climate action looks like regionally and locally. What is different here is that to do so, MAGIC towns will need to create a hub where actions can be tracked and assessed. This requires intention in the way that other project likely did not require. However, other projects were not responded to issue so large and so ignorant to local political boundaries.

Actions

- Inventory the actions that each MAGIC town has taken or will take to increase local climate change resiliency. Work could be coordinated through the MAGIC subregional council or another organization serving the 13 MAGIC towns.
- Organize the identified actions into a tracking table that identifies for each municipality the following (at a minimum): Town, Specific Action, Category (e.g., Transportation, Housing, etc.), Date of Implementation.
- Set a re-occurring time frame for assessing implementation status and impact. A two to three year time frame is recommended for the assessments.
- Develop a web-based clearinghouse for documenting implementation actions and findings from the assessments.
- Identify presentation opportunities (e.g., conference, workshop) for municipal and community partners to share work. Look for both state and national opportunities for presentation.

2 Monitor and Apply Local Predictions for Climate Changes

2.1 Operationalize climate change data use and updates

The past several years have seen the downscaling, or localizing, of climate change information. Starting with global predictions, national and state level predictions have become available. Likewise, municipal level predictions have become available in the Boston Metro region through climate change studies and planning efforts from the Cities of Boston and Cambridge and mapping efforts by the Massachusetts Department of Transportation (MassDOT).

The available Boston Metro region predictions have allowed for a more local characterization of impacts for the MAGIC region. That said, they are not yet the best characterizations for the region. The towns in MAGIC may be in a coastal region but they do not face the same immediate impacts that municipalities who have shorelines may face. There is different topography and hydrography in the inland region occupied by the MAGIC towns. Therefore, it will be important going forward to monitor for climate change predictions that address the MAGIC region and the individual towns that comprise the region.

Regional Applicability

As with other planning and implementation efforts, town staff and citizens prefer to use locally-applicable information. This information is more context sensitive (e.g., given certain topical features or built environment elements) and helps with community decision-making, especially when it comes to capital investments.

At present, localized information on climate change is limited. The MAGIC region will benefit from more local climate data and it will require a monitoring effort in order to determine when this information becomes available and updated over time.

Actions

- Identify a municipal department or board or committee to be responsible for monitoring the availability of updated climate change data.
- Initiate regular communications between the MAGIC Regional Council and the Executive Office of Energy Affairs, the Executive Office of Public Safety, and the Massachusetts Department of Transportation regarding the availability of local climate data and predictions (e.g., riverine modeling for impacts to state transportation facilities).
- Share updated data and predictions with all municipal departments so that information can be included in ongoing planning and implementation efforts (e.g., open space planning, capital improvement plans, etc.).
- Maintain current data on municipal critical infrastructure and assets that are important for assessing climate risk and making systems more resilient.

3 Protect Natural Resources and Maximize Use of Ecosystem Services

3.1 Adopt a Regional Green Infrastructure Approach

"Green infrastructure" describes a range of practices that mimic natural processes and use natural resources for organizing development and mitigating potential environmental needs and impacts of development. Green infrastructure practices use natural assets like soil, vegetation, water resources, and green spaces to help with issues such as water collection and recharge, habitat connectivity, and cooling. While mainly relying on natural resources, green infrastructure can integrate with traditional, or 'gray', infrastructure elements, especially in locations with existing development and impervious surfaces. Table 1 compares gray and green infrastructure features and functions.

Table 1. Gray versus Green Infrastructure

Conventional (Gray) Infrastructure	Green Infrastructure
Single function – carry waste and water; built for cars only; electricity from fossil fuels	Multi-functional - store and treat stormwater; aesthetically pleasing; provide wildlife habitat; electricity from wind, solar; multi-modality, etc.
Manufactured materials	Manufactured and natural materials
Transports stormwater away from site	Manages stormwater on site
Concentrates stormwater and pollutants	Naturally treats and disperses stormwater and pollutants
Roads built for cars only	Roads that accommodate bicycles and pedestrians, and often, have natural elements too.
Electricity from fossil fuels	Electricity from multiple renewable energy sources
Cookie-cutter approach, no room for creativity or complementariness	Work well in tandem with and are complimentary to other types of infrastructure

Source: Janak, Germond et al. 2008

Green infrastructure can address multiple climate change issues, including mitigating precipitation impacts to stormwater systems and reducing heat island effects. Habitat protection efforts across municipal borders offer a demonstration of the host of additional benefits from a green infrastructure approach, including reduced ecosystem fragmentation as well as cleaner air and water, flood mitigation, groundwater recharge, and passive recreational spaces for people.

Regional Applicability

Regional water resources protection and monitoring is a common practice across most of the towns in the region. However, there does not yet appear to be multi-municipal or regional green infrastructure planning initiative in MAGIC. Such a regional plan could offer an organizing principle for local planning related to natural resources as well as recreational opportunities. It could also help MAGIC identify how local and state action are needed to preserve terrestrial or aquatic resources that straddle multiple municipalities.

There are plans that could inform such efforts, including stormwater management plans, open space plans, and hazard mitigation plans. Additionally, the new NPDES General Permit for Stormwater Discharges from Small Municipal Separate Storm Sewer Systems (MS4) for

Massachusetts will go into effect in the near future and there are regulatory requirements for that may be satisfied through the use green infrastructure at the regional scale.

Actions

- Hold a regional meeting to share municipally-focused natural resource related plans and initiatives. The meeting should focus on available plans, such as recently updated open space and recreation plans, as well as other materials to identify where there are opportunities to establish regional infrastructure elements (including the use of state and federally protected lands) and what actions are needed to protect these spaces.
- Establish a regional fund that can serve as a match for outside funding and as source for purchasing or protecting land (local, state, or federal) that is essential to the regional green infrastructure network.
- Integrate green infrastructure plans into other local and regional planning efforts, such as master plans and transportation plans.
- Add provisions for green infrastructure into Hazard Mitigation Plans under development.

