NOVEMBER 4, 2021

CLIMATE RESILIENCE

A SURVEY OF MASSACHUSETTS MUNICIPALITIES

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Citation:

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Report prepared by a team of researchers at the **University of Massachusetts Amherst, Boston, Dartmouth, and Lowell campuses** with the support of the **Massachusetts Municipal Association (MMA)**.

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November 4, 2021

OUTLINE

EXECUTIVE SUMMARY

This survey-based study provides a comprehensive outlook and data baseline on climate resilience in Massachusetts from the point of view of municipalities. Disseminated to all of Massachusetts' 351 municipalities in August-October 2021, the survey received responses from 111 municipalities.

This study is part of the local engagement activities of the Northeast Center for Coastal Resilience (NCCR), a knowledge hub involving campuses of the University of Massachusetts system. The results of the survey will be used to align the hub mission, research activities, and deliverables with the actual regional needs of municipalities, planning agencies, decision makers, and practitioners. We will continue monitoring the resilience indicators collected in this baseline study in subsequent studies.

Section 1 outlines the **climate hazards experienced by Massachusetts municipalities.** Compared to inland municipalities, respondents from coastal municipalities reported more frequently greater effects from all climate hazards (e.g., severe storms and high-wind events, storm surges, sea-level rise, flooding, higher tides etc.), with the exception of heat waves and droughts that are more frequently reported by inland municipalities.

Section 2 describes the self-reported **climate impacts** both observed and anticipated by survey respondents, including environmental, infrastructural, and economic impacts.

- For most climate impacts (i.e., environmental, infrastructural, and economic) we observe an increasing severity gradient from inland areas to coastal communities.
- Negative impacts on coastal infrastructure (e.g., shoreline retreat, and impacts to ports and other coastal infrastructure) and on the blue economy (e.g., commercial fisheries) seem to have noticeable economic ramifications also in inland municipalities. This suggests a strong economic interdependence between coastal and inland municipalities.
- Population migration related to climate change seems to be a source of concern for both coastal and inland municipalities. In coastal municipalities, the most frequently reported strong economic impacts include additional costs related to disaster response, decreases in housing availability, and difficulty obtaining home and business insurance. More than 10% of respondents reported that their community is already strongly affected by increase in housing insecurity, and outmigration of residents. Meanwhile respondents in inland municipalities are more likely to anticipate future economic impacts from the in-migration of residents.

Section 3 investigates the **equity and social justice** dimensions of vulnerability to climate change in municipal settings.

- Veterans; Black, Indigenous, and other People of Color (BIPOC); and immigrants are identified as vulnerable groups by about 30% of respondents. Fewer than 20% of municipalities reported having dedicated resources to these populations in an effort to increase their resilience capacity.

- More than 75% of respondents identified elderly residents, people with disabilities, and low-income residents as groups vulnerable to climate change. These groups are also more likely to be the focus of targeted municipal resilience programs.
- Equitable resilience and adaptation planning requires reliable data to monitor climate impacts on vulnerable groups. Unfortunately less than 30% of municipalities seem to have access to reliable socio-economic indicators (e.g., employment statistics; food security metrics; health statistics; and housing and security indicators) and in less than 10% of cases the data available is disaggregated by race and ethnicity.

Section 4 analyzes the **resilience strategies** already adopted by municipalities and the strategies that they hope to adopt in the future:

- A large majority of respondents (89%) indicated that climate adaptation and resilience planning are a priority in the planning documents of their municipality. 80% have completed a vulnerability/risk assessment.
- Compared to inland municipalities, coastal municipalities seem to be more likely to have already adopted, and be interested in the future adoption of a vast array of engineering and nature-based resilience strategies.
- Strategies that municipalities most frequently report not having adopted and wanting to adopt in the future include: creation of post-disaster redevelopment plans (75%); increasing the climate resilience of telecommunication networks (74%); the development of adaptive management capacity (72%); weatherization and retrofitting of buildings (64%); improvement or expansion of stormwater drainage systems (61%); and increasing the resilience of power stations (60%); changes to building, plumbing, septic, and electrical codes (59%); changes to municipal zoning or planning practices (59%).

Section 5 examines the nexus between **covid-19 economic recovery strategies and the enhancement of municipal sustainable programs**, including resilience strategies, with a particular focus on financing opportunities.

- The most frequently reported post-covid sustainable recovery strategies (to be financed by state and federal COVID-19 recovery funds) focus on climate mitigation and include: electric vehicle charging infrastructure; expanded installation of renewable energy capacity within municipalities; and energy efficiency programs.
- Climate adaptation and climate resilience strategies are less frequently selected than climate mitigation strategies; they include climate resilient energy infrastructure and nature-based solutions to improve storm-water management or to prevent flooding and erosion.

Section 6 explores the **barriers that hinder or slow the implementation of resilience recovery strategies** including possible constraints on municipal resources, coordination and governance failures, and difficulties in accessing data.

- The most frequently reported implementation barrier to climate change resilience plans is limited staffing capacity, especially in smaller municipalities (92% of respondents from towns and 85% from cities).
- Other frequently reported barriers include lack of municipal expertise to address complex climate change issues (including assessing fiscal/economic impacts); insufficient resources to mobilize broad

community support; difficulties changing regulations and by-laws; lack of a centralized way to identify funds; lack of grant-writing capacity; lack of regulatory authority to support enforcement of strategies; need for more regional cooperation and intra-municipal coordination; and insufficient metrics and tools to monitor progress.

Section 7 concludes analyzing the **most urgent needs of Massachusetts municipalities** to facilitate and accelerate the implementation of climate resilience strategies.

- Economic evaluations of climate change impacts (89%) and local CO2 emissions data (59%) are the two types of data most frequently indicated as needed but not easily accessible. These data are crucial respectively in climate adaptation planning and in monitoring climate mitigation progress (i.e., actions that reduce emissions of greenhouse gases).
- Expert assistance, tools, and metrics to monitor impacts of climate change at the local level are among the resources most frequently selected (especially by cities) as most helpful to make progress toward climate adaptation.

Section 8 presents the **perspective of planning agencies** that participated in our survey. Their responses confirm the trends observed in municipal data. They also provide insights on challenges related to permitting costs necessary to implement resilience strategies.

NORTHEAST CENTER FOR COASTAL RESILIENCE: MISSION AND GOALS

The Northeast Center for Coastal Resilience (NCCR)[1] will serve as a regional knowledge hub to provide actionable coastal science, inform policy and local decision making, support sustainable blue economy development, and facilitate strategic regional collaborations. The survey results will help align the mission of the Center with regional needs of of communities, practitioners, businesses, and decision-makers.

There is an urgent need for regional collaboration in order to better understand the risks and impacts of climate change as well as the promising opportunities for the blue economy, adaptive planning, and coastal resilience. Climate change impacts on the Northeast will be most acute at the coast. New England is experiencing faster rates of atmospheric warming, coastal waters warming, and sea level rise, creating a compound effect. Here in Massachusetts, communities are increasingly impacted by rising waters, flooding, extreme storms, and erosion. These rapidly changing natural systems are intimately connected to people and society, requiring a holistic, systems-based approach to research, planning, development, training, and engagement with sustainable practices to enhance co-production, adaptation, and resilience.

Resources

NCCR is a proud partnership with UMass Amherst, Boston, Dartmouth, and Lowell campuses. Leveraging world-class scientists and scholars from across the Commonwealth's public universities, the Center aims to be a catalyst, accelerating resilience, adaptation planning, and a just blue economy in New England. NCCR's research team includes over 60 faculty with expertise ranging from physical sciences to engineering, technology, socio-economic and behavioral sciences, and stakeholder engagement. Serving as a hub, the NCCR team is also actively developing collaborative partnerships throughout the region with municipalities, planning agencies, public agencies, non-profit organizations, businesses, and other local stakeholders. Each campus brings important collaborating units to the NCCR partnership: UMass Amherst's School of Earth & Sustainability and Gloucester Marine Station, UMass Boston's Stone Living Lab and Nantucket Field Station, UMass Dartmouth's School for Marine Science & Technology, and UMass Lowell's Rist Institute for Sustainability & Energy.

Mission

Our mission is to "advance actionable coastal science, inform policy and decision making, and support Blue Economy development" in coastal New England and beyond.

Approach

To ensure the Center's research is timely, responsive, and aligned with the pressing needs of our region, NCCR's team is actively developing regional partnerships. The goal is to engage with the diverse range of leaders, communities, and stakeholders involved with adaptation, regional planning, climate resilience,

[1] NCCR: www.umass.edu/ses/nccr

management, and the blue economy. The Center will conduct basic and applied research aimed at understanding the key interactions between the socio-economic, built environment, and ecological features of coastal systems and shifting environmental stressors of a changing climate with rising sea levels. This research will yield valuable outputs to the regional and coastal communities. Foundational knowledge, actionable science, state-of-art tools and guidance, capacity building, regional engagement, and workforce training are some of NCCR's contributions to the region.

NCCR will take a collaborative approach to co-produce new knowledge and tools. Working collaboratively with stakeholders will ensure the science and activities effectively assist decision-makers, practitioners, and businesses on the front lines of climate change in Massachusetts. Moreover, NCCR will tailor tools and guidance to support thriving, equitable, and just coastal communities as they navigate an uncertain future.

In conclusion, regional partnerships will drive the relevance and success of NCCR as a hub for discovery, knowledge sharing, training, engagement, and collaboration.

CLIMATE RESILIENCE

A SURVEY OF MASSACHUSETTS MUNICIPALITIES

INTRODUCTION

A team of researchers from the University of Massachusetts system conducted a survey of Massachusetts municipalities and planning agencies from August 9th, 2021 to October 1st, 2021. The purpose of this survey was to gather information about the climate change hazards and impacts experienced in coastal and non-coastal (i.e., inland) municipalities; the resilience strategies adopted to address these challenges; the barriers encountered during the design and implementation of resilience strategies; and the data needs of Massachusetts communities and planning agencies to aid implementation of resilience strategies.

The results of this survey will be used to refine the mission of the Northeast Center for Coastal Resilience (NCCR), a knowledge hub involving all campuses of the University of Massachusetts system. Section 1 of this report provides more details about NCCR's general mission and goals.

Methodology

The Massachusetts Municipal Association (MMA) facilitated the organization of focus groups during the survey design and helped disseminate the survey to all Massachusetts municipalities. Numerous planning agencies contributed to the dissemination of the survey to municipalities within their region, including the Cape Cod Commission (CCC), the Martha's Vineyard Commission (MVC), the Metropolitan Area Planning Council (MAPC), the Merrimack Valley Planning Commission (MVPC), the Montachusset Regional Planning Commission (MRPC), the Northern Middlesex Council of Governments (NMCG), and the Old Colony Planning Council (OCPC).

The survey was distributed online to the municipal leaders in all of Massachusetts' 351 municipalities. We received 141 responses from 111 municipalities. In a few cases, the survey was answered by multiple administrators from the same municipality. We included all answers in our analysis, the reason for this is that respondents from the same municipality usually completed different portions of the survey in relation to their area of expertise and work. In addition, 10 planning agencies completed the survey.

Figure 1a and 1b show the spatial distribution of the municipalities that took part in the survey, presented by county (Figure 1a) and by planning region (Figure 1b).

Figure 1a. Municipal survey responses by county (n = 111)

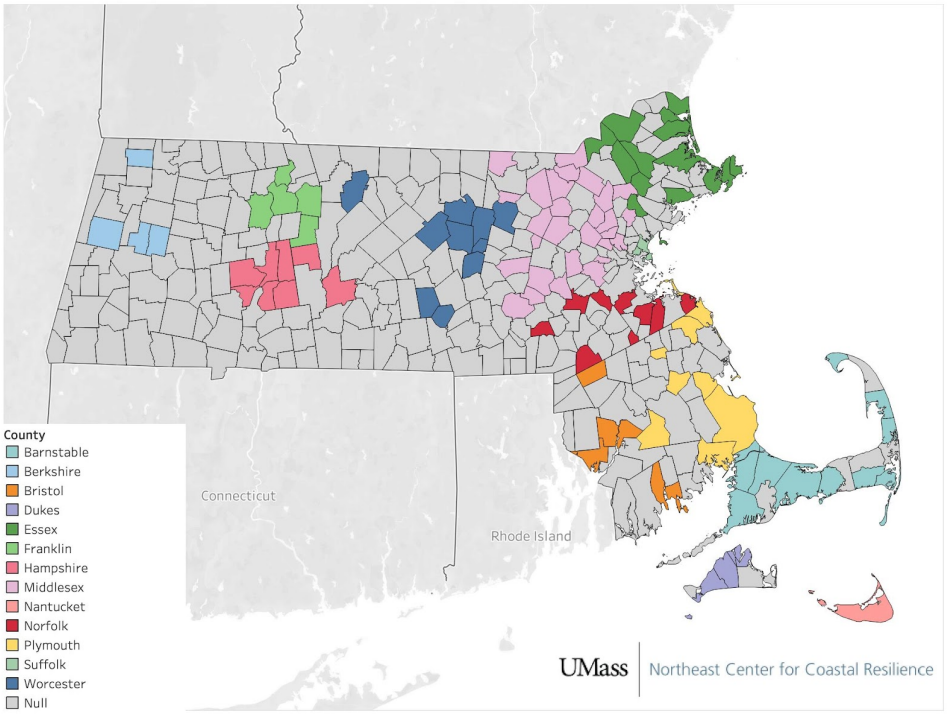
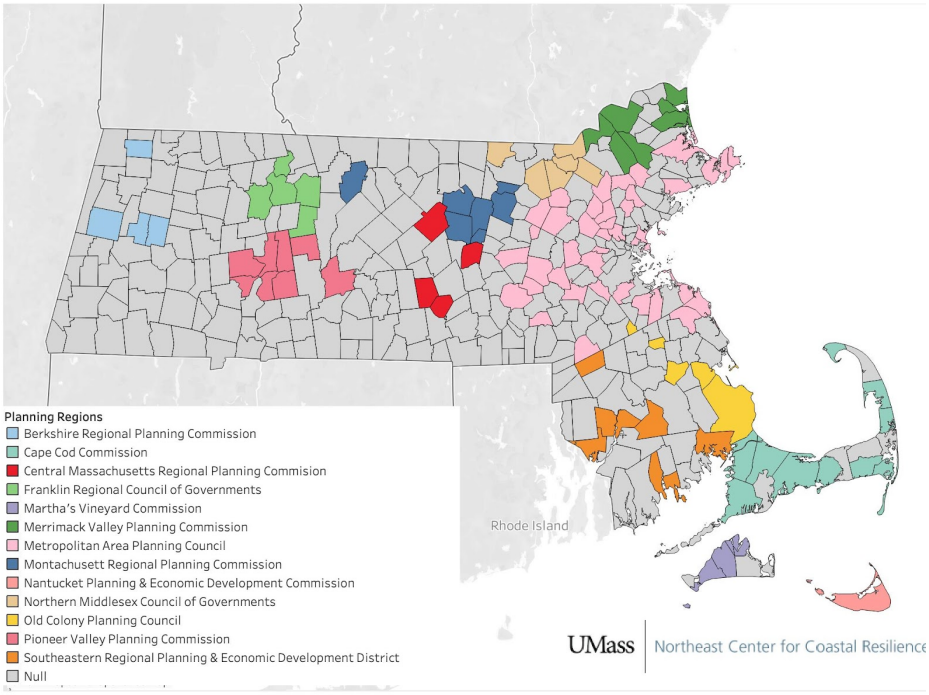


Figure 1b. Municipal survey responses by planning region (n = 111)



All Massachusetts counties and planning regions are represented in the survey sample. In performing our analyses we offer comparisons between coastal and inland municipalities; coastal municipalities are identified based on the categorization by the Massachusetts Office of Coastal Zone Management[2].

Table 1. Characteristics of municipalities

	Massachusetts		Sample in this study	
	Count	**Percent of Total**	**Count**	**Percent of Total**
Total number of municipalities	351	-	111	-
Number of cities	39	11%	21	19%
Number of towns	312	89%	91	81%
Coastal municipality (*)	78	22%	40	36%
Inland municipality	273	78%	71	64%
Not rural (**)	191	54%	75	67%
Rural level 1	104	30%	24	21%
Rural level 2	56	16%	13	12%
Average municipal per capita income (***)	$43,071		$49,531	
Average municipal population size (****)	19,637		21,549	

Sources:
(*) Coastal municipalities are identified based on the categorization by the Massachusetts Office of Coastal Zone Management: Link
(**) The definition of rurality is provided by the Massachusetts government. Link
(***) Per capita income in 2020 dollars - US Census Link
(****) 2019 US Census Link

The survey responses were likely not from a random sample of Massachusetts municipalities. Larger and wealthier municipalities, often associated with more urban areas, are more likely to have more resources (including staff members) dedicated to climate change issues, and for this reason they are more likely to respond. In our sample, the percentage of survey respondents from cities[3] (as opposed to towns) and of

[2] Massachusetts Office of Coastal Zone Management: https://www.mass.gov/files/documents/2016/11/nt/czm-regions.pdf

[3] Municipalities in the state of Massachusetts are classified as either towns or cities. Under state law the classification is based on their form of government. Towns have an open town meeting or representative town meeting form of government. Cities adopt a mayor-council or council-manager form. Based on the form of government, there are 294 towns and 57 cities in Massachusetts. There are 14 communities that have applied for, and been granted, city forms of government, though they wish to be known as "The Town of". List of cities and towns on the Massachusetts Secretary of State's website: https://www.sec.state.ma.us/cis/cisctlist/ctlistalph.htm
More information, including updated number of cities and towns: https://www.sec.state.ma.us/cis/cisctlist/ctlistidx.htm

municipalities that are not in rural areas[4] are higher compared to Massachusetts as a whole (Table 1). Average municipal per capita income and average population size are also slightly higher in our sample than the Massachusetts averages.

Despite this limitation, the survey results provide insightful information about climate impacts experienced by Massachusetts municipalities, and about their resilience strategies and needs. Actual impacts may be slightly underestimated because municipalities represented in our sample are on average wealthier than the Massachusetts average, and therefore have more resources to mitigate vulnerability to climate change impacts.

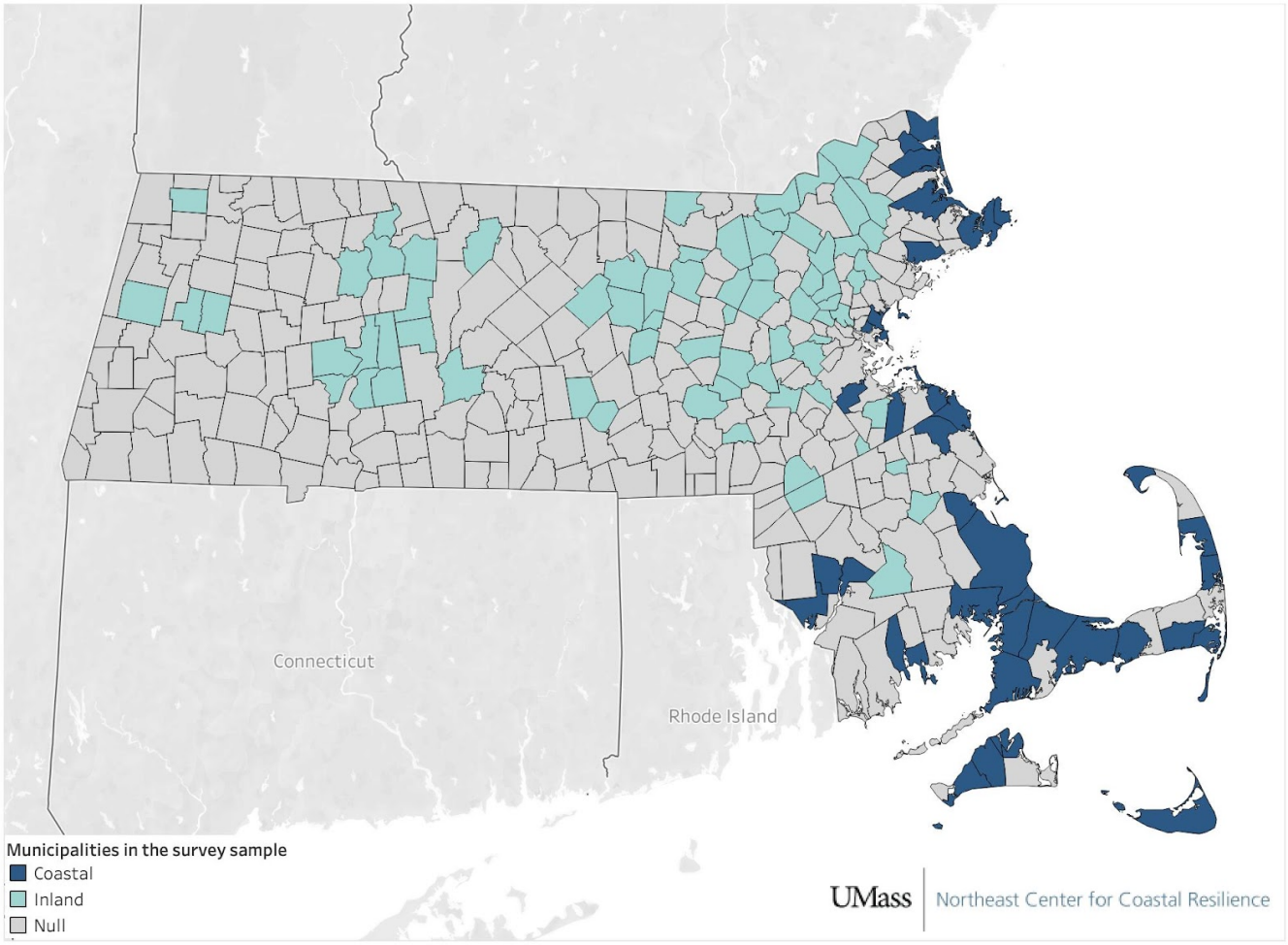
The remainder of the report is organized as follows: section 1 outlines the climate hazards experienced by Massachusetts municipalities; section 2 describes the self-reported climate impacts both observed and anticipated by survey respondents, including environmental, infrastructural, and economic impacts; section 3 investigates the equity and social justice dimensions of vulnerability to climate change in municipal settings; section 4 analyzes the resilience strategies adopted by municipalities and the strategies that they hope to adopt in the future; section 5 examines the nexus between covid-19 economic recovery strategies and the enhancement of municipal sustainable programs, including resilience strategies, with a particular focus on financing opportunities; section 6 explores the barriers that prevent or slow down the implementation of resilience recovery strategies including possible constraints in municipal resources, coordination and governance failures, and difficulties in accessing data; section 7 analyzes the most urgent needs of Massachusetts municipalities to facilitate and accelerate the implementation of climate resilience strategies; section 8 concludes presenting the perspective of planning agencies.

A comparative analysis between the survey results from inland and coastal municipalities (Figure 2) is offered throughout the report. While answering the survey, respondents often provided additional feedback sharing comments and thoughts; the report includes a selection of these contributions. In order to protect participants's confidentiality these contributions are reported as anonymous quotes.