3.2 Use Low Impact Development Techniques in Local Development

Low Impact Development (LID) is a site planning process that identifies critical natural resource areas for preservation and restoration. LID ensures that maintenance of natural drainage flow paths, minimization of land clearance, building clustering, and impervious surface reduction are incorporated into the project design. LID includes a specific set of strategies that treat stormwater management at the site level, ensuring that water is managed locally rather than engineering the discharge of water away from its source. Three examples of LID[10] are:

1. Bioretention: Bioretention is a practice of using soil, plants and microbes to treat stormwater before it is infiltrated or discharged. Bioretention "cells" are shallow depressions filled with sandy soil, topped with a thick layer of mulch, and planted with dense vegetation. Stormwater runoff flows into the cell and slowly percolates through the soil (which acts as a filter), into the groundwater, with some of the water taken up by the plants.
2. Raingardens: Raingardens are a type of small-scale Bioretention Cell. These are frequently on residential lots; include simple overland outlets/overflows; and require simple soil amendments, rather than specialized media often required of larger bioretention cells.
3. Vegetated Swales: Vegetated swales are open, shallow channels that slow stormwater runoff, filter it, and promote infiltration into the ground. As a result, runoff volumes are smaller, peak discharge rates are lower, and runoff is cleaner. This approach contrasts with conventional stormwater strategies that rely on gutters and pipes that increase the velocity of runoff and do nothing for water quality. Vegetated swales can replace curb and gutter systems as well as storm sewers that convey runoff. However, they are not just ditches under another name—they must be carefully designed and maintained to function properly. The vegetation in swales, usually thick grass, helps to trap pollutants (suspended solids and trace metals), and reduce the velocity of stormwater runoff; stormwater also percolates through the natural substrate.

Other examples of LID practices include permeable pavement, green roofs, and rainfall capture and harvesting.

As the climate changes, individual properties will have to take actions to manage precipitation, especially as it becomes less predictable, The LID method should assist the properties in building their resilience and making better use of the precipitation that falls on their sites.

Regional Applicability

Multiple towns in MAGIC have LID or a version LID regulations in place. How these regulations are applied is unclear as is how many properties have used LID techniques in their construction. Given this, there is the opportunity to increase and document use of the existing regulations, change the regulations to encourage broader use, and expand the regulations to towns who do not yet have them. Additionally, the new NPDES General Permit for Stormwater Discharges From Small Municipal Separate Storm Sewer Systems (MS4) for Massachusetts goes into effect July 1, 2018, and there are regulatory requirements for that may also be satisfied through such planning.

[10] "Low Impact Development (LID) Toolkit," Metropolitan Area Planning Council, accessed August 23, 2016

Actions

- The MAGIC Stormwater Partnership project is helping MAGIC communities prepare for MS4 compliance, and the planning process will identify and rank potential stormwater recharge retrofit sites on town parcels and roadway rights-of-way. Municipalities should evaluate how they can implement LID retrofits on identified sites through municipal projects.
- Identify opportunities for LID implementation as part of green infrastructure planning
- Require white, green, blue or photovoltaic roofs on large developments.
- Review and revise municipal requirements in order to reduce the percent of impervious cover, e.g., required road widths, number of parking spaces, street tree planting, etc.
- Provide incentives for developers to use LID practices. Incentives could include: expedited project review and approval, relief from specific development standards (e.g. density, lot size, etc.), or property tax reduction for a given period.
- Identify and implement incentives for private property owners to retrofit properties using LID techniques, such as rainwater harvesting and reuse. Programs could be modeled after energy efficiency programs already used by many MAGIC towns.

Resource

- MAPC's Low Impact Development Toolkit provides practical fact sheets on LID methods including rain gardens, bioretention, pervious pavement, and green roofs. It also includes model bylaw language and an LID codes checklist.

3.3 Plan for a stormwater utility

New requirements of the MS4 Permit will introduce new costs, and a significant increase in municipal stormwater management budgets. There is a more urgent need for communities to develop new, dedicated revenue sources to implement sustainable stormwater management and comply with new requirements. And, as precipitation amounts increase, greater burdens will be placed on stormwater systems to absorb larger volumes and prevent more runoff pollution from entering waterways. The combination of these factors – management requirements, fiscal requirements, increasing burden on systems – illustrate the need for a long-term funding source and incentives for improved stormwater management.

A stormwater fee, (a.k.a. drainage fee) collected via a utility structure holds potential for generating reliable stormwater management revenue. A municipally-based stormwater utility would generate dedicated funds for stormwater management and improvements, and support municipal green infrastructure and LID efforts. It could also incentivize reductions in impervious surfaces which would increase the amount of local recharge and if done strategically, could remove surfaces that contribute to heat islands.

Regional Applicability

Most of the towns in MAGIC will have to conduct more stormwater management activities due to the new MS4 regulation.[11] No towns at present have a stormwater utility or drainage fee in place. Since stormwater is a shared issue, the utility structure presents an opportunity for regional action. Towns could pursue the utility and fee structure individually; however, a regional approach could be used as it has in many other places in the US.

Actions

- Develop or update stormwater master plans in each town.
- Plan for and adopt municipal stormwater utilities in each MAGIC town.
  * During the MAGIC Stormwater Partnership project, MAPC will update its stormwater utility assessment methodology and prepare a preliminary analysis of stormwater rate alternatives tailored for each community using MAPC's parcel-based GIS analysis of impervious surfaces and alternative fee structures.
- Identify and implement municipal collaborations that use utility resources to invest in regional projects.
- Build from municipal collaboration projects to explore establishment of regional stormwater utility. Look to similar examples in the U.S. as models for MAGIC regional utility.
- Hold discussions with chambers of commerce, business associations, community-based organizations, and residents to present and gather feedback on the establishment of stormwater utility for the towns and the MAGIC region.

Resource

- MAPC's Stormwater Financing/Utility Starter Kit is designed to help municipalities analyze existing and anticipated budgets and design appropriate billing and revenue structures for stormwater utility programs.