[4] We refer to the definition of rurality provided by the Massachusetts government: https://www.mass.gov/service-details/state-office-of-rural-health-rural-definition

Figure 2. Coastal and inland municipalities in the survey sample*

(n = 111)



(*)Coastal municipalities are identified based on the categorization by the Massachusetts Office of Coastal Zone Management

1. HAZARDS

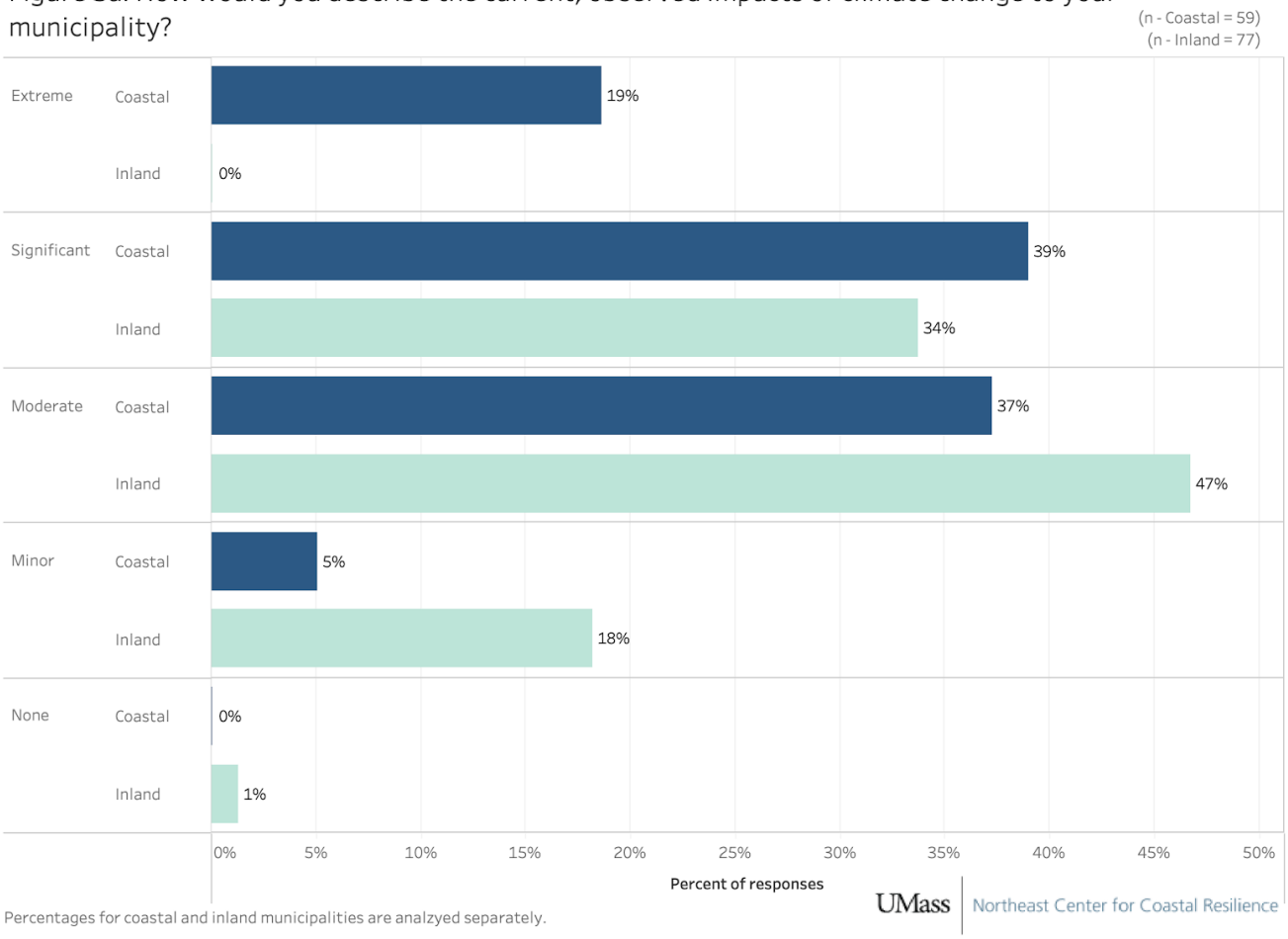
This section gauges the different types of climate-related hazards already observed in Massachusetts municipalities and their degree of severity. It also presents the hazards that municipalities expect will become an issue in the future.

1.1 EXPOSURE TO HAZARDS

99% of municipalities reported that they have already observed impacts from climate change in their municipality. The perceived intensity and spatial distribution of climate impacts differ across the Massachusetts municipalities in our sample (Figures 3a and 3b):

- 19% of respondents from coastal municipalities described the current, observed impacts as *extreme*. No inland municipalities reported extreme impacts.

Figure 3a. How would you describe the current, observed impacts of climate change to your municipality?



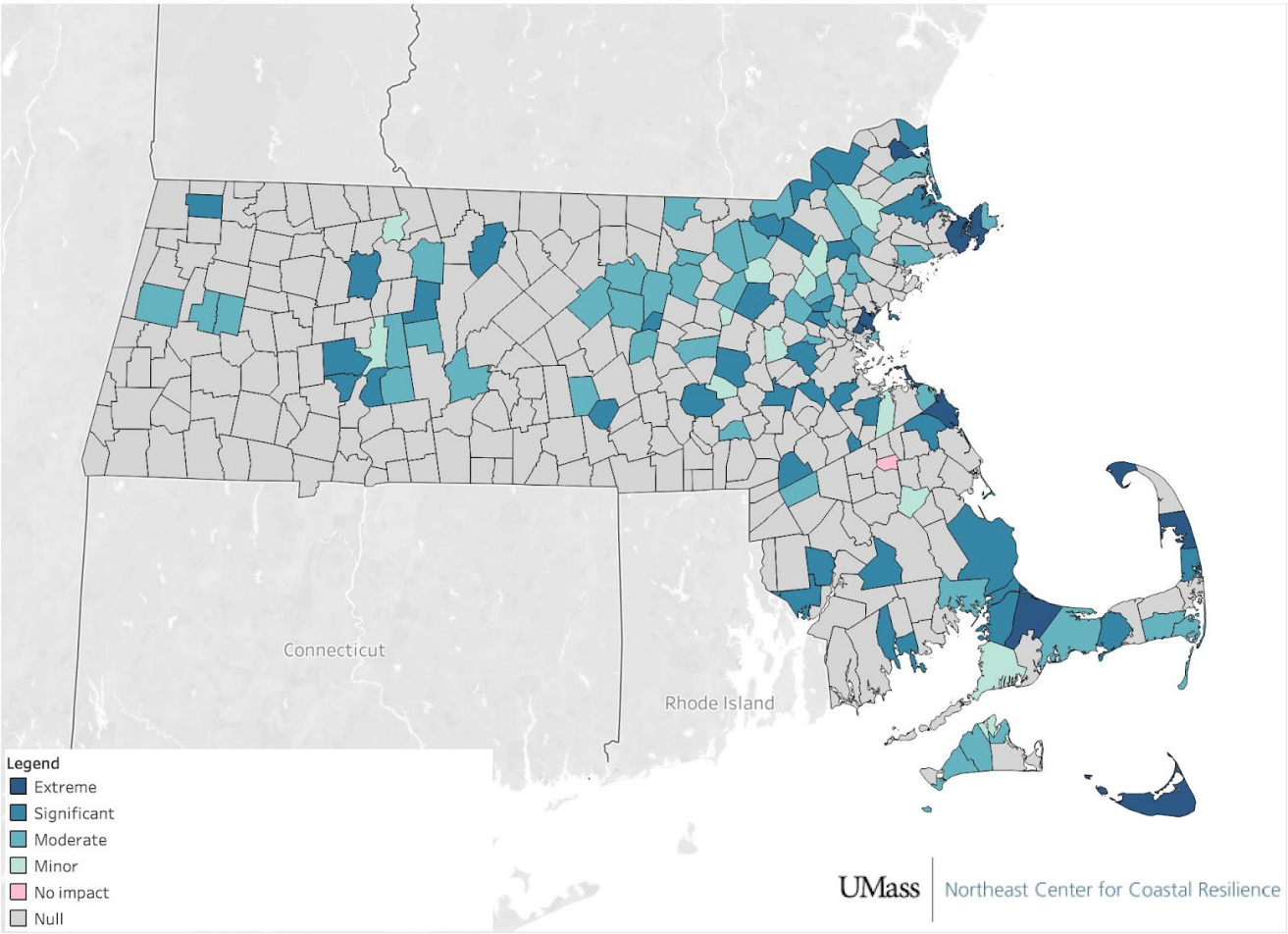
Percentages for coastal and inland municipalities are analzyed separately.

- The majority of respondents from coastal municipalities (39%) described observed climate change impacts as *significant*.

- The majority of respondents from inland municipalities (47%) characterized observed climate impacts as *moderate*.

Figure 3b. How would you describe the current observed impacts of climate change on your municipality?

(n = 108)



"We expect that climate change will cause more and more of our municipal resources be redirected to plan, mitigate, respond and recover from the impacts of extreme events."

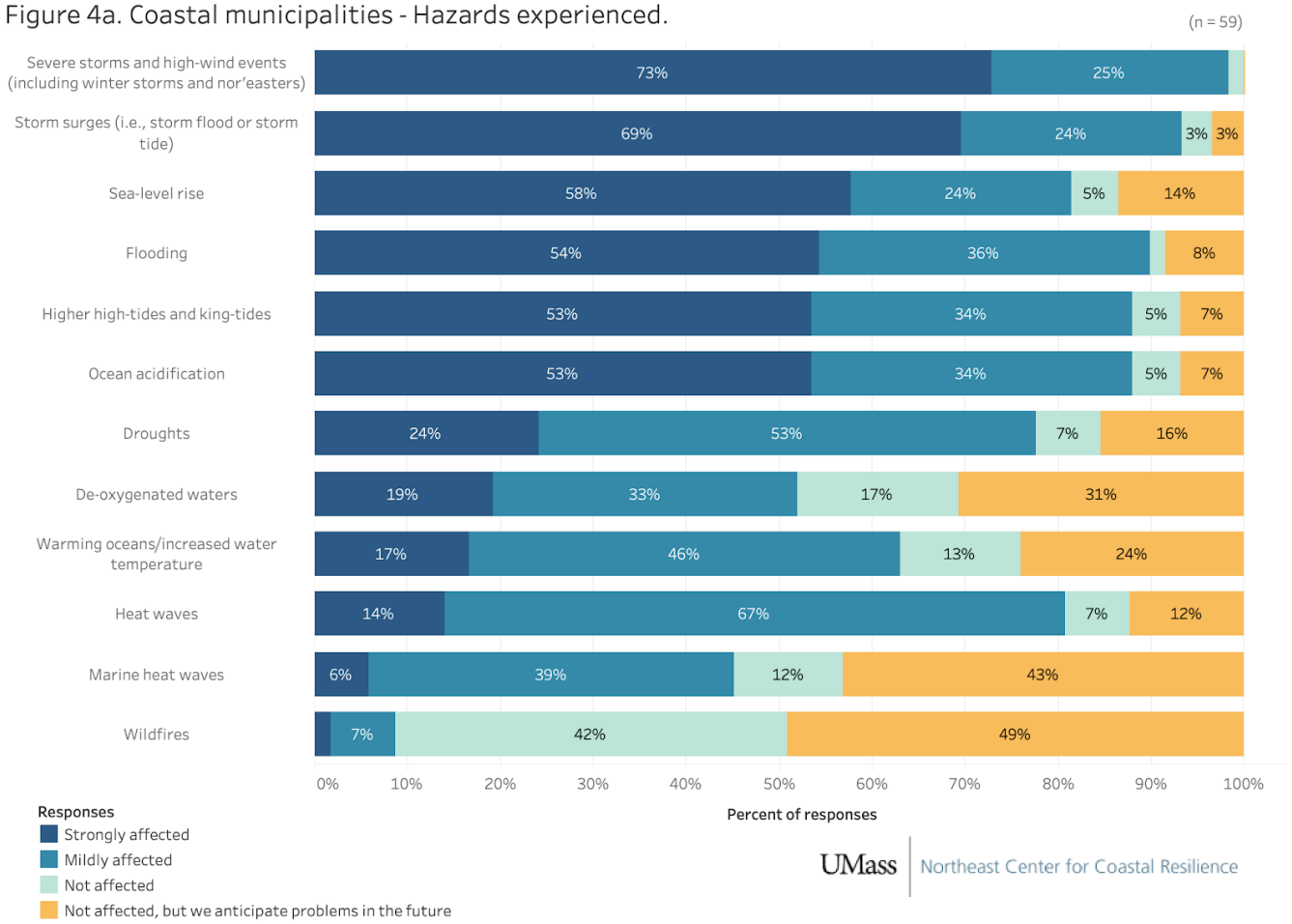
- Inland town

1.2 TYPE OF HAZARDS EXPERIENCED

As expected, there are considerable differences between coastal municipalities and inland municipalities in both the types of hazards experienced and in the severity of their effects (Figures 4a and 4b):

- Overall, respondents from coastal municipalities are more likely to report considerably greater effects from all hazards, except heat waves and droughts, compared to inland municipalities.
- The majority of respondents from coastal municipalities reported being strongly affected by the following hazards: severe storms and high-wind events (73%), storm surges (69%), sea-level rise (58%), flooding (54%), higher tides (53%), and ocean acidification (53%). (Figure 4a)
- Respondents from coastal municipalities reported being mildly affected by heat waves (67%), droughts (53%), and warming oceans (46%). (Figure 4a)
- In inland municipalities, the most frequently reported hazards with strong effects are severe storms and high-wind events (43%), heat waves (34%), flooding (31%), and droughts (27%). (Figure 4b)

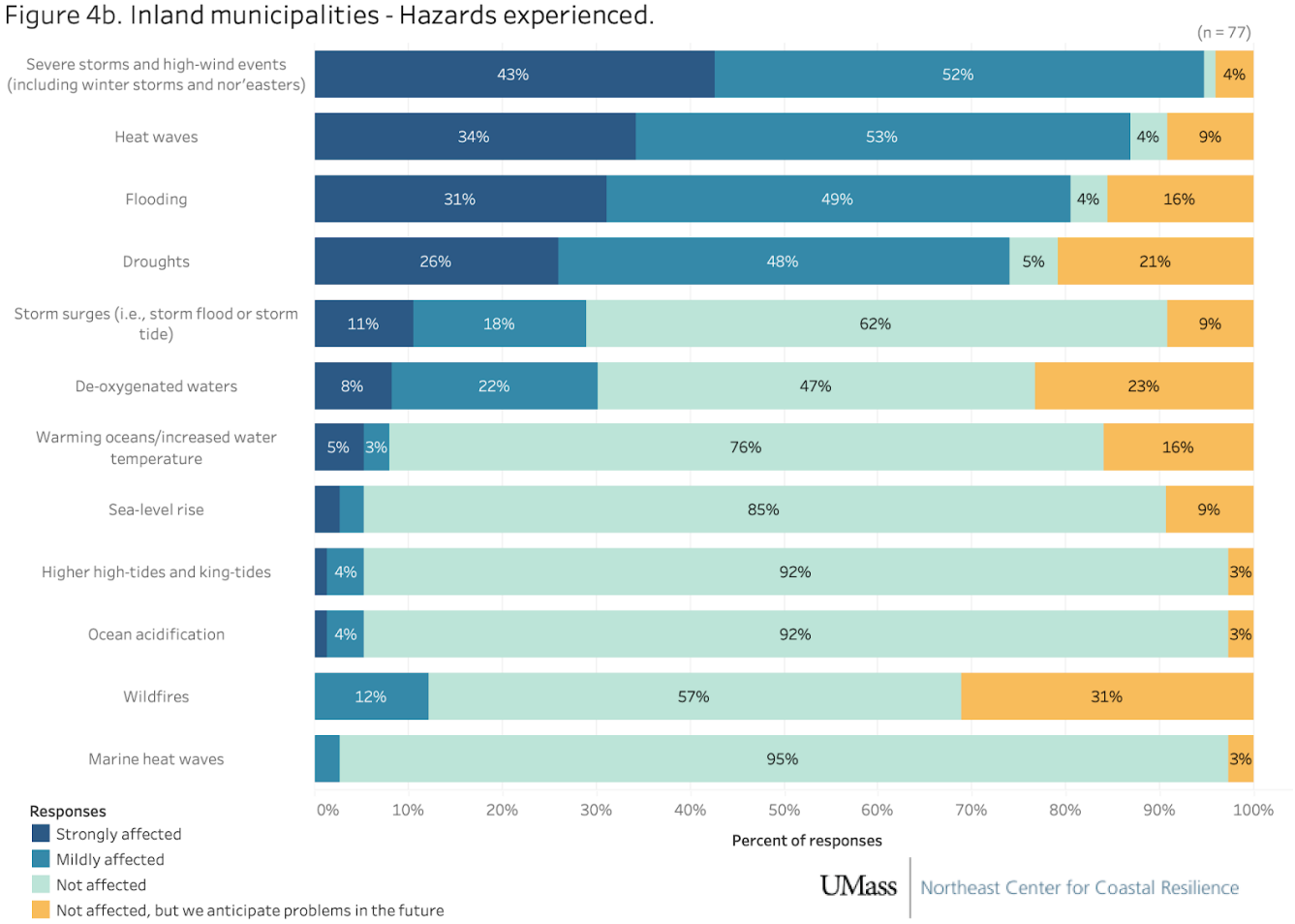
Figure 4a. Coastal municipalities - Hazards experienced.



"[Our city] remains highly dependent on the health of the ocean in ways both large and small. The reality of sea level rise becomes more ominous all the time.... There is a need for truly comprehensive planning for this community that has a rare combination of both blessings and challenges."

- Coastal city

Figure 4b. Inland municipalities - Hazards experienced.



"[We have experienced] high-intensity, short-duration storms which result in neighborhood flooding and significant tree damage (which can cause power outages & road blocks)..." *- Inland city*

1.3 PREDICTED HAZARDS

When municipalities are not already experiencing a specific climate-related hazard, they often anticipate being affected in the future (Figure 5):

- 49% respondents in coastal municipalities and 31% in inland municipalities predict that wildfires will become a hazard for their communities in the future.

- Unsurprisingly, respondents in coastal municipalities are much more likely to anticipate that marine heat waves will represent a concern in the future (43%). However, a small percentage of respondents from inland municipalities anticipate that marine heat waves and storm surges will become a problem for their communities too (3% and 9.2% or respondents respectively), likely due to indirect effects.

- 31% of respondents from coastal municipalities and 23% from inland municipalities expect that de-oxygenated waters will affect their community in the future. Increased water temperatures are expected to become a concern for 24% of respondents in coastal municipalities and 16% in inland municipalities.

- Respondents from inland municipalities are more likely to anticipate that droughts (21%) and flooding (16%) will represent a concern in their communities in the future, compared to respondents from coastal municipalities (15% and 9% respectively). Coastal municipalities are not anticipating floods becoming a problem in the future because more than 50% of coastal municipalities are already strongly affected by flooding.

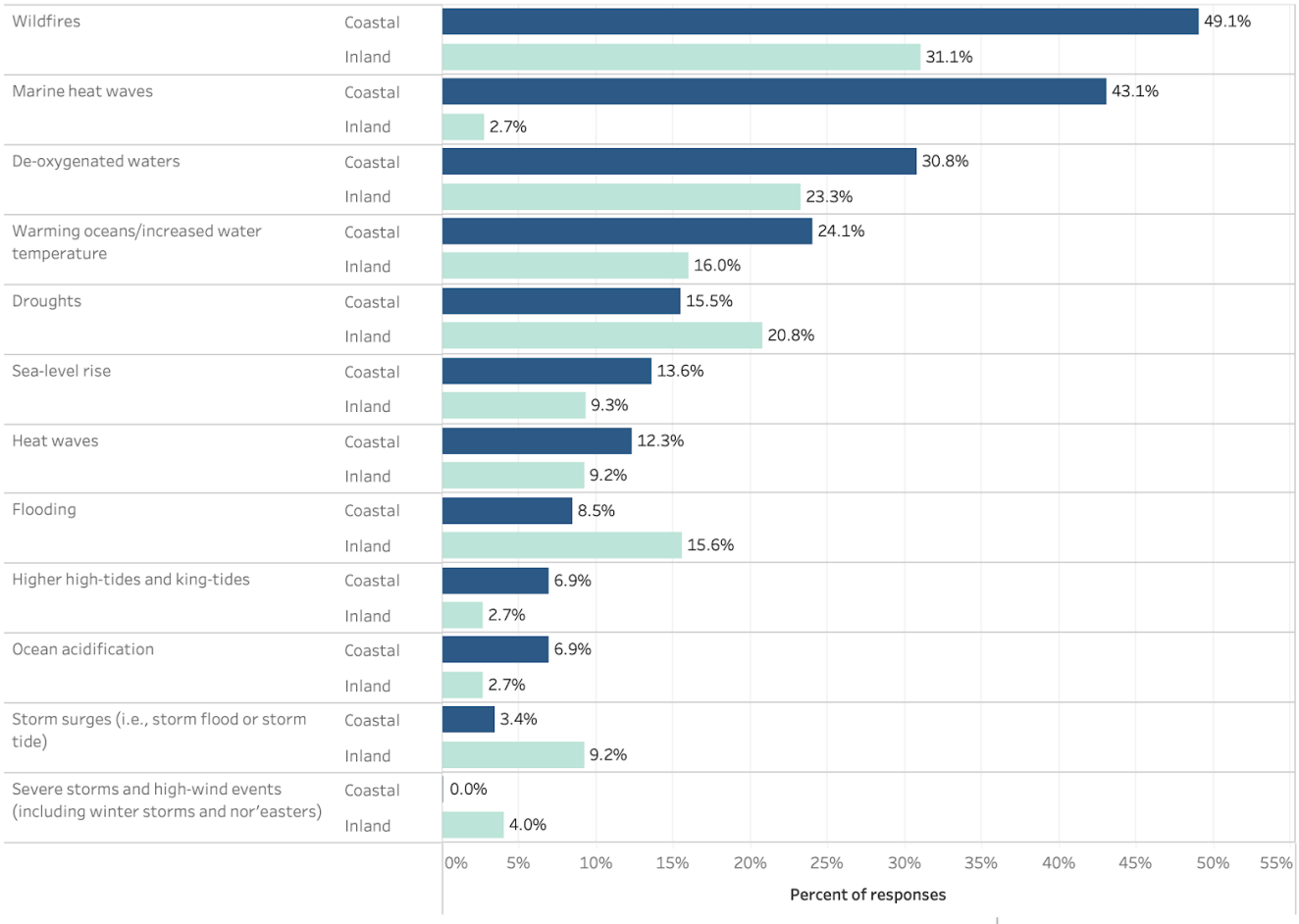
"Our City's biggest concerns are flooding (in-land riverine) and heat waves." *- Inland city*

"[Our city] is a coastal community significantly impacted by climate change and sea level rise. We experience flooding from the ocean, flooding of the back shore and inundation along the (local) river. We also have many creek brooks and low lying areas that flood with heavy precipitation events."

- Coastal city

Figure 5. Predicted hazards in coastal and inland municipalities.

(n - Coastal = 59)
(n - Inland = 77)



Percentages for coastal and inland municipalities are analzyed separately.

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2. IMPACTS

This section describes the climate impacts perceived and reported by survey respondents, including environmental, infrastructural, and economic impacts.

2.1 ENVIRONMENTAL IMPACTS

- In our sample, the most frequently reported strong environmental impacts of climate change include wastewater management concerns (34%), the introduction of invasive species (34%), tree loss from high winds, droughts, or storms (28%), and harmful algal blooms (28%).

- Overall, respondents most frequently reported mild effects include tree loss (54%), air-quality concerns (51%), and increased risks of vector-borne diseases (49%).

Coastal Municipalities

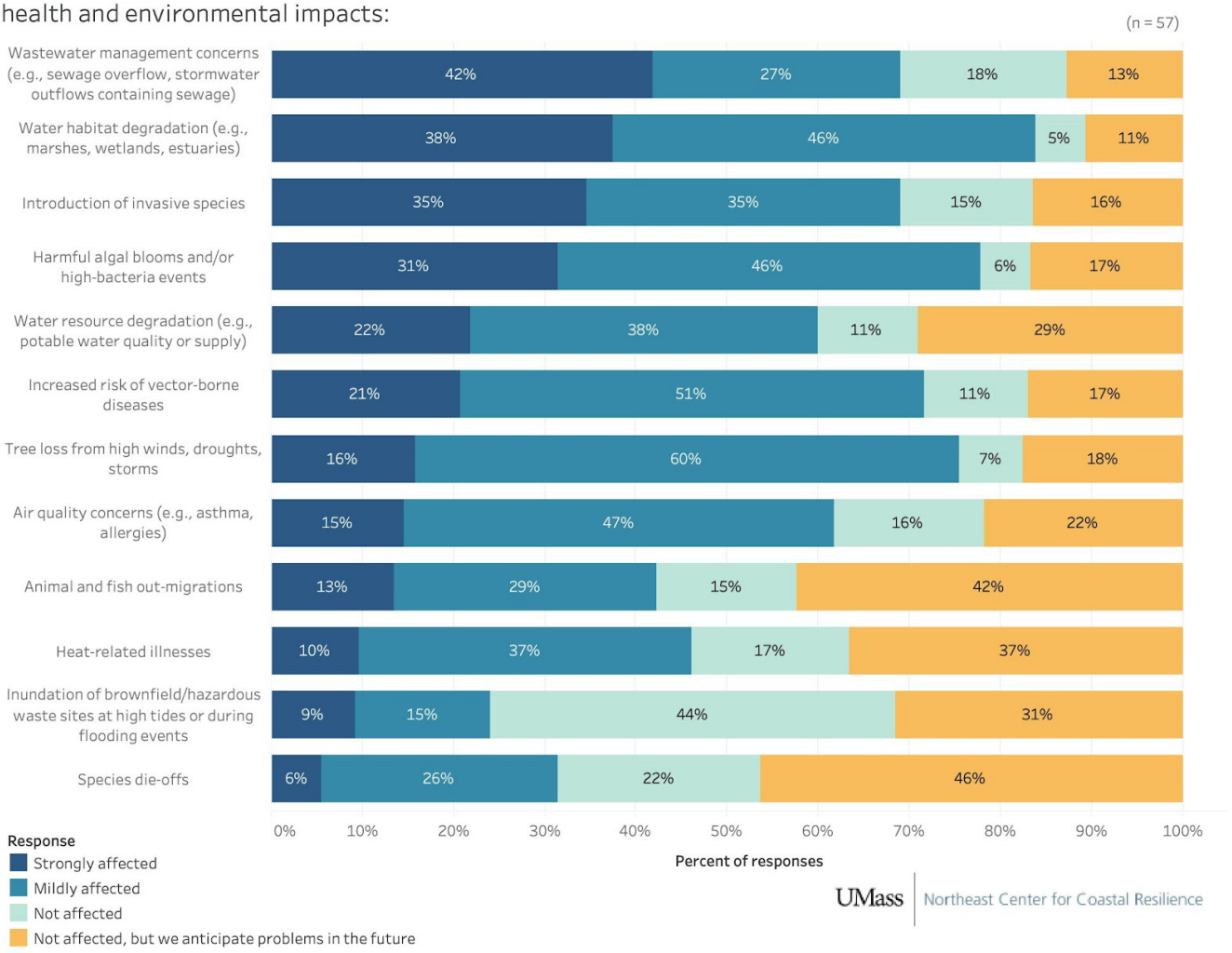
- On average, compared to inland communities, coastal communities are more likely to report strong effects related to all environmental impacts. (Figure 6a)

- In coastal municipalities, the most frequently reported strong environmental impacts of climate change include wastewater management concerns (42%), water habitat degradation (38%), the introduction of invasive species (35%), and harmful algal blooms (31%). (Figure 6a)

- In addition, mild impacts on coastal municipalities are frequently reported in relation to tree loss (60%), vector-borne diseases (51%), and air-quality concerns (47%). (Figure 6a)

"[In our municipality] marshes and beaches are being seriously eroded [...]" -Coastal town

Figure 6a. Coastal municipalities - Please indicate how strongly your municipality is affected by the following health and environmental impacts:



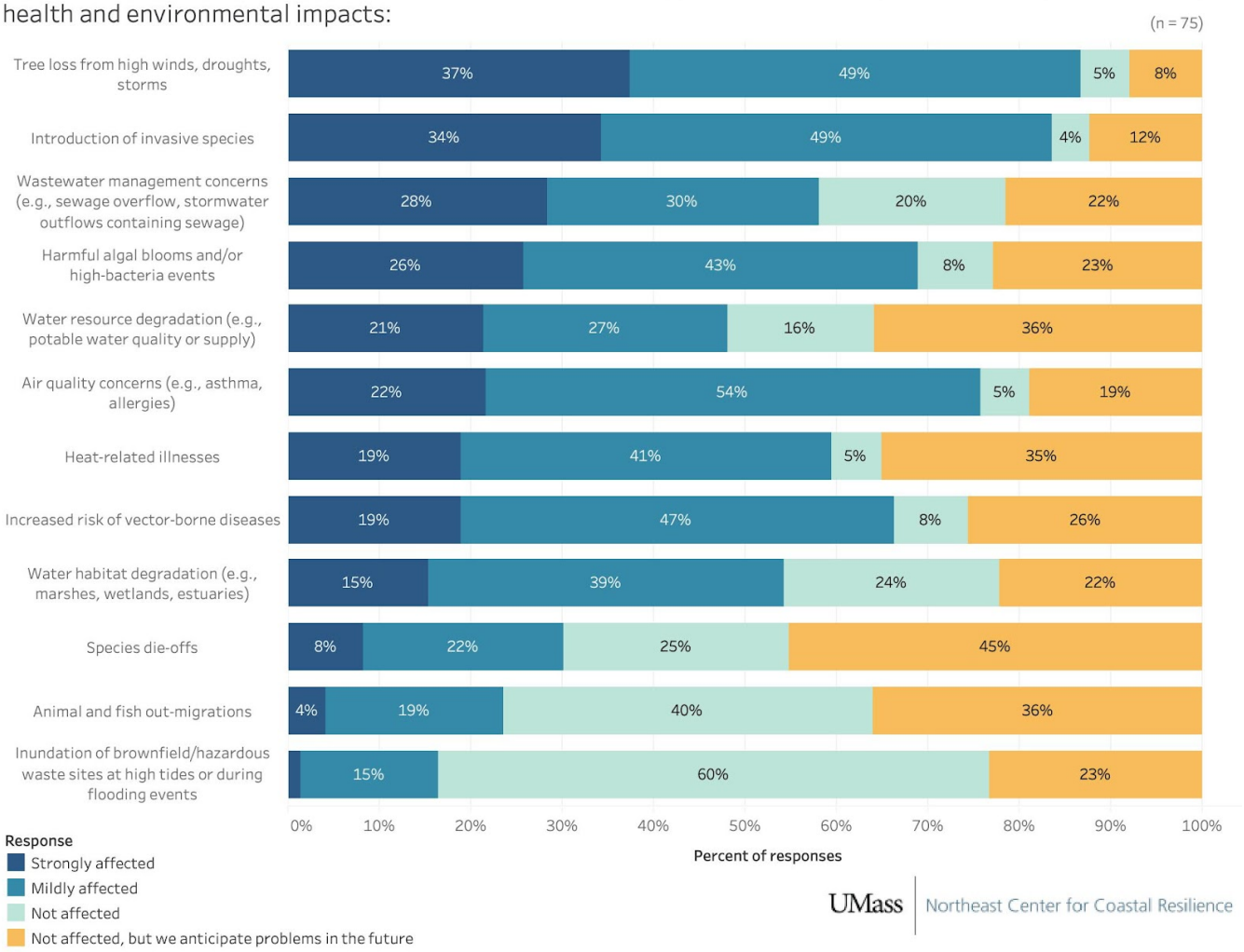
Inland Municipalities

- In inland municipalities, the most frequently reported strong environmental impacts of climate change include tree loss from high wind events (37%), the introduction of invasive species (34%), wastewater management concerns (28%), and harmful algal blooms (26%). (Figure 6b)

- In addition, mild impacts on inland municipalities are frequently reported in relation to air-quality concerns (54%), introduction of invasive species (49%), tree loss (49%), and increased risk of vector-borne diseases (47%). (Figure 6b)

- Tree loss, heat related illnesses, and air quality concerns are more likely to be reported as strong impacts in inland communities compared to coastal. (Figures 6a and 6b)

Figure 6b. Inland municipalities - Please indicate how strongly your municipality is affected by the following health and environmental impacts:



"Concerns include road erosion, bridges on dirt roads, flooding due storms, heat stress, need for cooling centers, drought, wells drying up." *- Inland town*

"We have experienced increased vectors (e.g., mosquitos, ticks) which are better adapted to warmer climates resulting in higher disease transmission (e.g., Triple-E, lyme disease)."

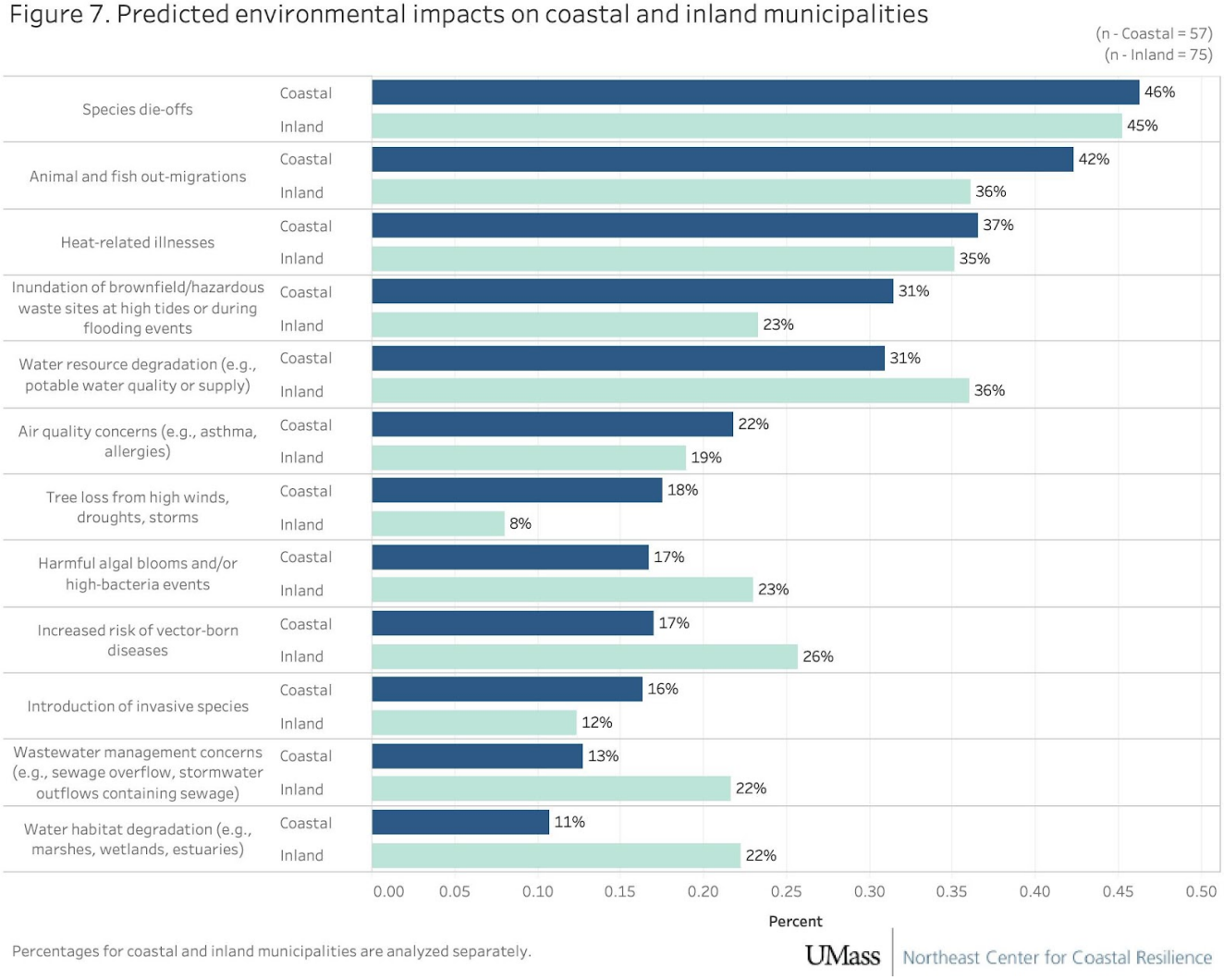
- Inland city

Predicted Environmental Impacts

Respondents anticipated future environmental impacts based on observation and experience. Coastal and inland municipalities had similar predictions for future environmental impacts (Figure 7):

- Overall, the most frequently predicted environmental impacts are future species die-offs (45% of both inland and coastal respondents), animal and fish-out migrations (42% of coastal and 36% of inland respondents), and heat related illnesses (37% of coastal and 35% of inland municipalities). (Figure 7)

Figure 7. Predicted environmental impacts on coastal and inland municipalities



- Inland municipalities were more likely than coastal municipalities to anticipate concerns related to water habitat degradation (Figure 8), introduction of invasive species (Figure 9), harmful algal blooms and

harmful bacteria events (figure 10), wastewater management concerns (Figure 12), and increased risk of vector-borne diseases (figure 14). This is largely due to coastal municipalities reporting that they are already experiencing impacts. (Figure 6a)

- Coastal municipalities were more likely than inland municipalities to predict all remaining categories of impacts; in the maps we often observe an increasing gradient of intensity of impacts from the inland to coastal areas. (Figures 8 to 15)

Figure 8. Health and environmental impacts: water habitat degradation (e.g., marshes, wetlands, estuaries)

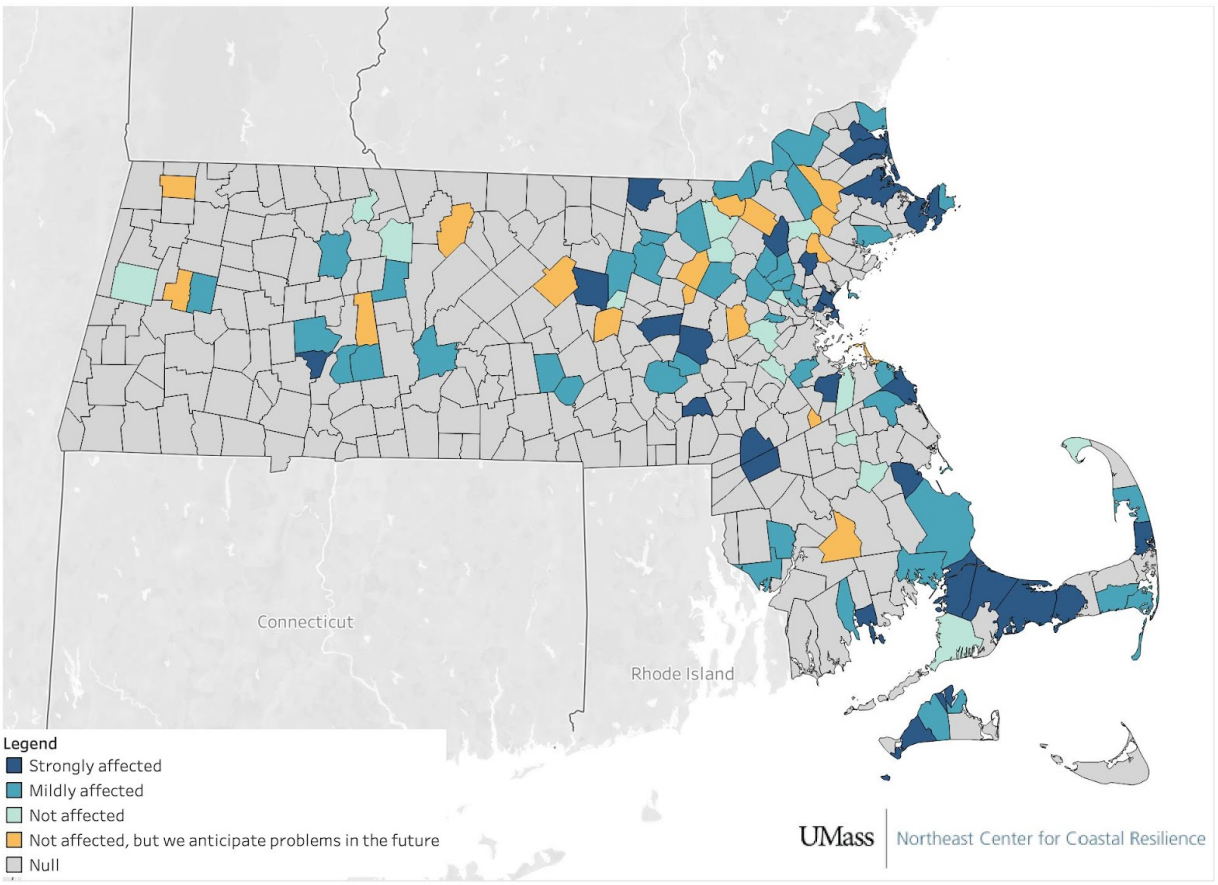


Figure 9. Health and environmental impacts: introduction of invasive species (n = 104)

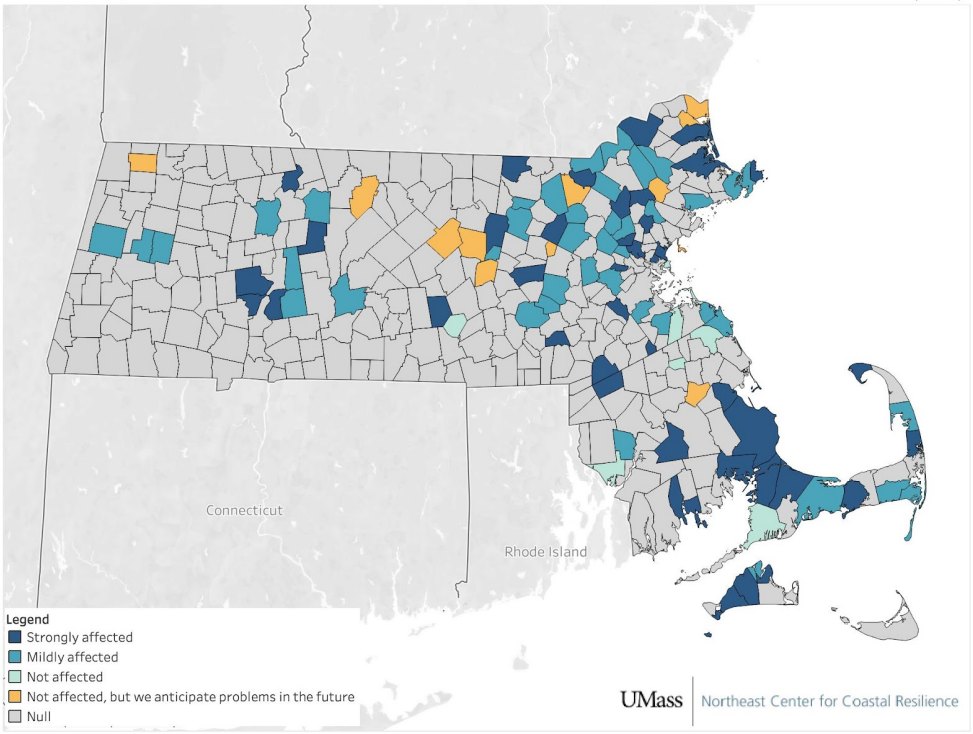


Figure 10. Health and environmental impacts: harmful algae blooms and/or high bacteria events (n = 104)

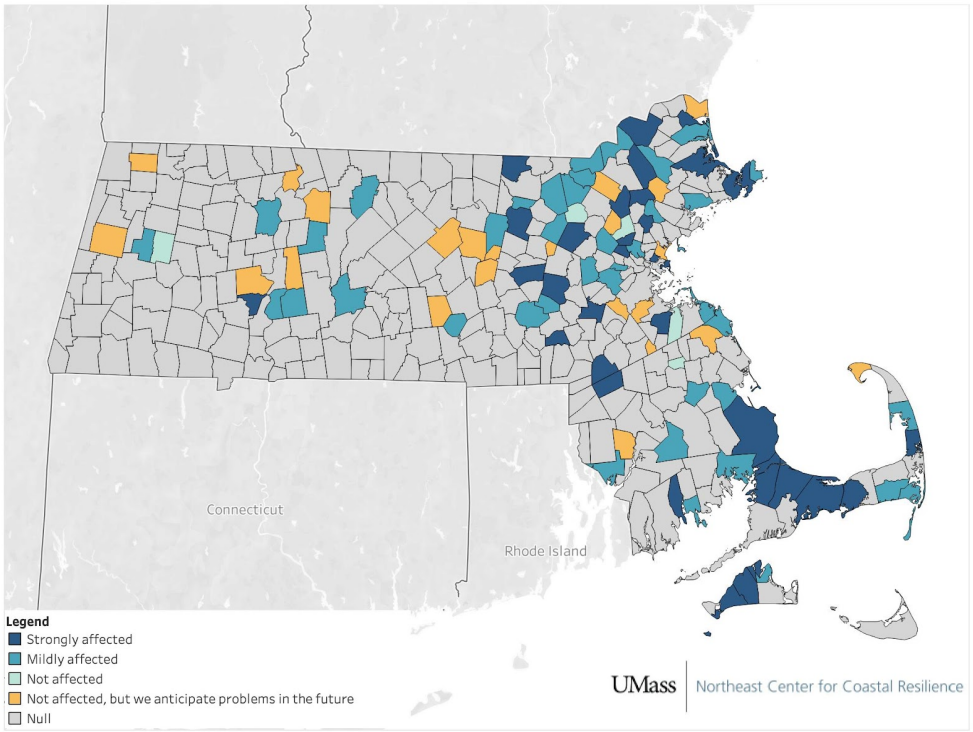


Figure 11. Health and environmental impacts: tree loss from high winds, droughts, storms (n = 106)