[11] Region 1: EPA New England, "Massachusetts Small MS4 General Permit", https://www3.epa.gov/region1/npdes/stormwater/MS4_MA.html, accessed April 8, 2017

3.4 Institute water conservation practices

Periods of low precipitation in Massachusetts (typically, mid-summer and fall), can significantly impact watersheds and surrounding ecosystems and diminish groundwater recharge. New and expanded development compounds this issue, increasing water demand and impervious surface coverage, which contributes to low-flow conditions and pollution in waterbodies. Water conservation is an important strategy for reducing impacts from low-precipitation and drought.

The Sustainable Water Management Initiative[12] (SWMI) promotes water conservation as a critical measure for mitigating water withdrawal impacts. The SWMI Framework lays out a set of eight standard conditions that all Water Management Act (WMA) permittees in the Commonwealth will be required to comply with. Of these, conditions four to seven have a direct bearing on water conservation. Additionally, requiring users of *private* irrigation wells, as well as users of public water supply to comply with water conservation restrictions is also a useful, indirect mitigation measure. These should be put in place now rather than waiting for the 2018 WMA permits in the Concord basin.

Regional Applicability

Each town with a municipal water system had water use restrictions in place 2016, as they have in most years in recent history. In 2016, some instituted complete bans on non-essential outdoor water use. In light of these immediate experiences, the towns can take a proactive approach in managing water resources and actively encouraging water conversation year round. The conservation would not only help with residential uses but would also make a key contribution to supporting the resiliency of local natural resources.

Actions

- Explore and, where possible, enact year round watering restrictions in municipalities with either public water supplies or private wells. Examples could include restrictions that limit irrigation to two days per week outside the hours of 9 am to 5 pm, and clear guidelines for restriction mandates or tiers such as “no sprinklers” and “total ban.”
- Explore, and where possible, enact new financial structures for water use such as seasonal rate structures that charge higher unit costs during peak demand periods, and higher water rates for outdoor meters to send an appropriate conservation signal to consumers.
- Provide educational templates such as flyers, press releases, notifications to be added to water bills, website postings, and outdoor sandwich board postings which describe the critical importance of conservation for climate resiliency. These templates can be easily altered by municipal officials to reflect their city/town bans. The public needs to be educated about the fact that water is a shared resource, and what actions they can take to use water responsibly. As part of the MAGIC Stormwater Partnership, MAPC will establish an online library of education and outreach resources and other useful resources available to the Partnership towns.
- Explore Net Blue bylaws to achieve no net increase in water use with future development.

[12] SWMI was a three-year, multi-stakeholder process to update the implementation of the Water Management Act (WMA).

3.5 Ecological and habitat restoration

Habitat restoration projects provide a range of valuable ecosystem services, including the generation and preservation of soils and soil carbon, cycling and movement of nutrients, partial stabilization of climate by removing carbon from the atmosphere, mitigation of droughts and floods, and purification of air and water. The ecosystem services concept is designed to illustrate the benefits of habitat restoration projects to local economy.

Another important function of ecological restoration for climate resiliency is the concept of "adaptive infrastructure," which includes the connection of habitat areas across scales and geography. Nina-Marie Lister at Harvard University Graduate School of Design promotes this concept which she describes as providing a landscape" network strategy." The idea is that landscape is infrastructure, features, edges, nodes, and bridges. Designers can use these landscape components to plan for "complex ecological interaction" to ensure that communities and wildlife become resilient to climate changes. The Lake Ontario Park master plan has been cited as a primary example of a master planning project, in this case along the waterfront, which includes ecological restoration as a primary focus including a flexible and resilient landscape framework.

The Massachusetts Division of Ecological Restoration (DER) has developed several studies identifying aquatic habitat resources and potential restoration opportunities and funding mechanisms. In addition, they have developed the Massachusetts Stream Crossing Handbook, which is a critical technical guidance document that informs and educates local decision makers about the importance of properly designed stream crossings to prevent flooding and maintain riverine habitat continuity. The Stream Crossing Standards, as described in the Handbook are required as part of Army Corps of Engineers Programmatic General Permit, and should be used when designing new crossings on perennial streams.

Regional Applicability

Habitat fragmentation is a constant risk. Private development often focus on immediate and proximate impacts to natural resources. As a region that is continuing to experience commercial and residential growth, MAGIC can begin to look to a larger systems to prevent and hopefully restore necessary linkages in the environment. These linkages such as contiguous forested lands or unobstructed waterways will increase the ability of current and future species to thrive as conditions change. Additionally, through mechanism such as density bonuses and transfer of development rights, the towns can direct development into appropriate locations and use potential proceeds (e.g., additional tax revenue) to restore lands that have been abandoned or are underutilized.

Actions

- Hold a session for municipal officials regarding ecological restoration.
- Include ecological restoration as a priority in open space and master planning processes.
- Work with DER to provide technical assistance regarding the prioritization and implementation of restoration projects.
- Explore potential for use of native species and introduction of species that may be better suited to grow under predicted future climate conditions. Avoid introduction or facilitation of growth of invasive species.
- Re-vegetate/stabilize riparian corridors with native plants.

- Redesign and/or remove impediments to flow, sediment supply, and habitat migration potential such as dams and undersized culverts.
- Use Stream Crossing Standards in the Massachusetts Stream Crossing Handbook to evaluate existing culverts that need to be replaced as well in the construction of new culverts.
- Adopt open space residential design and/or other mechanisms to protect and restore habitat and natural groundwater recharge.

3.6 Tree planting initiatives

The addition of trees is very effective at reducing heat magnification, especially in areas with significant amounts of impervious cover and that are lacking in vegetation. This strategy can also assist by being proactive in testing new types of tree species – those that reflect the predicted climate to come. As current tree populations change, tree planting can help foresters and municipal officials find options that can meet new conditions and potentially assist with terrestrial species adaptation. Lastly, these planting can remove carbon from the atmosphere, reduce air conditioning needs, and reduce negative air quality impacts to people and wildlife.