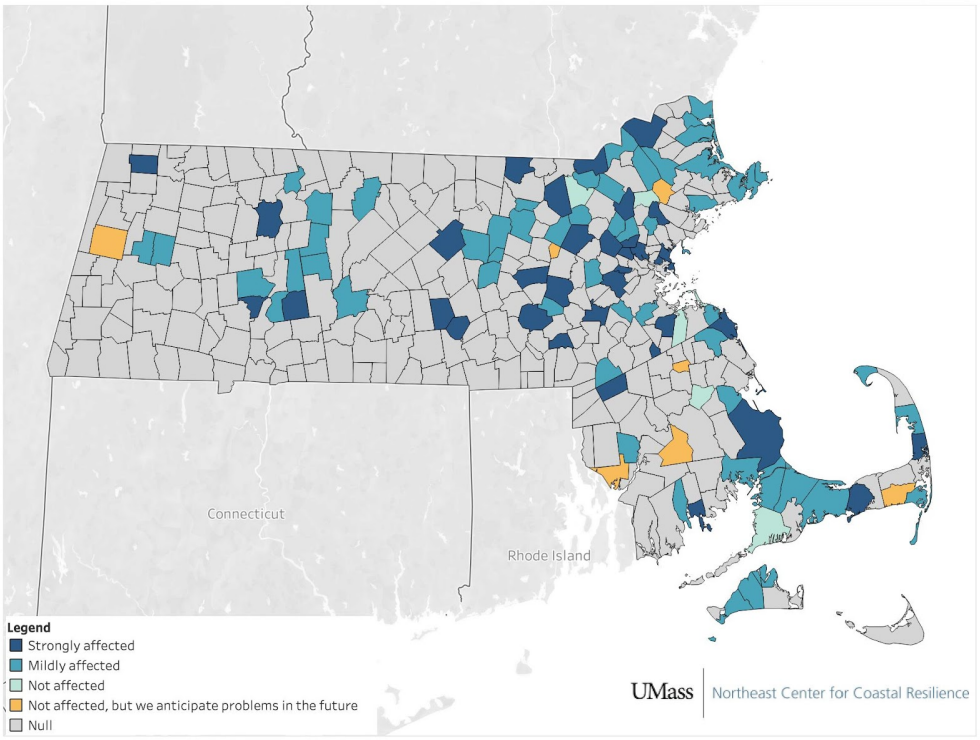


Figure 12. Health and environmental impacts: strength of climate impacts on wastewater management (e.g. sewage overflow, stormwater outflows containing sewage) (n = 104)

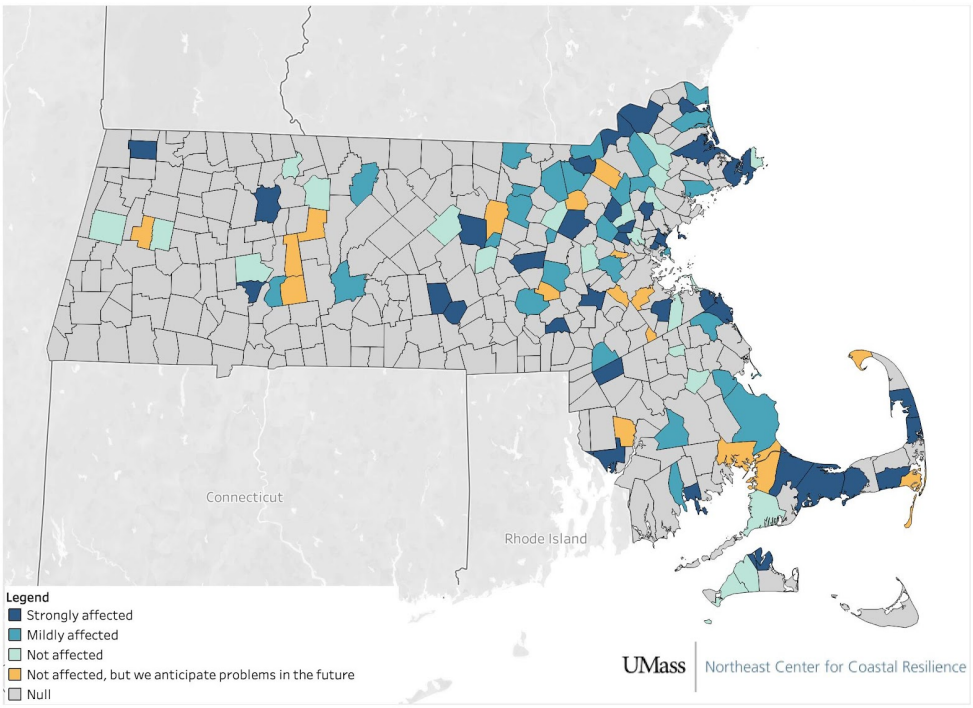


Figure 13. Health and environmental impacts: air quality concerns (e.g. asthma, allergies)

(n = 105)

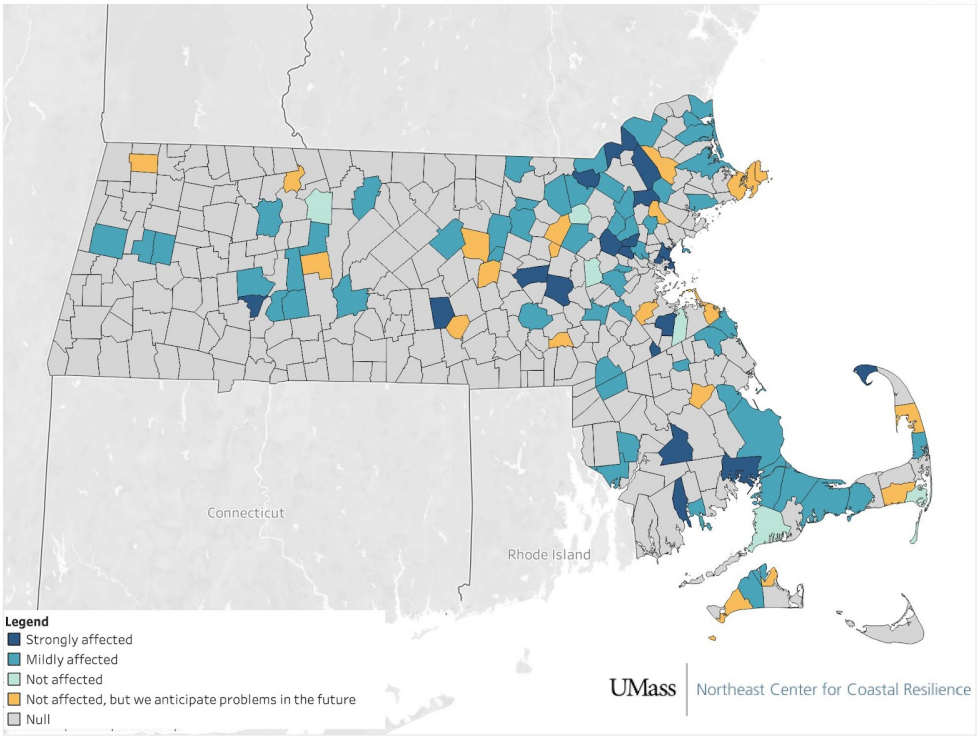


Figure 14. Health and environmental impacts: increased risk of vector-borne diseases

(n = 105)

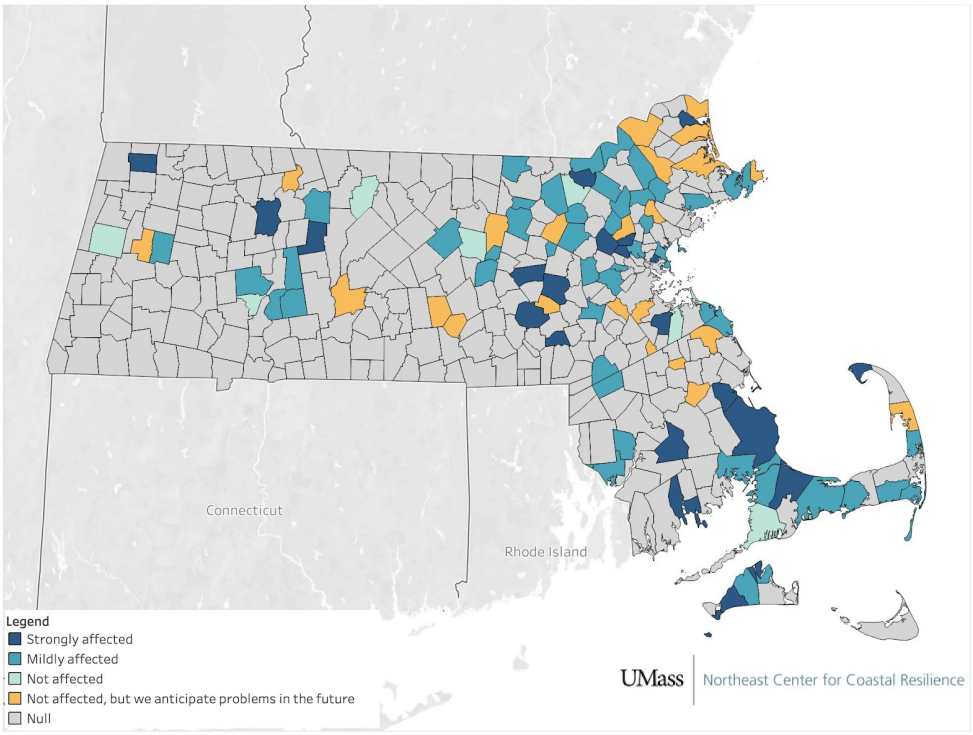
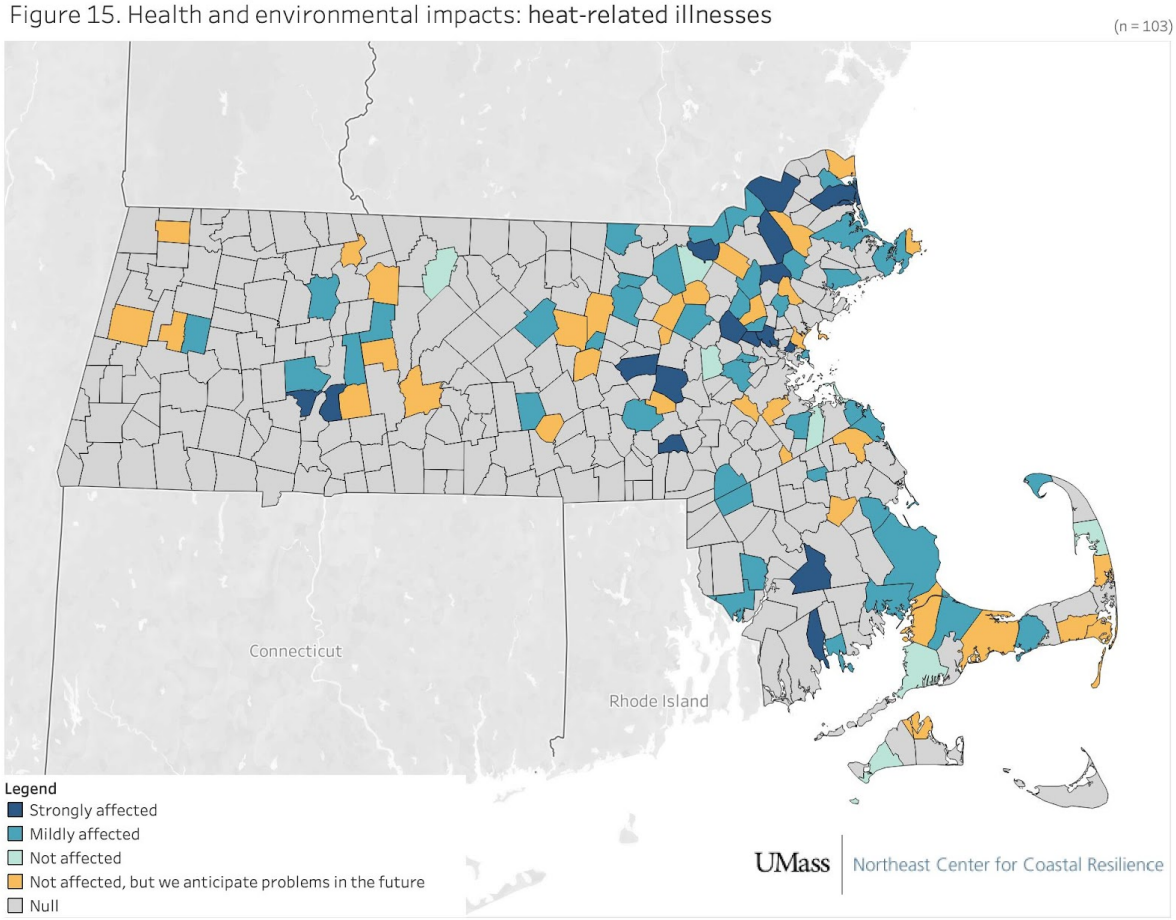


Figure 15. Health and environmental impacts: heat-related illnesses



2.2 INFRASTRUCTURAL IMPACTS

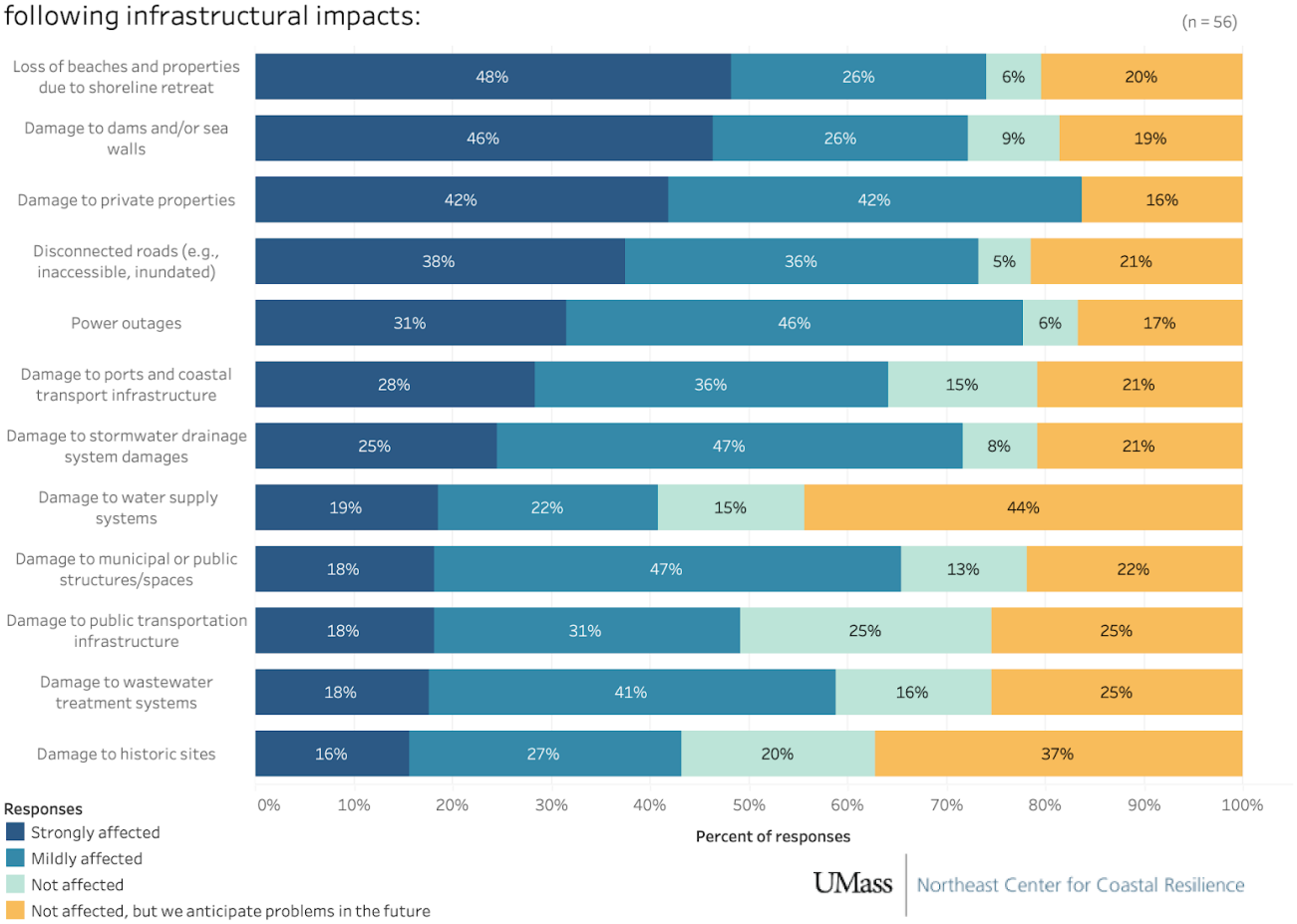
- Overall, our municipal sample most frequently reported strong infrastructural impacts of climate change in the following categories: power outages (27%), damage to dams or sea walls (24%), damage to private properties and stormwater drainage systems (each 24%), and disconnected roads (24%). We observe differences between the types of impacts experienced by coastal and inland municipalities.

Coastal Municipalities

- In all categories of infrastructural impacts, coastal municipalities were consistently more likely to report strong effects than inland municipalities. (Figure 16a)

- In coastal municipalities the infrastructural impacts most frequently reported as strong include beach-loss and shoreline property impacts (48%), damage to dams and/or sea-walls (46%), damage to private properties (42%), and disconnected roads (e.g., inaccessible, inundated) (38%). (Figure 16a)

Figure 16a. Coastal municipalities - Please indicate how strongly your municipality is affected by the following infrastructural impacts:



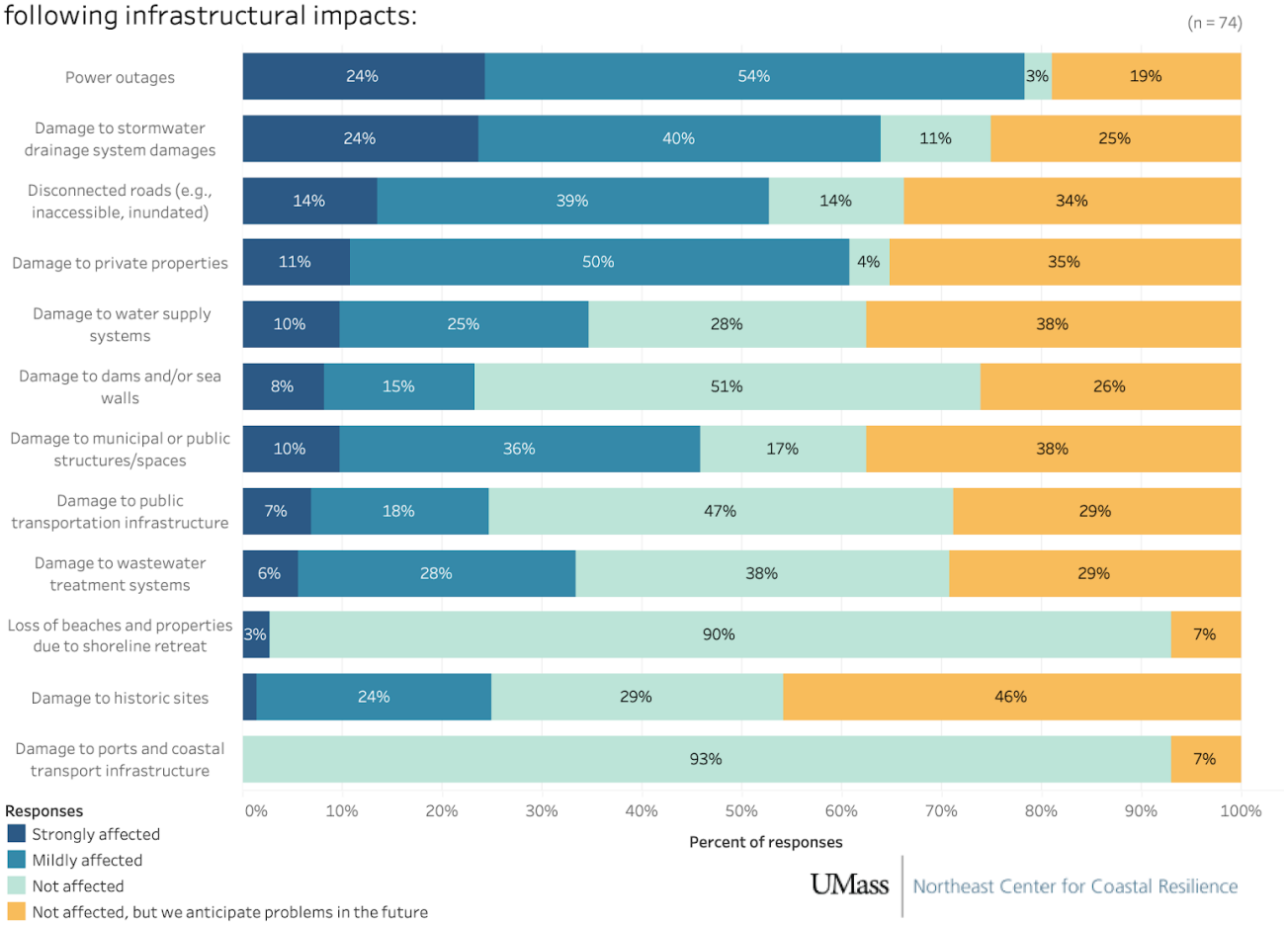
"Most of the impacts for the Department of Public Works are storm-water related." *- Coastal town*

"The public dock in our port has suffered from flooding during extraordinary high tides. We are currently seeking grants/ funding to construct new floating bulkheads/docks." *- Coastal town*

Inland Municipalities

- In inland municipalities the infrastructural impacts most frequently reported as strong include power outages (24%), damages to stormwater drainage systems (24%), and disconnected roads (14%). (Figure 16b)

Figure 16b. Inland municipalities - Please indicate how strongly your municipality is affected by the following infrastructural impacts:



"[Our city has experienced] downed power/communication as a result of storms - loss of power, loss of wifi, loss of traffic signals."

- Inland city

"Our [small municipality] is mostly in a flood plain and [is] impacted by regional climate issues. These include river flooding and stormwater runoff; closure of 2 beaches; increases in mosquitos, ticks, and rats; as well as regional climate-impacted services such as energy supply, transportation and solid waste management."

- Inland town

Predicted Infrastructural Impacts

Respondents anticipated future infrastructural impacts based on observation and experience. Infrastructural damages expected by coastal and inland municipalities present some differences (Figure 17):

Coastal municipalities

- In coastal municipalities, respondents most frequently predicted infrastructural impacts on water supply systems (44%). (Figure 17)

- In coastal municipalities, more than 20% of respondents predicted damages to historic sites, public transportation systems (including disconnected roads), port and coastal infrastructure, municipal or public structures, wastewater treatment systems, stormwater drainage systems, and loss of beach or shoreline retreat. (Figure 17)

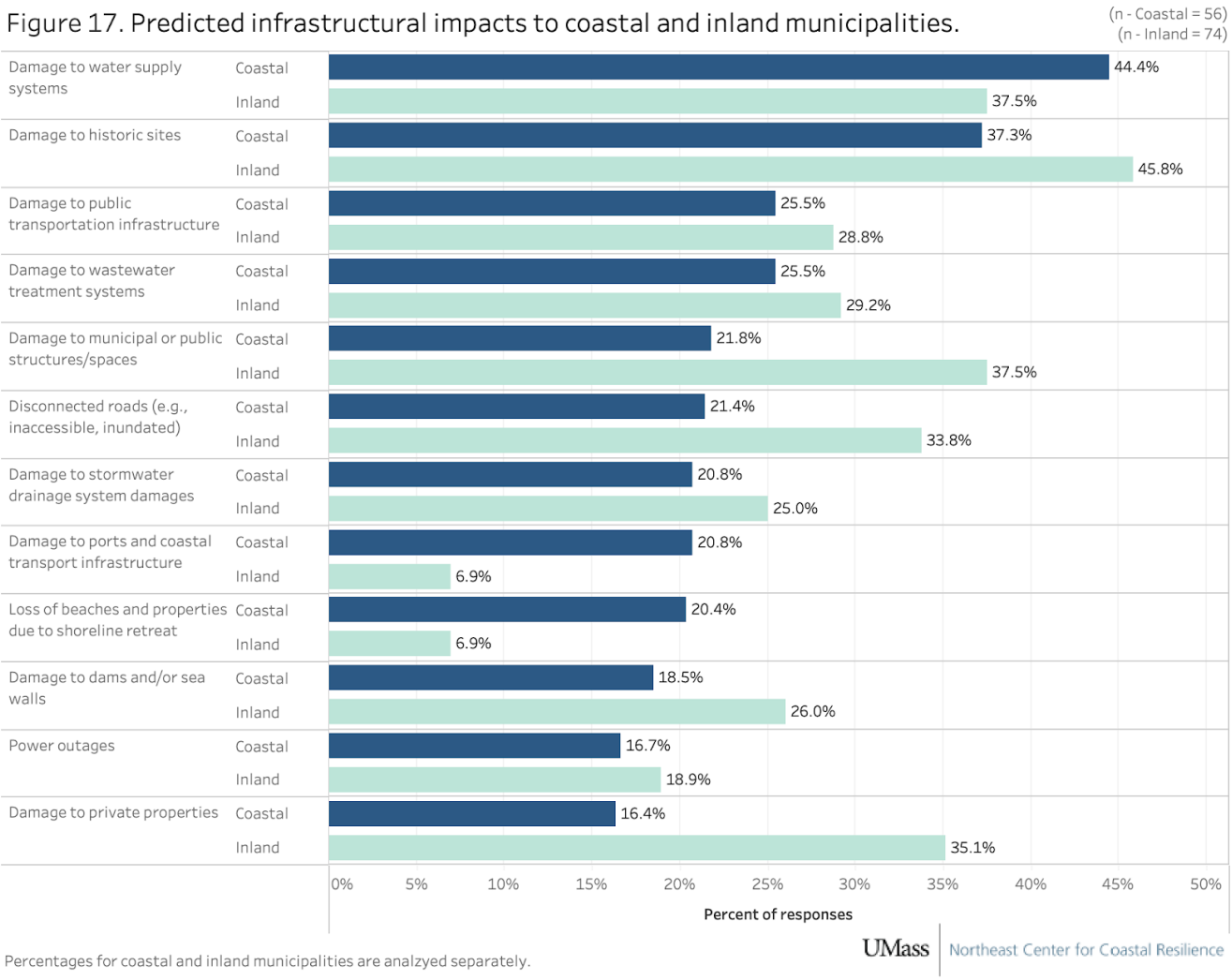
Inland municipalities

- In inland municipalities, respondents most frequently predicted infrastructural impacts on historic sites (46%). (Figure 17)

- Compared to coastal municipalities, respondents in inland municipalities more frequently predicted damages to municipal or public spaces (38%), damage to private properties (35%), disconnected roads (34%), damage to wastewater treatment systems (29%), and damage to public transportation systems (29%). This was largely due to coastal municipalities reporting that they are already experiencing some of the impacts that inland municipalities predicted. (Figure 17)

- Up to 7% of inland municipalities reported being presently affected or predicted effects from damages to beaches and shoreline retreat, and/or impacts on ports and other coastal infrastructure. This may indicate that economic activities in these inland municipalities are indirectly affected when coastal infrastructure is damaged. (Figure 17)

Figure 17. Predicted infrastructural impacts to coastal and inland municipalities.



Percentages for coastal and inland municipalities are analzyed separately.

"The MBTA commuter rail goes along the marshes in [neighboring towns] and parts of our city, but the other towns will flood quite easily at the locations... so we will be shut down if they don't raise the tracks."

- Coastal city

"As we are currently creating a climate resiliency fund, paying for degrading infrastructure is a major concern of ours. Jetty's, revetments, roads, stormwater, marinas, and bridges will be impacted in the immediate future and the price tag will be greater than our annual budget. With not much meat left on the bones of an annual budget, municipalities will depend on grants and borrowing to survive. Any help given to municipalities should be on how to pay for these climate affected infrastructure improvements."

- Coastal town

2.3 ECONOMIC IMPACTS

Overall, compared with inland municipalities, coastal respondents more frequently reported present and anticipated economic impacts of climate change in all areas except for public health costs (Figures 18a and 18b).

- The costs of disaster response and public health measures are the most frequently reported economic impacts experienced by coastal and inland municipalities respectively. (Figures 18a and b)

Coastal municipalities

- In coastal municipalities, the most frequently reported strong economic impacts include additional costs related to disaster response (41%), decreases in housing availability (26%), and difficulty obtaining home and business insurance (23%). (Figure 18a)

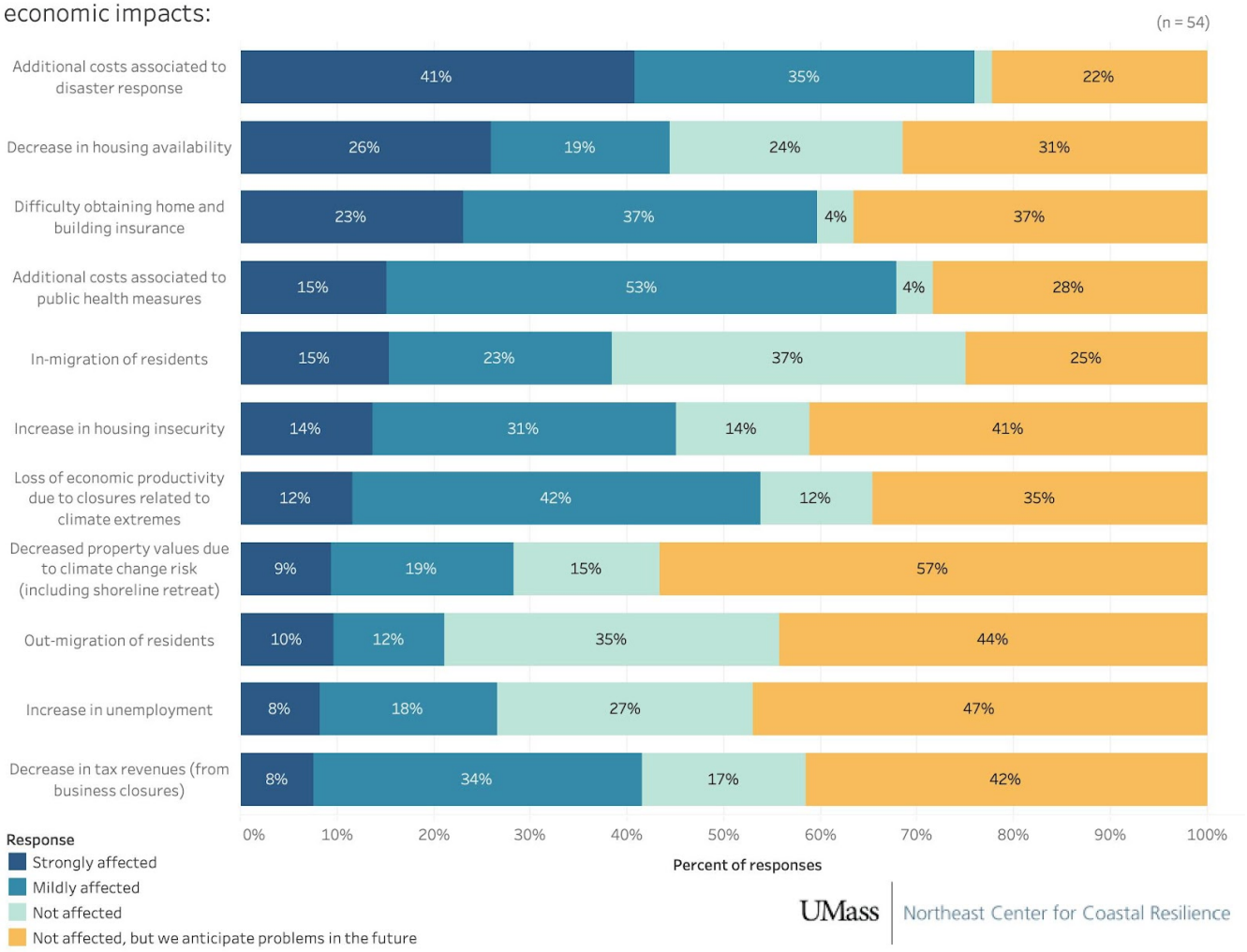
- In coastal municipalities, more than 10% of respondents reported that their community is already strongly affected by increased housing insecurity, and outmigration of residents. These areas are also among the most frequently anticipated areas of concern. (Figure 18a)

"Our shore [...] has been subject to some serious erosion. Some residences have had to retreat if the owners have sufficient land. [...] Our lobster fishery and other shell fisheries have already been affected by rising ocean and pond temperatures. We are in the planning stages (and beyond to implemented strategies) for anticipated future disaster community responses. Our committee has interviewed all community stakeholders and the harbormaster has the most pressing impacts to which he is responding with our help."

- Coastal town

"I'm not sure yet what the costs are related to climate change impacts yet, except the need to deal with several roads that are regularly underwater at high tide." *- Coastal town*

Figure 18a. Coastal municipalities - Please indicate how strongly your municipality is affected by the following economic impacts:

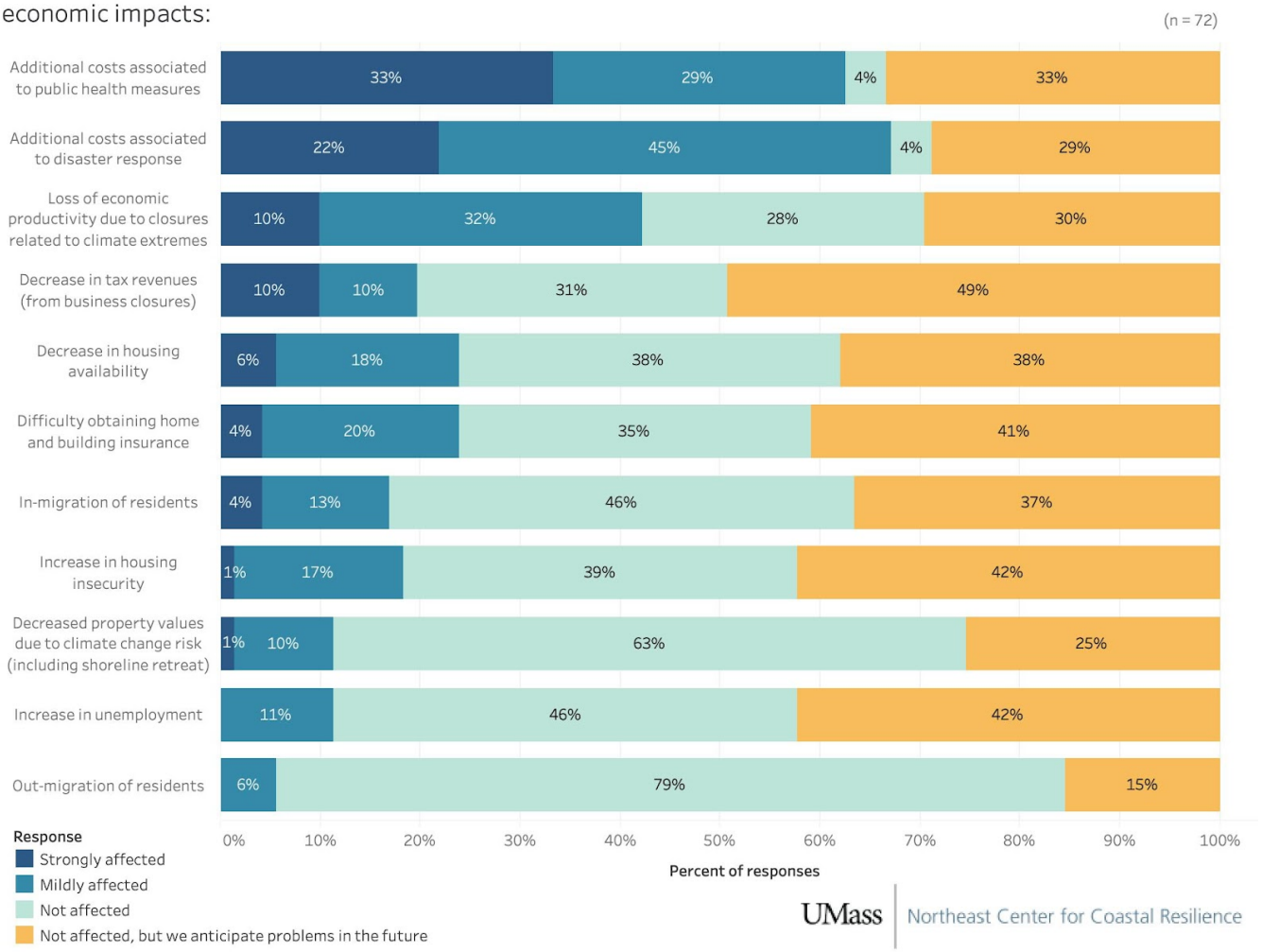


Inland municipalities

- The economic impacts most frequently reported by inland municipalities are additional costs associated with public health measures (33%) and with disaster response (22%). (Figure 18b)

- Emerging areas of concern include loss of economic productivity due to closures (10%) and consequent decrease in tax revenues (10%). (Figure 18b)

Figure 18b. Inland municipalities - Please indicate how strongly your municipality is affected by the following economic impacts:



"We are seeing bigger impacts from extreme storms - requiring significant emergency response resources."

- Inland city

"[In our city] many apartments are in flooded areas and renters don't have insurance to recover from property damage from flooding"

- Inland city

Predicted Economic Impacts

Respondents anticipated future economic impacts based on observation and experience. Predictions of future economic impacts for coastal and inland municipalities present some differences (Figure 19):

Coastal municipalities

- In coastal municipalities, the most frequently predicted economic impacts are decreased property values (57%); increased unemployment (47%); outmigration of residents (44%); decreased tax revenues (42%); and increased housing insecurity (41%). (Figure 19)

- Coastal municipalities more frequently anticipated decreased property values and out-migration of residents compared to inland municipalities. They also reported more observed impacts than inland municipalities in this area. (Figure 19)

Inland municipalities

- In inland municipalities, the most frequently predicted economic impacts are decreased tax revenues (49%); increased unemployment (42%); increased housing insecurity (42%); and difficulty obtaining home and building insurance (41%). (Figure 19)

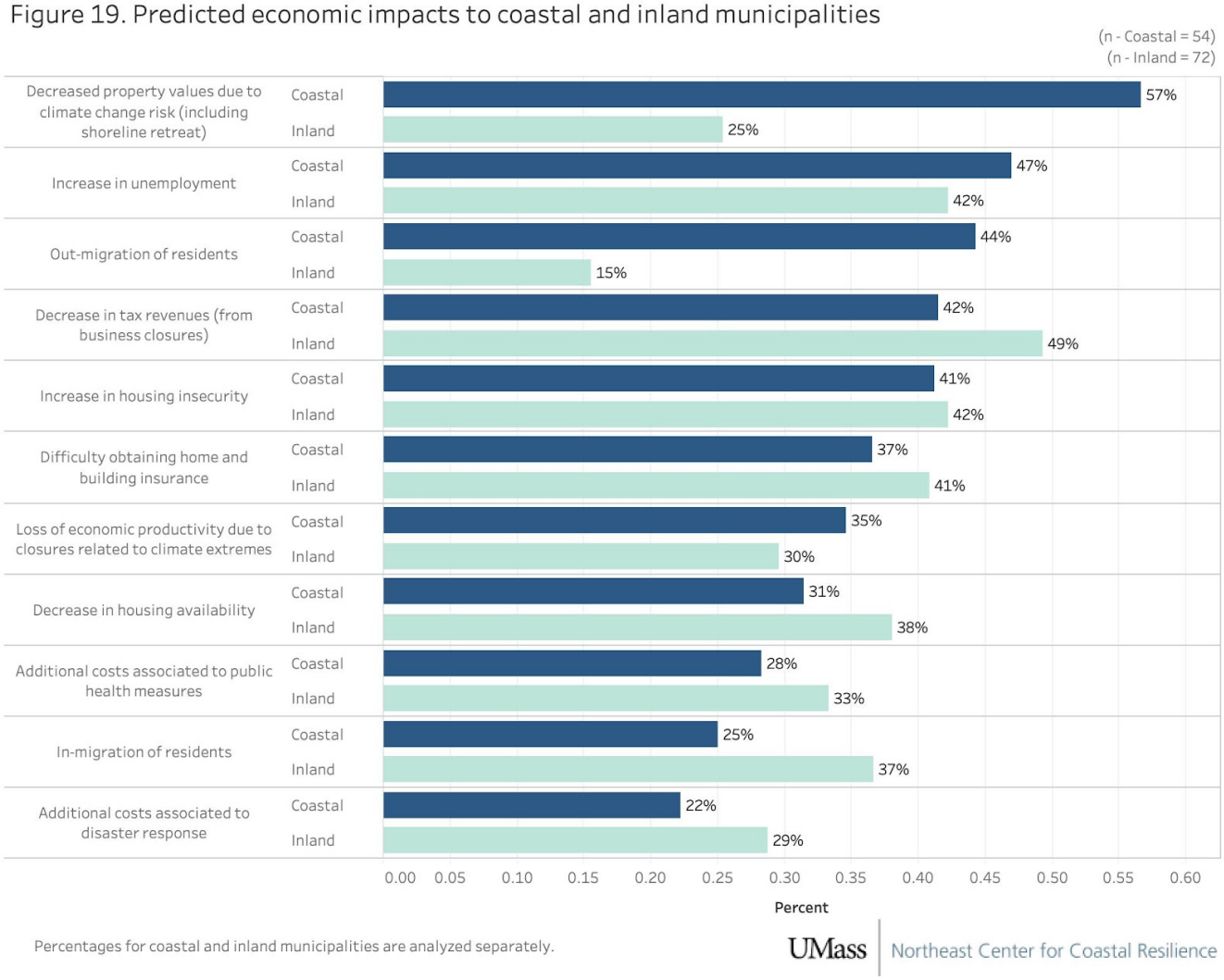
- It is worth noting that respondents in coastal municipalities are more likely to predict economic impacts from the out-migration of residents (44% in coastal and 15% in inland municipalities), while respondents in inland municipalities are more likely to anticipate economic impacts from the in-migration of residents (37% in inland and 25% in coastal municipalities). This might suggest the emergence of climate-related migratory flows. (Figure 19)

"In recent years we have seen a number of ocean-front homes being washed away by increased northeast storms. The shoreline continues to erode as a result of these intense storms." *- Coastal town*

"[We are] trying to figure out what to armor, and when to retreat and how to pay for this. We know it is only a matter of time, as shorelines are washing away faster and faster. Right now property values are surging, because of our attractiveness, but one good storm, things will change." *- Coastal town*

"If/when other parts of the country become unlivable then there will be bigger impacts in Mass."
- Inland town

Figure 19. Predicted economic impacts to coastal and inland municipalities



Percentages for coastal and inland municipalities are analyzed separately.

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2.4 IMPACTS ON SPECIFIC INDUSTRIES

Municipalities have started observing impacts on specific industries:

- Overall, the most frequently reported strong impacts are associated with commercial fisheries (13%) and tourism (11%).

- Moderate to strong impacts were frequently reported in relation to construction (55%); administrative, support, waste management and remediation (52%); healthcare (47%); and hospitality and food services (45%).