Regional Applicability

Tree planting programs already exist in the MAGIC region. Likely these look to introduce species that are already present or that are known to not impact things like utilities or stormwater management. These programs could begin to integrate a climate lens and investigate new species. The planting of these new species would allow a better understanding of potential benefits and consequences in proactive fashion.

Actions

- Share climate change predictions with municipal foresters and arborists so that tree species selection and maintenance is resilient to climate disruptions. If there is no municipal foresters and arborists, identify a lead in another department or seek contract with outside party to fulfill the role.
- Develop an inventory of tree species that would accommodate future climate conditions and detail their requirements.
- Review new tree species relationship to existing animal species and potential for reducing of exacerbating climate change impacts (e.g., trees that may produce more pollen and add to local allergens).
- Require an increase in the percentage of tree cover in all new developments, especially over parking lots and roadways.

4 Increase Use of Clean Energy and Green Building Measures

4.1 Continue transition to renewable and resilient energy systems

Renewable energy technologies, such as solar panels or wind turbines, work by harvesting naturally available forms of energy and converting them into electric energy. Use of renewable energy mitigates climate change by helping to reduce GHG emissions. In addition, renewable energy can increase local resilience by increasing the amount of energy that is sourced and produced locally. The energy use of buildings can be significantly reduced and the heat island effect diminished by using white roofing, or installing green or blue (water-holding) roofs. Solar panels may also be part of the design, and all buildings can to be solar-ready structurally.

Local resiliency can be increased more through the use of new technologies such as microgrids. This type of power grid is self-contained with the ability to generate and store its own energy. When a larger system goes down, the microgrid could remain available for critical facilities like hospitals and shelters in order to aid in emergency response and recovery efforts. While the microgrid concept holds much promise, it too should be getting its supply through clean energy systems (e.g., solar) in order to avoid contributing to greenhouse gas emissions and reducing local air quality (e.g., use of diesel generators).

Regional Applicability

MAGIC has been making progress in assessing opportunities for energy efficiency improvements and implementing changes in the built environment. Many MAGIC towns have gained Green Community designations, and have received state funding for energy efficiency and renewable energy projects. Progress should continue in this regard and towns – individually or as groups – should pursue more advanced plans or policies like net zero, microgrids, and battery storage. A factor in this will be the mix of current energy providers: where some towns have municipal light plants, others having service from regional utility companies.

Actions

- Maintain municipal Green Community designations in the region in order to leverage state support and funding for energy efficiency and renewable energy measures.
- Develop municipal energy and GHG emissions baselines to inform short- and long-term clean energy planning.
- Develop more local and regional renewable energy generation for shared or on-site consumption.
- Adopt net zero plans or policies at the municipal level
- Build capacity to execute clean energy and climate initiatives through creation of dedicated local and regional staff positions and sustainable funding mechanisms, such as green revolving funds.
- Facilitate widespread adoption of residential solar photovoltaic, but not at the expense of tree cover.
- Support the uptake of renewable technologies not yet common in the region including renewable thermal technologies, microgrids, district energy, and battery storage.

4.2 Establish weatherization and green building measures

It is critical to retrofit existing buildings with proper weatherization, energy conservation, and efficiency upgrades. Given the age of existing buildings, weatherization measures would improve the ability of buildings to protect residents from exposure to severe weather events and increased heat, and humidity that causes mold, pollen, and other allergens. In addition to reducing public health impacts, these measures provide economic benefits by reducing energy usage and related expenses.

New developments present an opportunity to equip structures to meet future needs and reduce overall exposure to climate change effects in the built environment. There are a number of standards that can be used or referenced (e.g., LEED by USGBC, EnergyStar, etc.) to guide local green building practices. While these standards may have a modest impact on construction, they have the potential for reducing an economic, social, and municipal costs in the long term under climate change scenarios.

Regional Applicability

A few towns in MAGIC have promoted a green building standard or provided weatherization support. There is space to increase the number of towns promoting these changes especially in regard to the number of older buildings that may face exposure to flood and increased high heat days. Greater use of these changes would assist residents in reducing energy loads by shifting to more efficient cooling systems, increasing efficiency of homes, and potentially build resiliency in the event of disruptions.

Actions

- Municipalities will work with property owners to retrofit existing. Prioritize efforts by looking for homes most risk, such as location relative to floodplain, year built (e.g., pre-1970), household income (e.g., 30% area median income), and age of resident (e.g., older residents).
- Work with state agency partners and legislators to develop technical assistance and grant/loan programs for water damage and mold abatement at private residences (e.g. Solarize MA).
- Support green building standards and energy use reductions within developed areas. This includes sustainable building practices for new construction, the promotion of energy audits and retrofits for existing buildings, and exploration of behavior-based programs across all sectors.

4.3 Develop and institute building practices that are climate resilient and restorative

Climate resilient building design can leverage and apply existing and new design approaches. Some existing measures go beyond what might be currently included in green building guidance or certification. As examples, the table below compares a list of the United States Green Building Council's (USGBC) site selection ("sustainable site") categories with items specific to climate adaptation.

Table 2. USGBC v. Adaptation Measures

	USGBC Measure	Adaptation Measure
Site Development—Protect or Restore Habitat	**X**	**X**
Open Space	**X**	**X**
Rainwater Management	**X**	**X**
Heat Island Reduction	**X**	**X**
Light Pollution Reduction	X	
Design and Construction Guidelines	**X**	**X**
Joint Use of Facilities	X	
Places of Respite	X	
Outdoor and Indoor Water Reduction	**X**	**X**
Flood Proofing		X
Water Reuse		X
Decentralized Wastewater		X
Alternative Energy Sources	**X**	**X**
Protect/Utilize Natural Resources		X
Green Infrastructure		X

Going further, there are likely to be new techniques that increase building resiliency and may assist in restoring past impacts to natural systems. For example, builders may want to experiment with new techniques to address flooding risks or the collection of rainwater. Towns should consider where and how they might like to accommodate, or even incentivize, such experimentation. Similarly, redevelopment or reconstruction of properties can provide a chance to restore aspects of the natural environment that have been interrupted or degraded. Towns can use such instances to encourage restoration, such as wetlands or habitat corridor, in order to increase adaptive capacity of the resources.