Coastal municipalities

- Overall, coastal municipalities reported strong impacts on local industries more frequently than inland municipalities. (Figure 20a)

- In coastal municipalities, the most frequently reported strong impacts are associated with the following industries: commercial fisheries (including permitting issues related to species migration) (30%); tourism (20%); real estate and rental leasing (16%); and agricultural activities (15%). (Figure 20a)

- In addition, moderate to strong impacts were frequently reported for impacts to commercial fisheries (71%); construction (61%); administrative, support, waste and remediation services (60%); and tourism (58%). (Figure 20a)

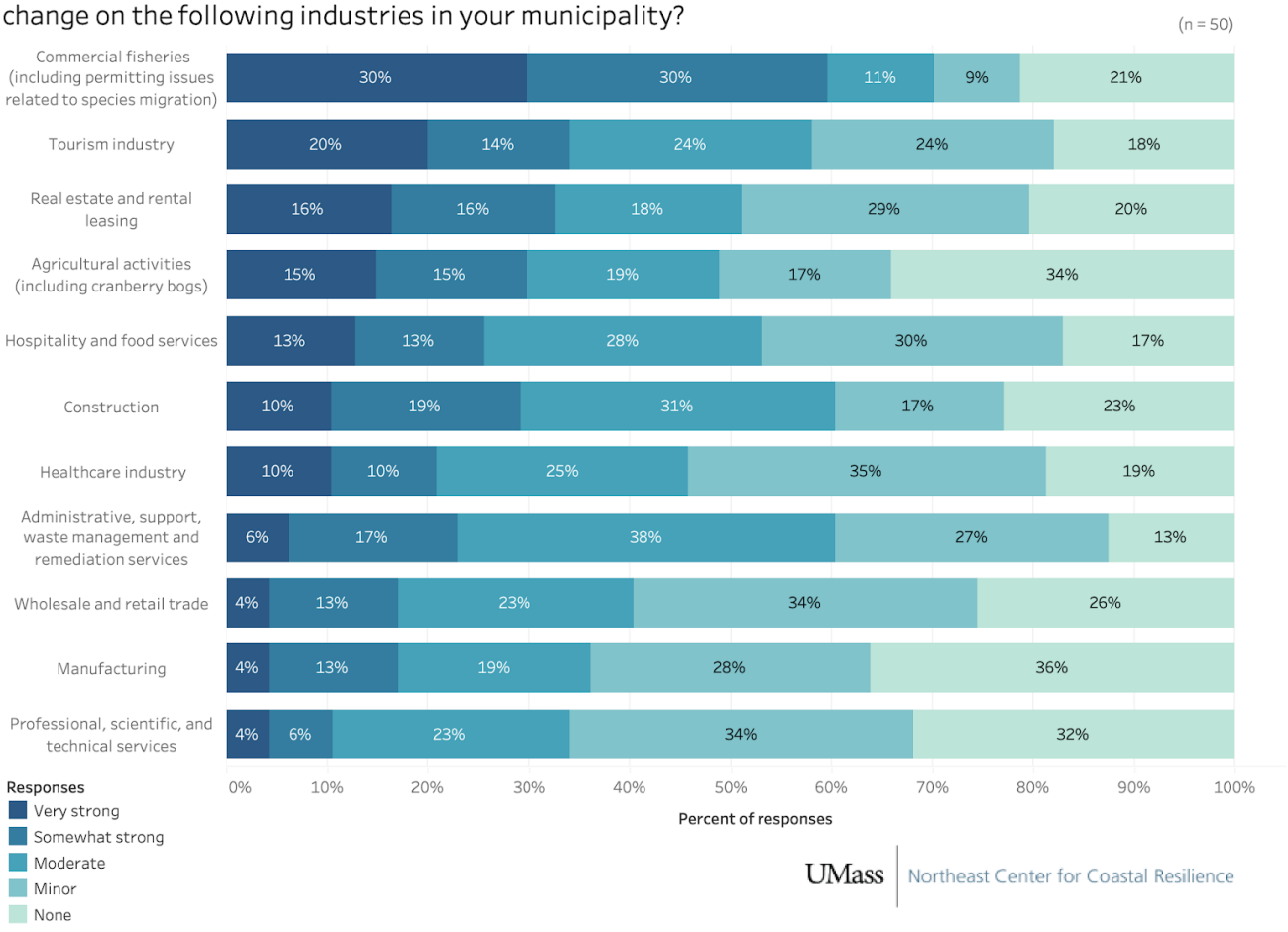
Inland municipalities

- In inland municipalities the most frequently reported moderate to strong impacts are associated with construction industry (49%); healthcare industry (47%); and administrative, support, waste and remediation services (48%); and tourism (32%). (Figure 20b)

- In inland municipalities, 9% of respondents reported that their communities are strongly to moderately affected by impacts on coastal industries such as commercial fisheries (1%). (Figure 20b)

- This suggests that the Massachusetts blue economy has important economic ramifications in inland municipalities. (Figure 20b)

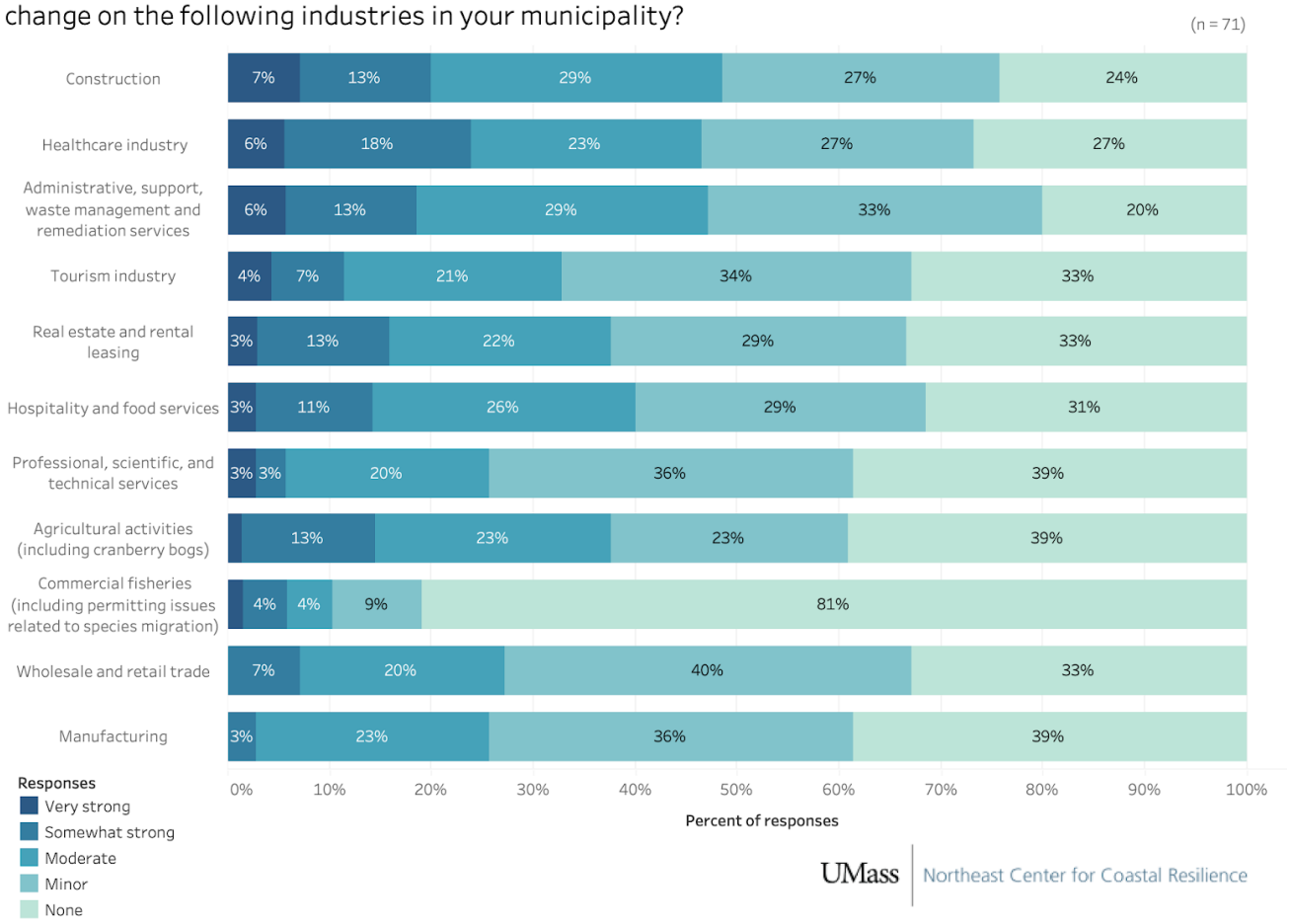
Figure 20a. Coastal municipalities - To your knowledge, how strong are the negative impacts of climate change on the following industries in your municipality?



"There have been several red tides and cases where extremely high coastal waters caused sewage to flow into the coastal waters, thus impacting both the shellfish industry, fishing industry and safe use of our coastal waters for swimming, kayaking, boating, etc."

- Coastal town

Figure 20b. Inland municipalities - To your knowledge, how strong are the negative impacts of climate change on the following industries in your municipality?



The reported intensity of impacts to selected industries is presented spatially in the following maps including: commercial fisheries; tourism; real estate and rental leasing; construction industry; and administrative, support, waste management and remediation services. (Figures 21 to 25)

Figure 21. To the best of your knowledge, how strong are the negative climate impacts on commercial fisheries in your municipality (including permitting issues related to species migration)? (n = 98)

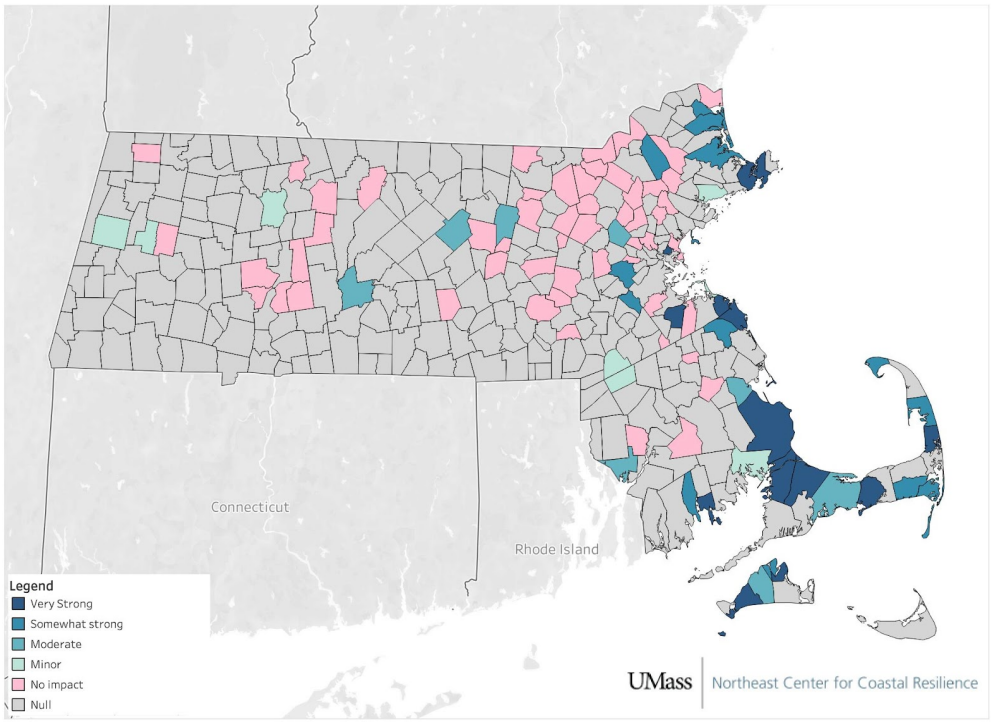


Figure 22. To the best of your knowledge, how strong are the negative climate impacts on tourism industry in your municipality? (n = 99)

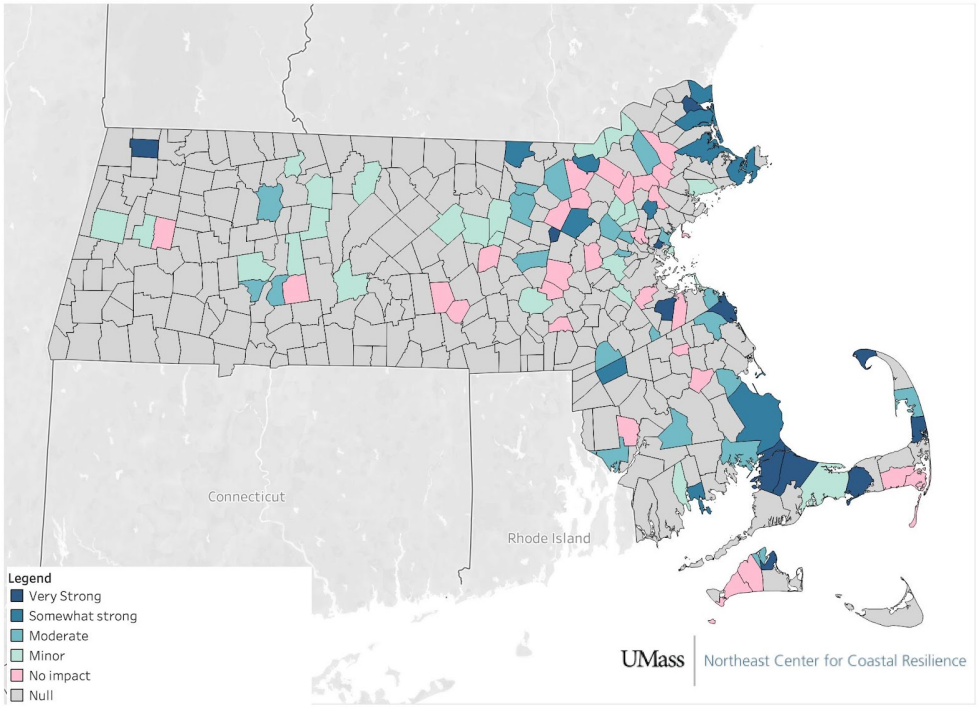


Figure 23. To the best of your knowledge, how strong are the negative climate impacts on real estate and rental leasing in your municipality?

(n = 98)

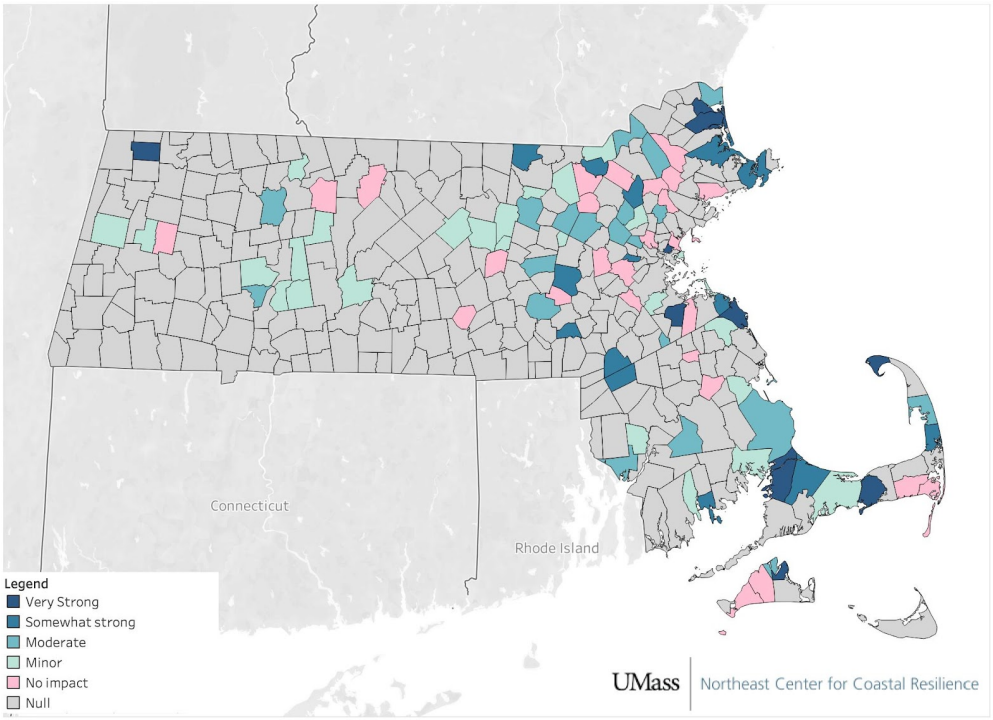


Figure 24. To the best of your knowledge, how strong are the negative climate impacts on construction industry in your municipality?

(n = 99)

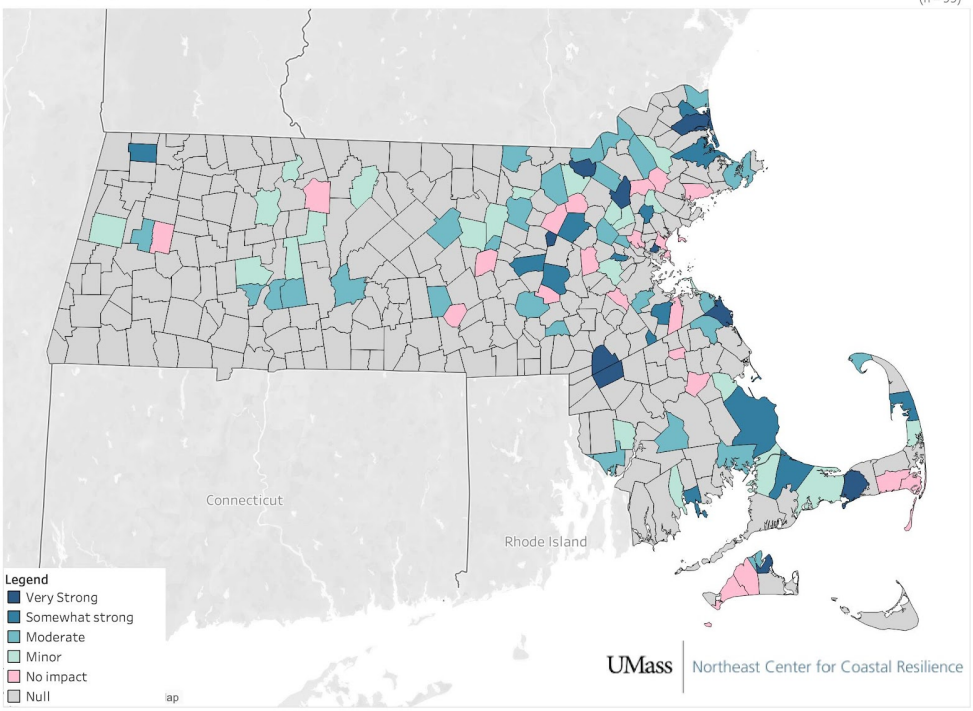
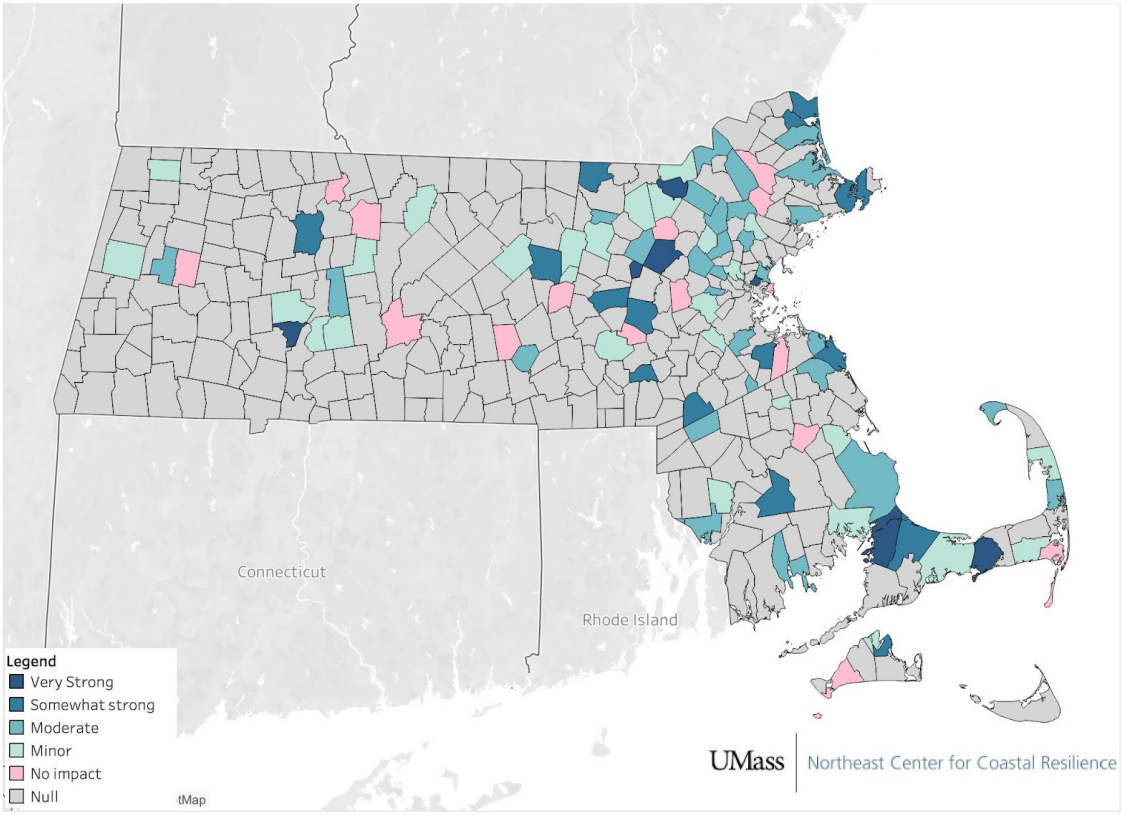


Figure 25. To the best of your knowledge, how strong are the negative climate impacts on administrative, support, waste management and remediation services in your municipality? (n = 98)



3. EQUITY

This section investigates the equity and social justice dimensions of vulnerability to climate change in municipal settings.

Vulnerable groups to climate change impacts

Some populations are expected to be more vulnerable to climate hazards because of higher exposure (due to geographic location), pre-existing health conditions, age or other socio-economic factors. Figure 26 shows the groups most frequently reported as vulnerable in MA municipalities.

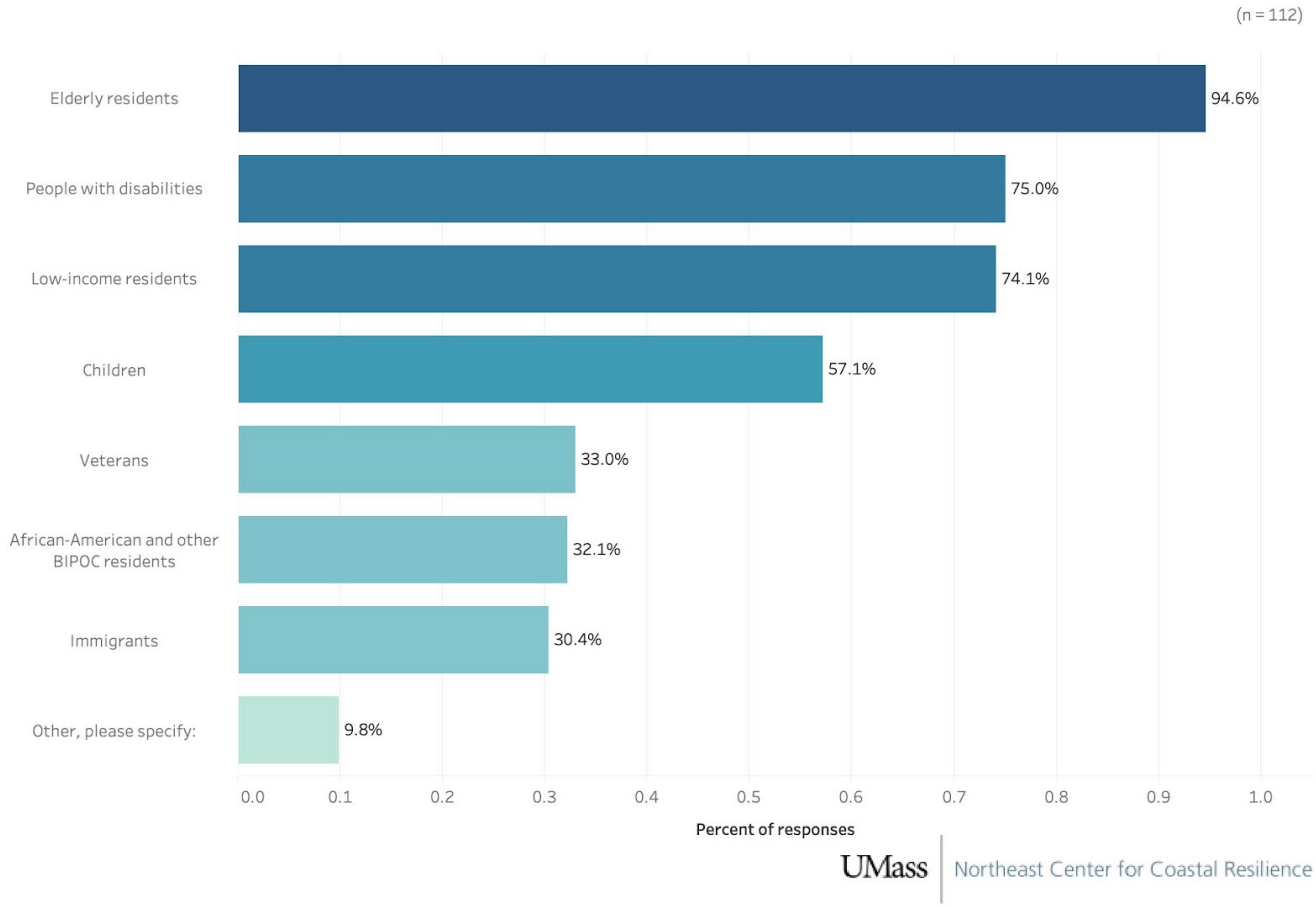
- The majority of respondents identified the following groups as vulnerable to the impacts of climate change: elderly residents (95%), people with disabilities (75%), low-income residents (75%), and children (57%).

- The three groups least likely to be identified as vulnerable are veterans (33%), African-American and other POC (32%), or immigrants (30%). This could be partially explained by the low degree of racial and ethnic diversity in MA municipalities. However, this is an area where more research may be beneficial.

- Respondents sometimes indicated "other" vulnerable groups including undocumented residents, residents who spoke languages other than English, people who work outdoors, people living in heat islands or central neighborhoods, and renters.

"We have several high-risk communities including Environmental Justice and seniors who are being impacted more than others. We are trying to use lessons learned about inequities and public engagement from the covid pandemic to apply to climate resiliency." *- Inland city*

Figure 26. Some populations are more vulnerable to climate hazards because of higher exposure (due to geographic location), pre-existing health conditions, age, or structural and socioeconomic factors. In your municipality, which among the following groups have been identified as vulnerable populations to climate change? (Please check all that apply):



Resources devoted to vulnerable groups

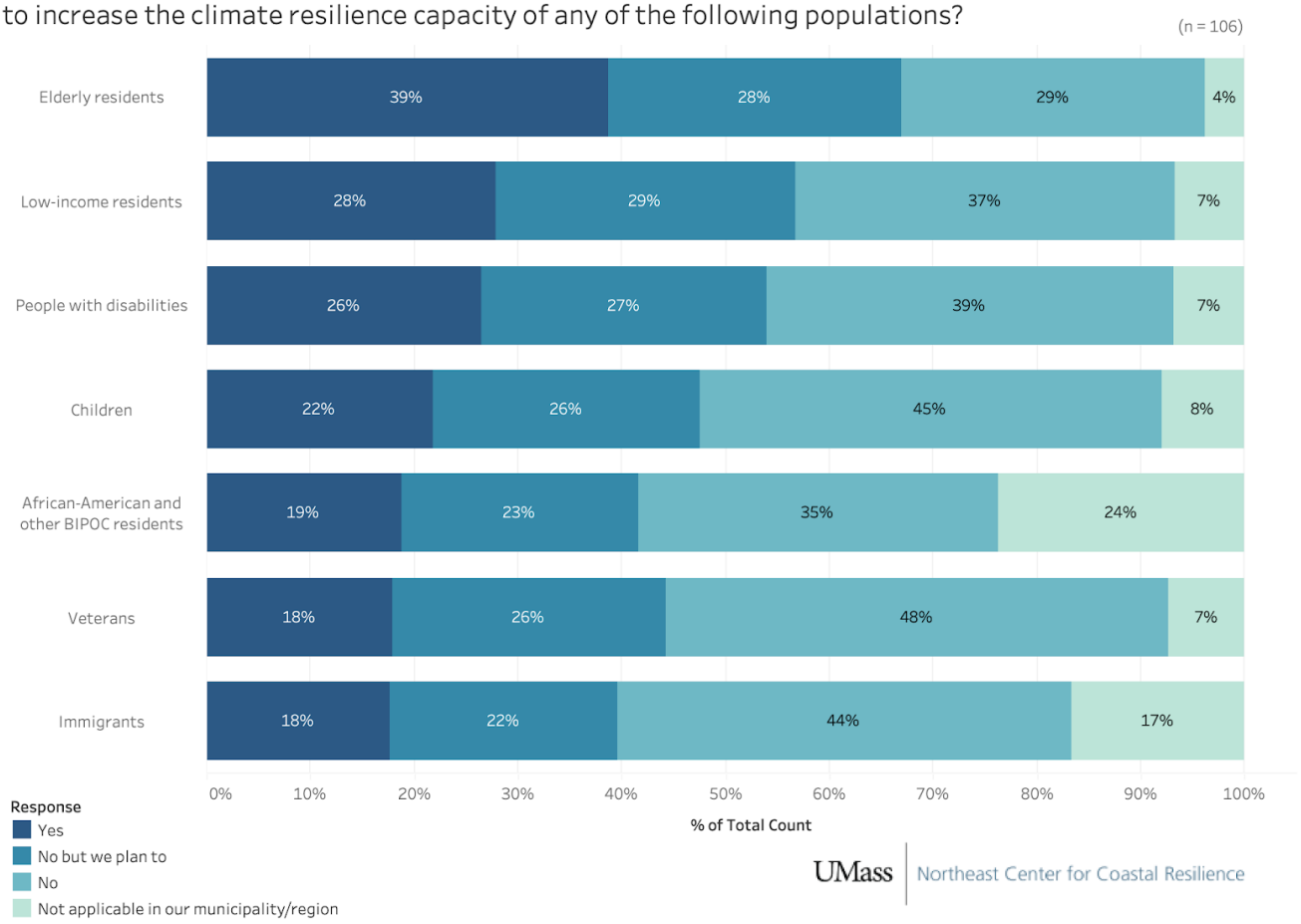
Several municipalities have already dedicated (or plan to dedicate) resources to vulnerable groups to increase their climate resilience capacity (Figure 27):

- Elderly residents are most frequently identified as the focus of resilience plans and programs. 39% of respondents reported that their municipalities have already dedicated resources to this group and 28% plan to dedicate resources in the future. (Figure 27)

- After elderly residents, low-income residents (28%) and people with disabilities (26%) are the groups most frequently selected as the focus of resilience plans and programs. (Figure 27)

- Consistent with the results in figure 26, the three groups least likely to be focus of municipal resilience programs are African-American and other Black, Indigenous, People of Color (BIPOC) residents; Veterans; and immigrants. Fewer than 20% of municipalities reported having dedicated resources to these populations in an effort to increase their resilience capacity. (Figure 27)

Figure 27. Has your municipality dedicated resources (i.e. assessed needs, developed plans or programs) to increase the climate resilience capacity of any of the following populations?



Socio-economic data and welfare indicators

Equitable resilience and adaptation planning requires reliable data to monitor climate impacts on minorities and marginalized groups. Unfortunately only a small percentage of Massachusetts municipalities seem to have access to reliable indicators (Figure 28):

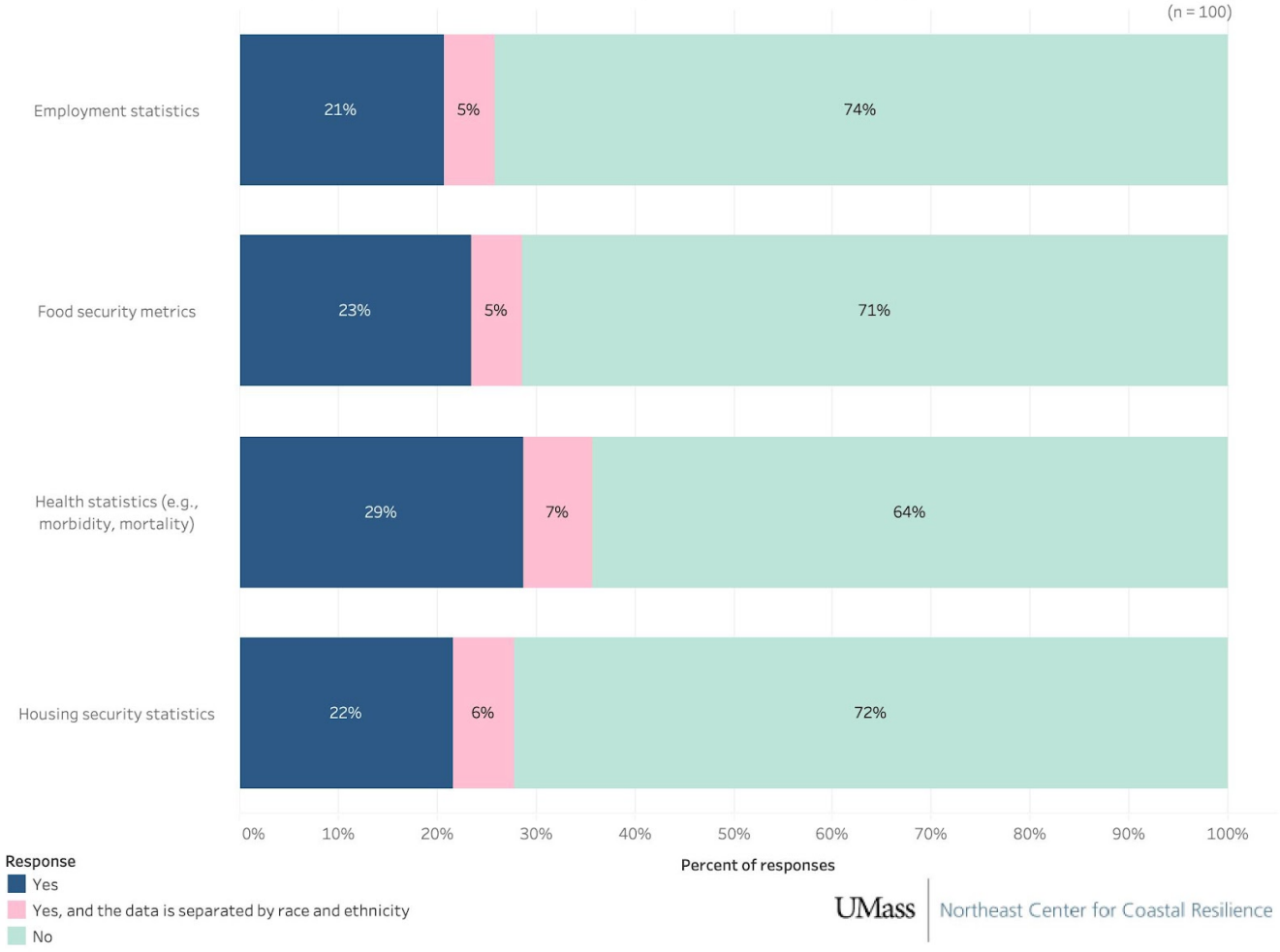
- More than 60% of respondents reported that their municipalities are not using (possibly because they do not have access to) the following types of local data in monitoring impacts of climate extremes: employment statistics; food security metrics; health statistics; and housing and security indicators. (Figure 28)

- Health statistics are the type of data most frequently used to monitor the impacts of climate extremes (36% of municipalities). Only 7% of respondents indicated that their data is separated by race and ethnicity. (Figure 28)

- Employment statistics, food security metrics, and housing and security indicators are used by less than 28% of respondents. Only 5-6% of respondents indicated that their data is separated by race and ethnicity. (Figure 28)

- Municipalities that do not have access to reliable indicators, particularly data disaggregated by race, ethnicity, and other relevant socio-economic signifiers, may be unable to identify, monitor, and support vulnerable groups.

Figure 28. Is your municipality using any of the following types of local data in monitoring impacts of climate extremes? And if yes, is the data separated by race and ethnicity? (Please check all that apply):



4. RESILIENCE STRATEGIES AND PROGRAMS

This survey asked Massachusetts municipalities what resilience strategies and programs they had already implemented and what strategies they would like to adopt. This section outlines the results for both gray/ engineered infrastructural strategies and green infrastructural strategies.

4.1 PLANNING STRATEGIES

A large majority of municipalities (89%) have indicated that climate adaptation and resilience planning are a priority in their planning documents.

- A large majority of municipalities in our sample have already performed vulnerability/risk assessments (80%). This positive outcome is probably associated with the Municipal Vulnerability Preparedness (MVP) grant program[5] developed by the Commonwealth of Massachusetts.

- Additional climate resilience planning strategies adopted by he majority of municipalities include collaborations with other municipalities (57%), conservation restrictions (52%), and public education projects (52%).

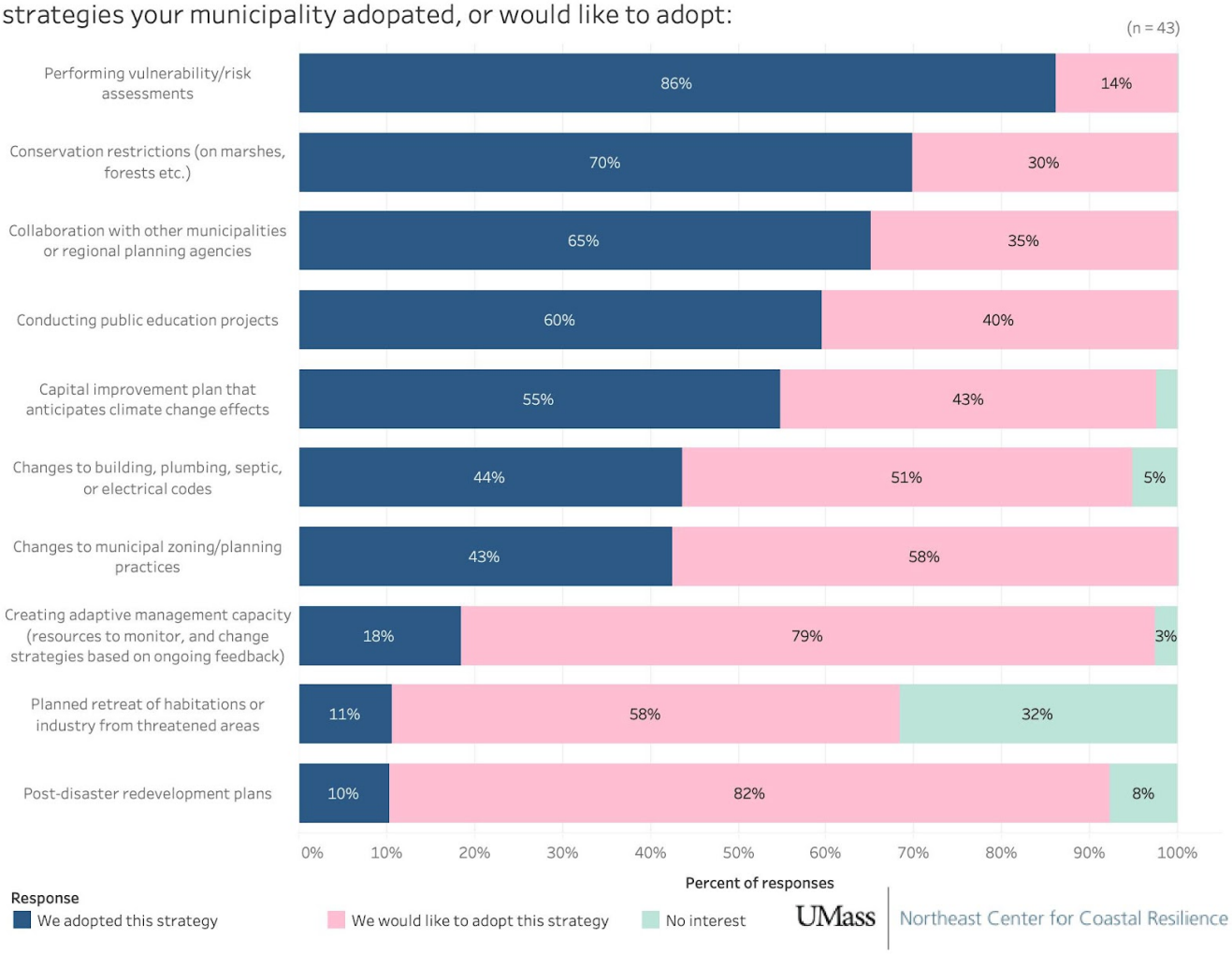
- The majority of municipalities expressed interest in the future adoption of post-disaster redevelopment plans (75%); the creation of adaptive management[6] capacity (72%); changes to building, plumbing, septic, and electrical codes (59%); and changes to municipal zoning or planning practices (59%).

Results for coastal and inland municipalities are presented in figures 29a and 29b.

[5] Municipal Vulnerability Preparedness grant program: https://www.mass.gov/municipal-vulnerability-preparedness-mvp-program

[6] Adaptive management is interpreted as resources to monitor and change strategies based on ongoing feedback.

Figure 29a. Coastal municipalities - Please indicate which of the following climate resilience planning strategies your municipality adopated, or would like to adopt:



"Regarding planned retreat, our municipality does not have any room for horizontal retreat of most structures. We would like to develop a comprehensive plan to assist property owners to elevate their structures."

- Coastal town

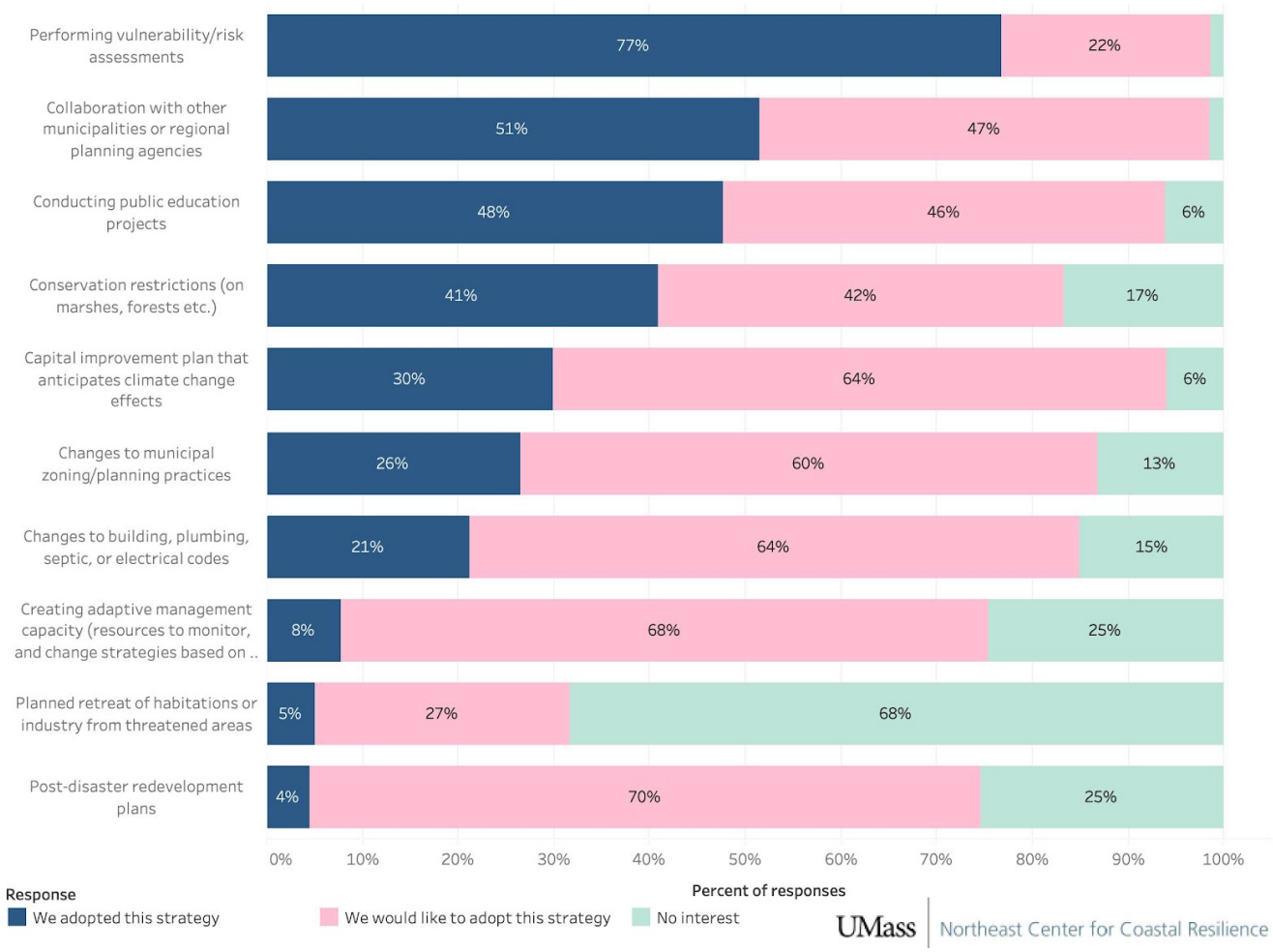
"Our Planning Department is currently trying to make changes but it's slow, turns quite legal, and they hesitate. [...] Fear is preventing us from doing anything. Fear of an exodus of residents. Fear of lawsuits.

- Coastal city

"Additional support [that] municipalities [need] aside from financial resources include regional transportation approaches. Some of the most vulnerable roadways are under state control."

- Coastal town

Figure 29b. Inland municipalities - Please indicate which of the following climate resilience planning strategies your municipality adopated, or would like to adopt: (n = 69)



4.2 ENGINEERING STRATEGIES

- Among MA municipalities in our sample, the most common frequently adopted engineered (gray) infrastructural strategies are improvement or expansion of stormwater drainage systems (37%) and improvement or expansion of wastewater systems (36%).

- Strategies for which municipalities have most frequently expressed interest for future adoption include: interventions to increase the resilience of telecommunication networks (74%), weatherization and retrofitting of buildings (64%), improvement or expansion of stormwater drainage systems (62%), and increasing the resilience of power stations (61%).