Regional Applicability

MAGIC has been a leader in many regards. Building on its work with the Green Communities program and in open space protection, the region could identify where and how it wants to encourage development that has resiliency as one of its core principles. This could take the form of one town taking on the challenge or several towns working collectively for outside resources to support new forms of building.

Actions

- Hold forum on climate resilient design.
- Identify how natural systems have been fragmented and key locations for restoration.
- Incentivize experimentation with new building approaches.
- Provide information on municipal building department websites that promotes climate resilient designs. Sources for design examples include the City of Boston's Article 37 Green Building

and Climate Resiliency Guidelines and the City of Hoboken's (NJ) Resilient Building Design Guidelines.

- Require evaluation of green building and landscape design as part of all medium and large project reviews, at a minimum.
- Consider a Net Zero bylaw (see Cambridge's Net Zero Ordinance).
- Offer resiliency audits in flood-prone areas, covering flood walls, backflow prevention and raised electrical and essential equipment.

5 Enforce and Enhance Regulatory Measures Affecting the Built Environment

5.1 Wetland and floodplain regulations

Protecting wetlands and floodplain areas are extremely effective climate adaptation strategies. Wetlands function as sponges, as buffers against storms, and as sources of fresh water and food. Another important function of wetlands is its natural ability to sequester carbon. For the purposes of this section, the term floodprone will be used to capture all areas exposed to flooding, not just the areas regulated under FEMA. This is because the FEMA Floodplain Insurance Rate Map (FIRM) does not take climate change impacts into account within inland riverine systems and past experience has shown that flooding occurs not just in flood plains.

The Massachusetts Wetlands Protection Act (WPA) and its accompanying regulations is the typical basis for protection of wetland resources that many MAPC municipalities choose to rely on. However, the WPA does not protect the values and functions of aquatic resources (listed below), which could provide flood protection and habitat for critical species. It is also based on FEMA's 100-year flood delineation which is likely to be an underestimate given anticipated precipitation changes.

Regional Applicability

Wetland and floodplain regulations are common in most MAGIC municipalities. This demonstrates an understanding of potential impacts and the need for local policy and action. It is not clear how well regulations are enforced or whether they are consistently applied across municipalities. It is also not clear when the regulations were last updated and whether any consider potential climate change effects, e.g. changing floodplains.

Actions

- Explore local policy changes to increase, or possibly mandate, protective buffers to the following resources:
    - Land Outside the FEMA 100-year Floodplain, e.g., ,use the 500-year floodplain
    - Isolated Vegetated Wetlands
    - Vernal Pools
    - Intermittent Streams
    - Landward Migration of Wetlands
- Strengthen local wetlands bylaw restrictions in buffer zones to restore original 100' no-build buffer of resource areas under the Wetlands Protection Act. Work with partners and towns to map areas outside the FIRM that reflects changing conditions and to ensure flood protection.

5.2 Transfer of Development Rights (TDR)

Transfer of Development Rights (TDR) includes a similar principle of preserving natural areas for flood protection by increasing development in other designated areas. The method for doing so identifying specific "sending areas" (preservation areas) and "receiving areas" (development districts), and described in full on the Commonwealth's Smart Growth/Smart Energy Toolkit. Once areas are identified, zoning amendments can be adopted that authorize landowners in the sending areas to sell their development rights to landowners in the receiving areas. This approach allows market forces to enter into the transaction and requires land owners to negotiate the final value of development rights.

It is important to note that the use of disincentives in "sending districts", as well as incentives in "receiving districts" is important to creating a successful TDR program, making it more attractive to landowners. Examples of development disincentives in sending districts are increasing lot size requirements in the base zoning and increasing permitting requirements due to the sensitive nature of these areas. These strategies are designed to decrease the development potential of a resource area. Development incentives in receiving districts typically include density bonuses awarded as a part of a TDR transaction.

Regional Applicability

TDR is a known application in the MAGIC region (e.g., included in section of Town of Concord zoning ordinance) although it is not currently applied in the towns. In coastal situations, an approach referred to as rolling easements is being considered to accommodate inland migration of wetlands. Similarly, TDR could be used inland to help accommodate changes in wetlands and floodplains while helping property owners maintain equity in their land and its development or redevelopment potential. It could also serve as another tool for redirecting development to locations that are less sensitive to climate change and that could reduce transportation-related GHG emissions.

Actions

- Evaluate outcomes and lessons learned from TDR application in MAGIC.
- Identify what areas could potential serve as sending and receiving zones in individual towns.
- Explore potential for a regional TDR application that would take advantage of efficiencies of scale and recognize larger system impacts from climate change.
- Enact TDRs.
- Consider Net Zero policy where possible on energy use.

5.3 Implement climate responsive land use policies and regulations

Policy and regulations form the basis for the measures that ensure development occurs in a manner consistent with local plans and for basic community protections. As the climate changes, existing polities and regulations regarding development can be updated to reduce community impacts from new development and protect existing development. The model of smart growth can be used as the foundation from which to build local land use policies and regulations like zoning that will create a more resilient community. Recent examples from extreme inland storm events has shown that a lack of preparedness and development in higher risk areas can cause personal and economic harm.

There are innovative changes that can be implemented to protect social and physical assets in a community. A number of these measures have previously been identified, such as local policies to promote green infrastructure and energy and water conservation measures. Additional, protective regulatory measures include:

- Inclusion of climate change and predicted impacts in local plans including master plans, open space and recreation plans, and housing production plans.
- Identify opportunities to reduce vehicle trips through zoning that encourages more compact, walkable developments.
- Incentivize existing property owners to make changes like reducing impervious surfaces, similar to incentives used to promote the use of solar panels.
- Plan for community gathering facilities that can serve as mustering points and that support community cohesion and resilience.
- Adjust wetland and stormwater bylaws to increase protection and resilience.

Regional Applicability

The MAGIC region has shown a willingness to consider future conditions and determine how best to act in response. The region has also shown creativity in implementing past solutions such as the development of suburban TMA that include both public and private sector transit services. It will likely require taking a risk, but there is precedent for the region to consider new approaches – regulatory and by incentive – to alter how and where development occur in the region.

Actions

- Review of local regulations and zoning to make required cross-sectional changes to eliminate prohibitions of climate resiliency measures.
- Explore model zoning that would promote reductions in impervious surfaces on already developed properties.
- Explore model zoning to reduce parking requirements and the use of impervious surfaces for off-street parking lots.

5.4 Flood proofing

Flood proofing measures for buildings and structures in floodplains is critical. It protects physical assets as well as residents, local economic assets, and the natural environment by reducing potential exposures. Unfortunately, there are existing barriers to allowing more innovative or progressive, yet necessary flood proofing measures, as described below.

The revised Massachusetts State Building Code, Appendix 120.G includes the following standards:

- National Flood Insurance Program (NFIP) conformity
- Post Hurricane Katrina FEMA recommendations
- Consistency between the Massachusetts Building Code and the Massachusetts Wetlands Protection Act regulations and permit approvals.

However, the state building code does not account for increased flooding frequency and intensity caused by climate change. Therefore, municipalities could consider more actively promoting building design standards in existing flood zone areas and even in adjacent areas that are identified through future modeling of impacts. FEMA produces Technical Bulletins for floodproofing (e.g. FEMA Technical Bulletin 3-93: Non-Residential Floodproofing), which can be used as a guide for establishing local guidelines. Municipalities that participate in the NFIP must adopt minimum building standards of the NFIP regulations; 44 CFR 66.3. However, cities and towns are not typically encouraged to adopt and enforce floodplain management ordinances or laws more stringent than the minimum requirements.

Regional Applicability

In each MAGIC town, there are many properties with high financial values that are located in the 1% floodplain. It is not clear at this time whether flooding risk is going to change for these properties and the exact extent to which buildings and other fixed assets would be impacted. Although these unknowns exist, it can be anticipated that there will be impacts given past experiences with flooding and given the age of many of the buildings in region. Consideration and use of more protective zoning could reduce exposure in the region as new development and redevelopment occurs.

Actions

- Incentivize the elevation of the lowest floor (including basement mechanical and utility equipment, and ductwork) one - two feet above the Base Flood Elevation (BFE), which should reduce exposure and may improve the flood insurance rating for the building. Although the state building code can prevent municipalities from regulating this change, local incentives can encourage property owners to elevate in other flood prone areas outside the floodplain and in flooding areas that are not mapped.
- Foundations and structural components having the capability of resisting hydrostatic and hydrodynamic loads and the effects of buoyancy. This requirement would allow the municipality to receive CRS Credit Points for higher regulatory standards (CRS Credit for Higher Regulatory Standards).
- Promote the elevation of utilities and sanitary facilities, including heating, air conditioning, electrical, water supply, and sanitary sewage services, in new and redeveloped sites above the base flood elevation and be completely enclosed within the building's watertight walls.

Or, make utilities watertight and capable of resisting damage during flood conditions. All of the building's structural components should be capable of resisting specific flood-related forces.

5.5 Agricultural land conservation and farm resilience

Farm acreage loss[13] continues to pose a major threat to local food production and the agricultural economy. As farmers age and plan for the future of their farm operations, the MAGIC region, like most of Massachusetts, is faced with the need to preserve local farmland and enable new farmers to gain access to these lands. Moreover, farming is inherently risky, and with increasing weather volatility, agricultural production is made more vulnerable. Changing temperatures and more intense periods of precipitation or drought have impacts on crop and livestock, and can create conditions for the introduction of new pests and disease. On-farm interventions and precautions can serve to minimize these impacts of climate change and make farming operations more resilient.

Farmers will need to employ adaptive farming techniques as climate conditions introduce new and dramatic challenges in the field. Anticipating more and new insects and disease, and greater water shortages, a range of techniques can help increase agricultural resiliency, including crop diversification, integrated pest management (IPM), no till soil management, increasing soil organic content, and drip irrigation.[14] UMass Extension is the primary statewide entity providing technical assistance to farms in Massachusetts. It conducts extensive agricultural research, monitors conditions, and promotes best practices in farming. Its research and education efforts include addressing climate change threats to agricultural production, and developing early warning systems and promoting adaptive farming practices. The services UMass Extension offers are important for MAGIC's farms to remain informed about potential issues affecting the state's farms, and to receive the technical assistance and other support to remain adaptive.

Regional Applicability

The MAGIC region highly values its agricultural identity and the farming uses that can be found in the region. It reflects the history of the region and is a reflection of how the communities in the region support local food production and access. In addition to loss of farmland, climate change will stress farms in how they produce current crops and in how they make transitions to new crops that can grow under changed weather patterns. Adaptation actions will be critical to make sure farms uses in the region can prosper, and even expand, going in to the future.

While MAGIC farms are mostly under 50 acres, and are relatively minimal emitters, farms that employ energy reduction measures and produce renewable energy can contribute to efforts to reduce the contributions of agriculture to climate changes. Massachusetts' Department of Agricultural Resources (MDAR) manages two programs, the Agricultural Energy Grant Program and the Agricultural Energy Special Project Grant Program that support projects for renewable energy or energy reduction. Anaerobic digester, solar photovoltaic, and green building construction are examples of projects funded through these programs.

Actions

- Amend bylaws and ordinances to provide zoning relief for accessory land uses that provide diversified revenue for farms. Make sure that any new regulation of accessory uses does not

[13] American Farmland Trust, Farmland Information Center (2014). Census of Agriculture, Total Land Area (acres). Retrieved May 26, 2014 from http://www.farmlandinfo.org/statistics/Massachusetts.
[14] K:\SG Land Use\Planning Projects & Information\DLTA 2016\MAGIC Climate Project 2015\Task 2 - Data Collection and Analysis\Economy\ IPCC_AR5__Implications_for_Agriculture__Briefing__WEB_EN

overstep the MGLc. 40A, §3, agricultural zoning exemption. Consider permitting accessory uses as of right instead of by special permit, or if some measure of review is needed, create and utilize a modified site plan review process that is tailored to agricultural land uses.

- Implement an agricultural overlay district that requires any development within the district be clustered in order to preserve prime agricultural soils.
- Identify and promote farmers' use of resources, technical assistance, and funding provided by the Massachusetts Department of Agricultural Resources, UMass Extension, USDA branches, and other agricultural agencies to support adaptive farming practices for climate resilient livestock, produce and other operations.

6 Maintain and Protect Critical Infrastructure

6.1 Water infrastructure

Protection of drinking water sources and infrastructure from changes in precipitation and increased heat are critical measures for a community's overall health. Drinking water availability is likely to become less reliable due to increased frequency of droughts and loss of aquifer recharge due to development and increasing intensity of rainfall events. The periods between precipitation events change and potentially reduce water availability. Wells and water sources can be compromised due increased flooding and the potential introduction of toxic materials carried by floodwaters.

EPA cost estimates associated with protective measures for potable water in the Northeast ranges from $70 to $90 billion. They estimate the costs associated with wastewater adaptation strategies (capital and operation and maintenance) to range from $31 to $61 billion. These estimates nearly triple the current $38 billion gap in funding to merely upgrade and repair existing water infrastructure in Massachusetts.15

Due to these financial and resource-based constraints, it is recommended that municipalities consider a long-term integrated water management (IWM) approach to protecting water resources. IWM looks holistically at drinking water, stormwater, and wastewater systems along with water resource management. In the case of developed areas, the goal of IWM is to maintain watershed integrity and waterbodies natural flood protection functions. Resources can be shared amongst water, wastewater, and stormwater managers. In addition, innovative techniques that provide mutual benefits to each water management division are possible under an IWM plan. For example, policies mandating or incentivizing reclaimed wastewater or rainwater harvesting would reduce water demand.

Regional Applicability

Most of the MAGIC towns have local control over the water resources. They do not need to wait for larger systems or authorities to consider and make changes. Given this, there is potential for these systems to refine their water management practices in the current in order to prepare for future impacts. Moreover, given the close working relationship among the towns, this work could occur collectively in order to develop a regional systems strategy that reflects a long-term integrated water management (IWM) approach.

Actions

- Monitor and regulate existing systems (e.g., ecological monitoring and protection, pollution control, monitoring population growth).
- Maintain, rehabilitate, re-engineer, and relocate existing systems for climate adaptation (e.g., dams, pumps, tide gauges, streams/beds, and wetlands).
- Systematize and promote water conservation measures (e.g., low flow showers, toilets, weather smart irrigation, etc) among residential, commercial, and institutional uses, providing incentives (e.g., provide equipment for free, reduce permit fees, etc.) to accelerate adoption of the measures.

[15] Massachusetts's Water Infrastructure: Toward Financial Sustainability. Water Infrastructure Finance Commission. Feb. 7, 2012.

- Modify and reduce demands on existing systems (e.g., rainwater harvesting, water conservation, pricing, regulation, basin planning, funding for ecosystem services, stakeholder participation, consumer education and awareness).
- Introduce more efficient technologies for water supply, is needed (e.g., biotechnology, and wastewater reuse and recycling).
- Develop protective flood walls around key infrastructure and treatment facilities, prioritizing those that are unable to be relocated.
- Develop and maintain interconnections with other towns in case of emergency water needs.
- Ensure uninterrupted power supply to water and wastewater treatment facilities and pump stations.

6.2 Transportation

Transportation is typically viewed as one of the "causes" of climate change due to the sector contributing a full third of total carbon dioxide emissions released in the United States.[16] Therefore, emphasis on mitigation techniques has been the focus of not only climate change policy but also transportation planning. However, it is widely recognized that adaptation practices protecting existing and future transportation facilities must be implemented in order for many mitigation measures to be effective.

Protection of low lying transportation facilities is an important aspect of adaptation planning. Roadways, bridges and other transportation infrastructure can be flooded on a reoccurring basis, and these facilities can be damaged significantly by powerful storm events. Loss of access to these roads and bridges can result in economic losses and reduce capabilities for emergency services. An example of this risk can be seen in the impacts to Vermont towns as a result of Tropical Storm Irene.

As transportation facilities are evaluated for repair, reconstruction, and re-design, their proximity to flood prone area should be carefully reviewed. If the facility is within an area that could be impacted by flooding, alternatives such as relocation or enhanced drainage systems should be explored. In other cases, increased maintenance to coastal structures that protect these facilities may be necessary. A related consideration is the integration of roadway reconstruction with wetlands restoration, as culverts can be widened to improve the flow of water below a roadway. This would allow more water to be sent into wetlands and adjacent water bodies.

Regional Applicability

Transportation assets and services are a priority for MAGIC. While most of the residents in the region typically rely on personal vehicles, the region has been taking action to increase multi-modal options and active transportation. This work is beginning to meet current needs such as travel options for older adults and those seeking more physical activity and if continued will help reduce GHG emissions generated by those in region.

Actions

- Adopt and implement Complete Streets policies in order to increase non-motorized transportation facilities and options that are essential to reducing GHG emissions and promoting healthier behaviors.
- Include performance measures in local circulation plans and transportation elements of capital improvement plans that are tied to mitigation and adaptation of climate change impacts.
- Encourage behavioral changes in mode choice through prioritization of funding to support transit services (e.g., shuttles) and construction of pedestrian and cycling facilities (e.g., shared use paths, cycletracks, Leading Pedestrian Intervals). Use pilot projects to demonstrate project's changes and impact on non-motorized transport.
- Promote compact and transit-oriented development patterns through the development of travel demand forecasts, population projections, and a regional vision.
- Ensure that state stream crossing standards are applied to all bridge and culvert repairs and proactively at vulnerable stream crossings.

[16] Ewing, R., Bartholomew, K., Winkelman, S., Walters, J., and Chen, D. (2008). Growing Cooler: The Evidence on Urban Development and Climate Change. Urban Land Institute, Washington D.C.

7 Safeguard Health and Human Resources

7.1 Protect vulnerable populations

Warmer temperatures and more instances of life-threatening heat waves will put certain populations at greater risk for disability and death. The heat will tax cardiovascular systems and, in combination with changes in air quality, it will directly impact the respiratory health of residents. Population that could be especially affected are the elderly, children, and those with pre-existing chronic health issues such as asthma and heart disease.

Protracted heat waves and flooding will likely also have large economic consequences that affect health and wellbeing. This comes not just from the initial events, but from the prolonged disruptions – economic, transportation, communication - that may follow a climate event. These tolls will be more difficult to bear for those already struggling economically and with fewer resources to for recovery. Loss of property is only one such effect of major climate threats. These population include those who are small businesses, low income workers, live on fixed budgets, and depend on outdoor work like farming and landscaping.

Regional Applicability

MAGIC is an aging region and will have more residents who are 65 and older in the coming decades. These older residents are a highly vulnerable population for the region. MAGIC also values and supports agricultural uses in addition to other outdoor workers like those in landscaping, public works crews, construction and segments of the tourism economy. Lastly, the towns in the region are aware of other populations that may more vulnerable to impacts – disabled residents, residents who have low incomes and who are cost-burdened – and can take actions to include these populations in climate resiliency efforts.

Actions

- Identify and develop relationships with partners (e.g., independent living, community health network area) that serve vulnerable populations in order to share information about potential climate impacts.
- Ensure that emergency preparedness materials are translated into languages that represent populations that do not speak English as a first language in the region.
- Enable vulnerable residents to evacuate when needed, as well as employing specific procedures to handle communications with vulnerable populations during a disaster.
- Ensuring that new and redeveloped affordable housing includes resilient design elements, especially in regard to heat. Elements should include elevated utility panels and equipment in flood-prone areas, pervious areas and green infrastructure, insulation to keep buildings cool or warm during power outages, and back-up or alternative energy generation.
- Provide financial assistance (low interest loans or grants) to owners of properties where vulnerable populations reside to perform climate proofing measures.
- Create financial and technical assistance programs to help older and low-income households acquire, install and run high-efficiency air conditioning units.
- Develop plans for cooling centers and locations in each municipality that will be operational during extreme heat events and periods of lost electrical services during storms.
- Access to prescription medication and to medical equipment during emergencies.

7.2 Build and bolster community resilience

There is a clear role for social connectedness in helping populations prepare for, respond to, and recover from the impact from climate change. As witnessed in the recovery from several recent natural disasters, communities that had stronger ties and networks have reacted faster to meet needs and begin recovery efforts. These community responses have also occurred in the context of overwhelming need throughout a region and in the absence of trained emergency personnel who were not able to cover entire communities. Additionally, there is a growing body of evidence that social cohesion is a protective health factor as those with stronger connections typically experience healthier outcomes.

Regional Applicability

The MAGIC region has demonstrated its ability to collaborate and to make collective process on key issues such as agricultural preservation and growth and suburban transit. Climate change is another area to leverage the community social capital in the region. Work on this strategy builds on an existing asset and would provide a human component to the other work that may be occurring to create more resilient natural and built environments.

Actions

- Strengthen and build ties with business and trade organizations as part of outreach and education about the risks of climate change. Co-generate materials about actions that can prevent and respond to these risks such as disruptions in electrical services, flooding, vector-borne diseases, and extreme heat events.
- Use existing projects and programs to build community connectedness related to natural hazard preparedness and response. Use formal and informal meetings to create more connections among residents and link to capacities that may be needed during extreme heat and weather events, such as checking on an elderly neighbor and participation in MRCs or Community Emergency Response Teams (CERTs).
- Establish partnerships with community, faith-based, and culturally-focused organizations as well as properties that house or serve populations with limited incomes or limited mobility. Through these partnerships build and foster capacity of organizations and people to network with one another so that informal community networks are strengthened.

7.3 Ensure access to food

Monitoring efforts will need to address the quality and safety of food production and distribution. Food supplies should be monitored for potential disease outbreaks, especially to identify the occurrence of new diseases and disease patterns. It will be critical for public health partners to implement steps to monitor and respond to changes related to our current food resources while creating the space to embrace new opportunities.

It will also be critical to understand where there may be current and potential future gaps regarding access to food. For those that rely on vehicles to access food, disruptions that may last several days or more may lead to having less food that may be needed on a daily basis. These individuals, especially those that may not have the ability to store food, will be at risk for poor nutrition. This has been especially noted for those that are older and may not drive and people disabilities who rely on being driven or a service in order to access supermarkets and convenience stores.

Regional Applicability

A mostly suburban region, residents in MAGIC typically need to drive to meet daily needs for food, medicine and shopping. Given its reliance on transportation infrastructure and services, parts of the region could be cut off from food access due to flooded or blocked roadways. Where electricity is cut off, refrigeration of perishable food would be significantly limited, in residences, at local food businesses and hunger relief organizations. Diminished capacity to safely store foods could also lead to residential or supply chain food safety issues.

Actions

- Encourage backup power systems in supermarkets and stores selling food and at community food pantries. Renewable energy microgrids could serve as a solution for backup energy.
- Emergency response strategies should include identifying roadways vulnerable to flooding, and alternative routes for vehicles servicing food stores and hunger relief organizations.
- Verify baseline conditions related to food-borne diseases and begin to explore and estimate if other diseases could be introduced into the system as a result of new environmental conditions or changing policies and regulations.
- Provide technical and financial support to those in the production sector of the food systems. For example, farmers should be provided with opportunities to learn how to transition to new crops and what new infrastructure might be required.
- Support and maintain local sustainable food systems. These systems would reduce reliance on foods that rely on long distance distribution networks. The added capacity would provide a source of food in the event that the transportation networks were disrupted or if local access to grocery store and other food access points was restricted.