Coastal and Inland Municipalities

Our data suggests that coastal municipalities are more likely than inland municipalities to have already adopted gray infrastructural projects. Moreover, because of their geography and different exposure to climate extremes, coastal municipalities have, at times, prioritized different projects when compared with the inland municipalities priorities. (Figures 30a and 30b)

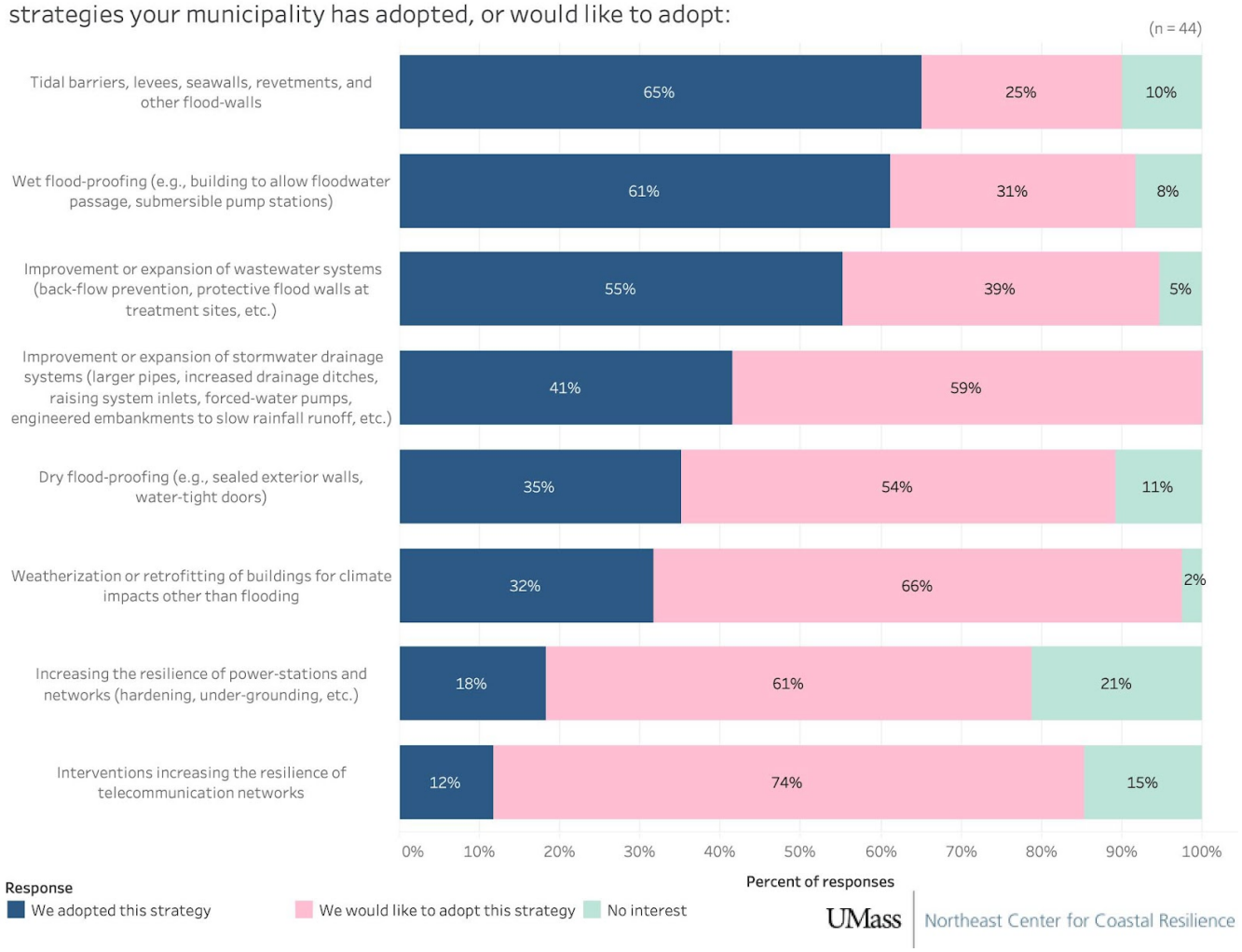
- In coastal municipalities, the most frequently adopted engineered (gray) infrastructural strategies are tidal barriers, levees, revetments, and other flood walls (65%); wet flood-proofing (61%), improvement or expansion of stormwater drainage systems (55%), and improvement or expansion of wastewater systems (41%). (Figure 30a)

- Unsurprisingly, coastal municipalities reported more interest in wet and dry flood-proofing, and sea-walls/tidal barriers. (Figure 30a)

- In inland municipalities, the engineered (gray) infrastructural strategies most frequently adopted are expansion of stormwater drainage systems (34%); weatherization or retrofitting of buildings (25%); and improvement or expansion of wastewater systems (24%). (Figure 30b)

- Coastal and inland respondents reported similar priorities for the future adoption of gray infrastructure to increase coastal resilience, including interventions to increase the resilience of telecommunication networks (74% of both inland and coastal municipalities); weatherization and retrofitting of buildings (66% of coastal and 63% of inland municipalities); improvement or expansion of stormwater drainage systems (59% of coastal and 63% of inland municipalities); and increasing the resilience of power stations (61% of coastal and 60% of inland municipalities). (Figures 30a and 30b)

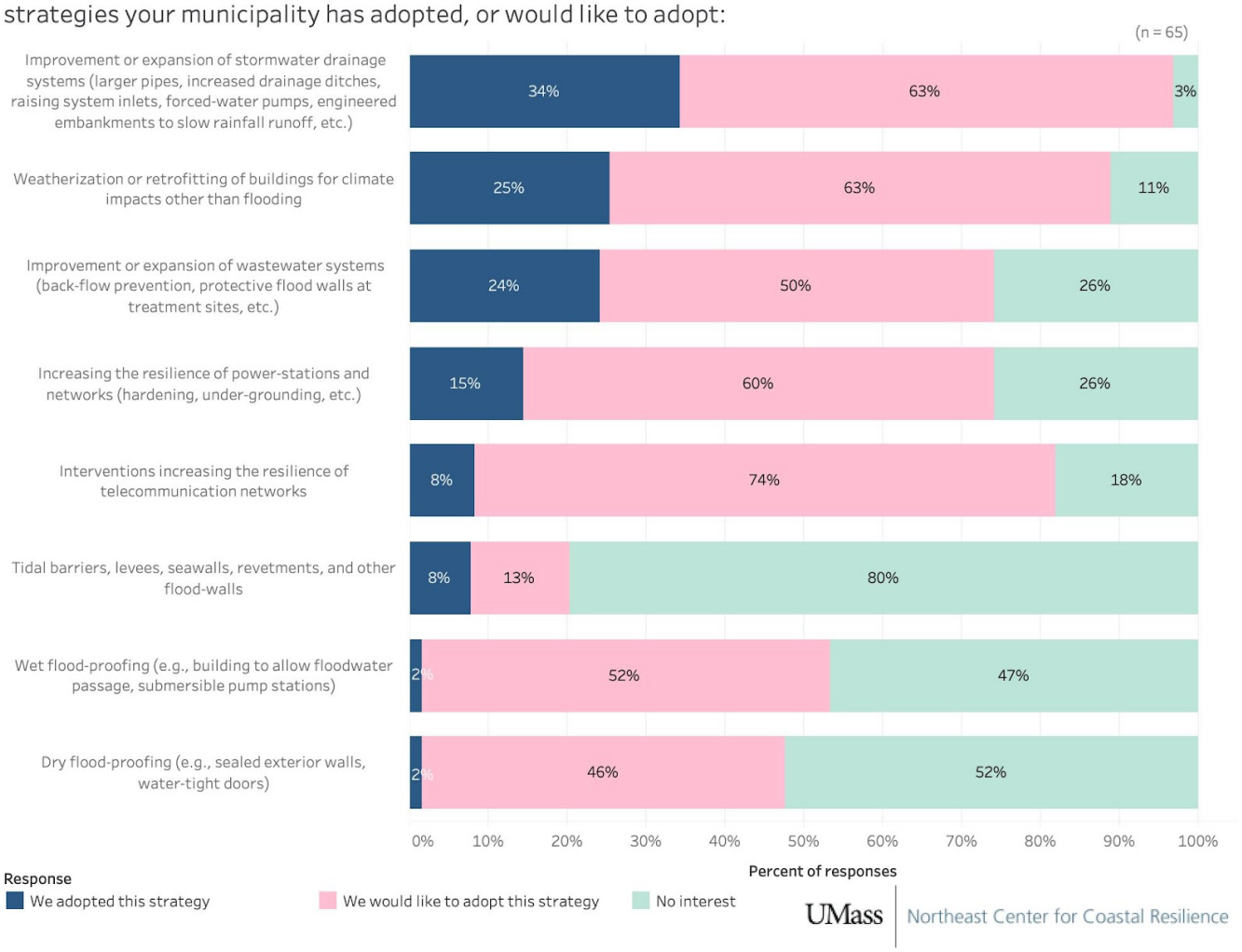
Figure 30a. Coastal municipalities - Please indicate which of the following engineered (gray) infrastructure strategies your municipality has adopted, or would like to adopt:



"[We are facing] difficulties getting utility company to help us with increased electrical infrastructure, modernizing our electrical grid and with resilience and distributed generation projects."

- Coastal town

Figure 30b. Inland municipalities - Please indicate which of the following engineered (gray) infrastructure strategies your municipality has adopted, or would like to adopt:



"Culvert repair and tree removal are the target priorities. It can be difficult to convince residents of the need to spend what is needed. The regulatory requirements for culverts (stream crossing standards) make them very expensive." *- Inland town*

"We need more assistance with road washouts after big storms. All the communities in the [area] have these issues, and we need a better way of addressing the problem. The water this summer has washed out the edges of paved roadways. If we cannot get them all fixed quickly, the next storm will undermine the roads, leading to even larger problems." *- Inland town*

4.3 GREEN INFRASTRUCTURE AND NATURE BASED-SOLUTIONS

Municipalities in our sample expressed a considerable amount of interest in green infrastructure and nature-based solutions.

- Overall, the most frequently adopted green infrastructural practices are land conservation strategies to increase resilience (69%), nature-based stormwater management systems[7] (56%), and nature-based flooding prevention (46%).

- Municipalities expressed the greatest interest in future adoption of green roofs (67%), restorative agricultural practices (58%), nature-based cooling strategies (56%), and urban forests (55%).

Strategies already adopted

Data suggests that coastal municipalities are more likely than inland municipalities to have already adopted green infrastructure and nature-based solutions projects. This is consistent with what we have already observed in the case of gray infrastructure. Moreover, because of their geography and different exposure to climate extremes, coastal municipalities have frequently prioritized different projects than inland municipalities (Figures 31a and 31b).

- In coastal municipalities, the majority of respondents reported that they have already adopted land conservation practices (81%); nature-based erosion control measures (72%); nature-based flooding prevention (67%); and nature-based stormwater management (64%). (Figure 31a)

- In inland municipalities, the green infrastructure strategies most frequently adopted include land conservation practices (69%); nature-based stormwater management (56%); and nature-based solutions to prevent flooding (46%). (Figure 31b)

Strategies that municipalities wish to adopt

Coastal municipalities are on average more likely to express interest in the future adoption of green infrastructure and nature-based solutions compared to inland municipalities:

[7] 25% of respondents reported that their municipality adopted engineered resilience strategies to stormwater management systems.

- In coastal municipalities, the majority of respondents expressed interest in the future adoption of green roofs (73%), urban forests (58%), and nature-based cooling strategies (54%). (Figure 31a)

- In coastal municipalities, the majority of respondents expressed interest in the future adoption of green roofs (67%), restorative agricultural practices (58%), nature-based cooling strategies (56%), and urban forests (55%). (Figure 31a)

- Inland municipalities were 9 percentage points more likely to express their interest in restorative agricultural practices and slightly (2 percentage points) more likely to support nature-based cooling strategies. In all other categories, compared to inland municipalities, coastal municipalities more frequently indicated interest in future adoption of green strategies. (Figure 31b)

Figure 31a. Coastal municipalities - Please indicate which of the following green infrastructure and nature-based solutions your municipality or planning region has adopted or would like to adopt: (n = 43)

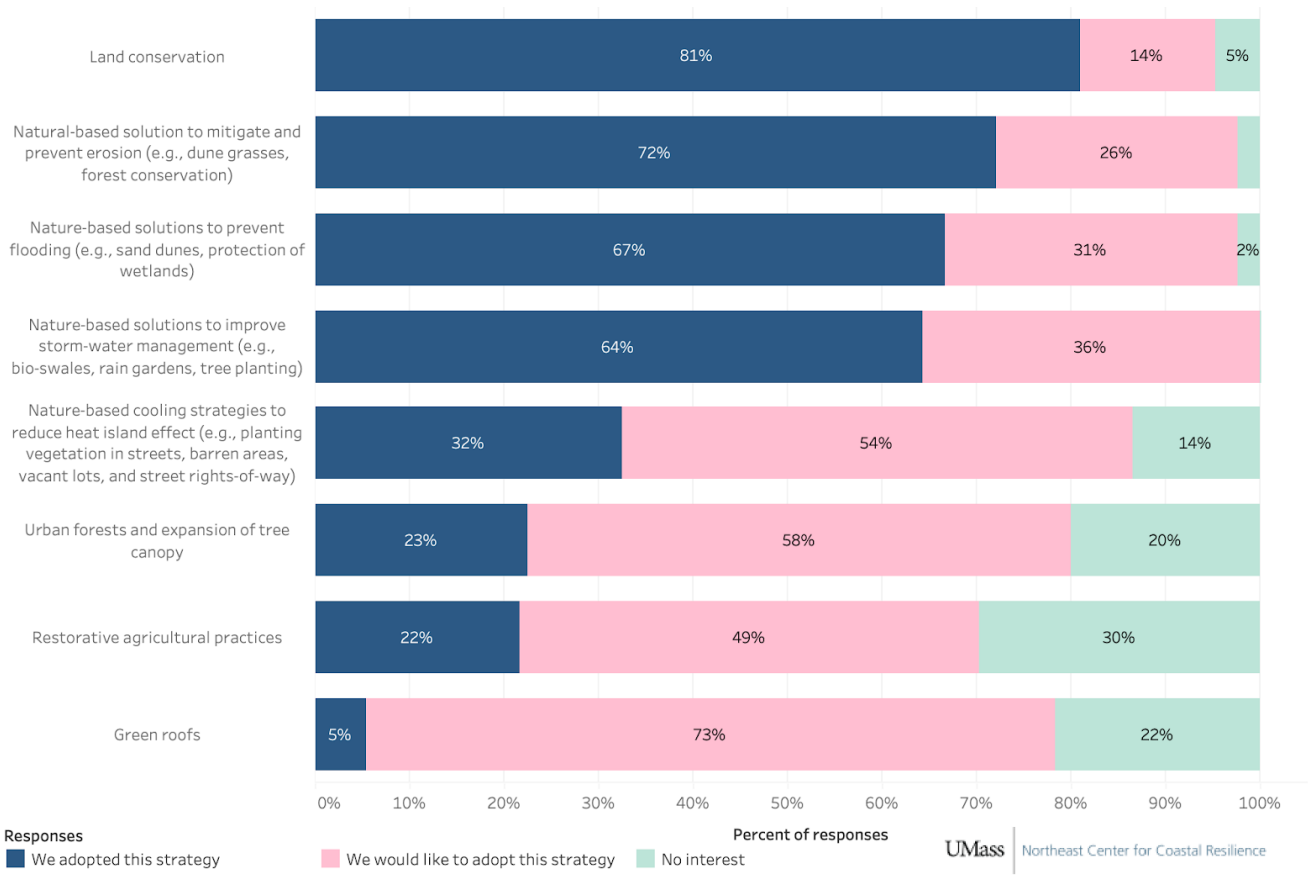
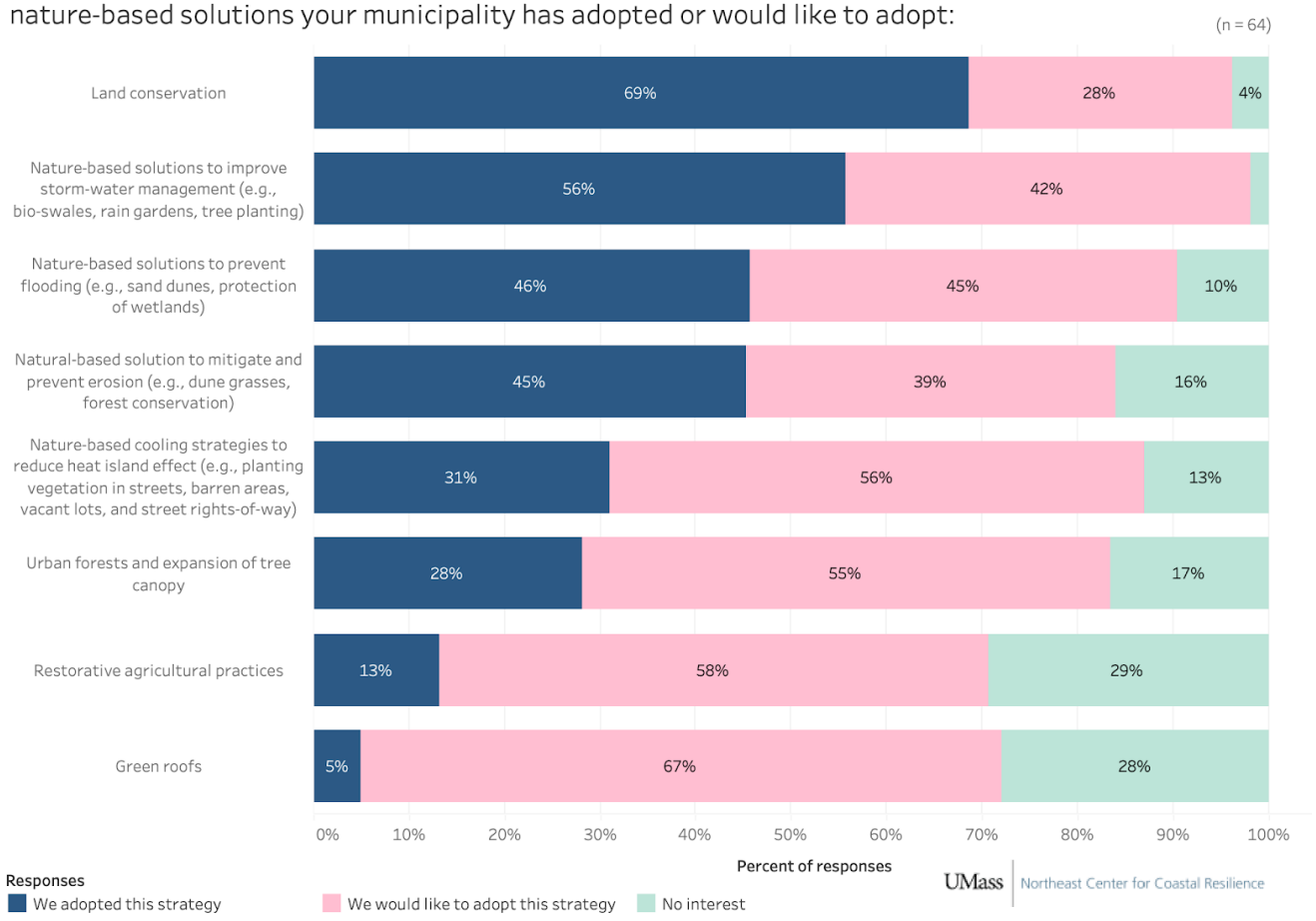


Figure 31b. Inland municipalities - Please indicate which of the following green infrastructure and nature-based solutions your municipality has adopted or would like to adopt:



5. USE OF COVID-19 RECOVERY FUNDS TO FINANCE SUSTAINABLE PROGRAMS

COVID-19 green recovery

States and municipalities around the US have started exploring possible COVID-19 economic recovery pathways. The expression *green recovery* has emerged to describe policies that push for low-carbon economic growth, prioritizing renewable energy, energy efficiency, green transport, climate resilience and other environmentally beneficial projects.

- 36% of respondents reported that the concept of "green recovery" strategies had been discussed in their municipalities vs. 41% of respondents declaring that there had not been discussion of "green recovery" strategies. 23% of respondents were not sure.

Financing green recovery strategies

Several MA municipalities are using or planning to use state and federal COVID-19 recovery funds to finance sustainable policies and programs (Figure 32):

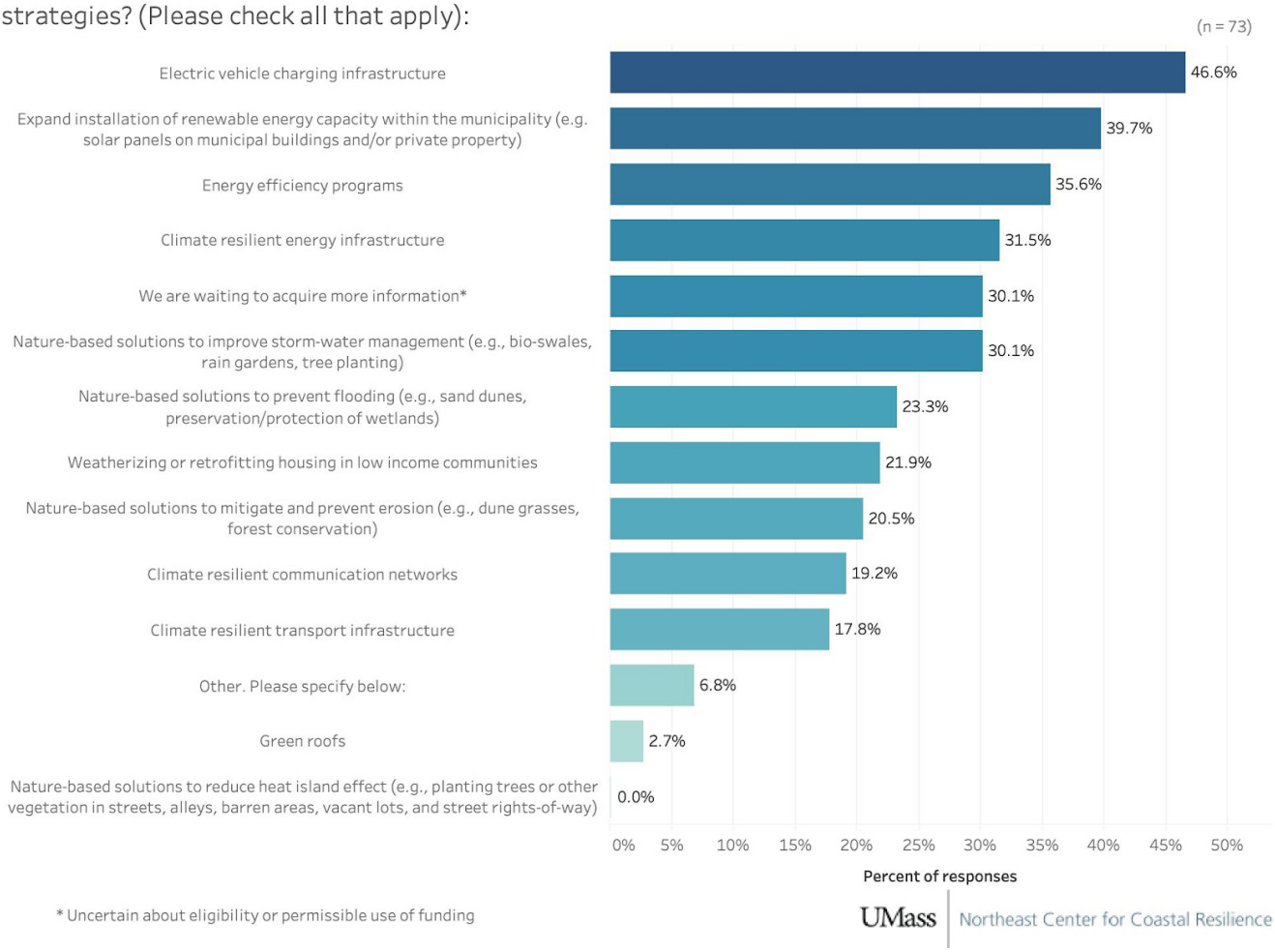
- The top three programs and strategies most frequently selected focus on climate mitigation and include electric vehicle charging infrastructure (47%), expansion of renewable energy capacity within the municipality (40%), and energy efficiency programs (36%).

- Climate adaptation and climate resilience strategies are less frequently selected than climate mitigation strategies. 31% of respondents indicated using or planning to use COVID-19 recovery funds for climate resilient energy infrastructure while 30% selected nature-based solutions to improve storm-water management or to prevent flooding and erosion.

- 30% of respondents reported that they aren't sure about allocations and/or permissible uses for these funds at this time.

- In specifying "other" responses, respondents indicated that they also planned to invest recovery funds into water supply projects, wastewater and stormwater management projects, and hiring staff members if these were permissible categories of spending.

Figure 32. Is your municipality using or planning to use Coronavirus State and Local Fiscal Recovery Funds (CSFRF/CLFRF, Fiscal Recovery Funds, ARPA funds) to finance the following sustainable programs and strategies? (Please check all that apply):



"We are still waiting for direction on how we can use this money. We need to pay for staff to manage this work as well as the capital costs of the work."

- Coastal town

6. BARRIERS

This section explores possible barriers to the implementation of resilience strategies including, resource limitations (e.g., limited staffing capacity); governance and coordination barriers; and deficiencies in data and information.

6.1 RESOURCES CONSTRAINTS

- As seen in Figure 33, the most frequently reported barrier to implementation of climate change resilience plans is limited staffing capacity (92% of respondents from towns and 85% from cities).

- Other frequently reported barriers related to municipal resources include lack of a centralized way to identify funds (51%), lack of regulatory authority to support enforcement of strategies (47%), lack of expertise (43%), and lack of grant-writing capacity (40%). (Figure 33)

Towns

- In towns, the most frequently reported barriers include staffing constraints (91%); lack of a centralized way to identify funds (51%); lack of grant-writing capacity (46%); and lack of expertise to address complex issues related to climate change (45% of towns). (Figure 33)

- Lack of grant-writing capacity is a considerably more prominent issue in towns (46%) than in cities (19%). (Figure 33)

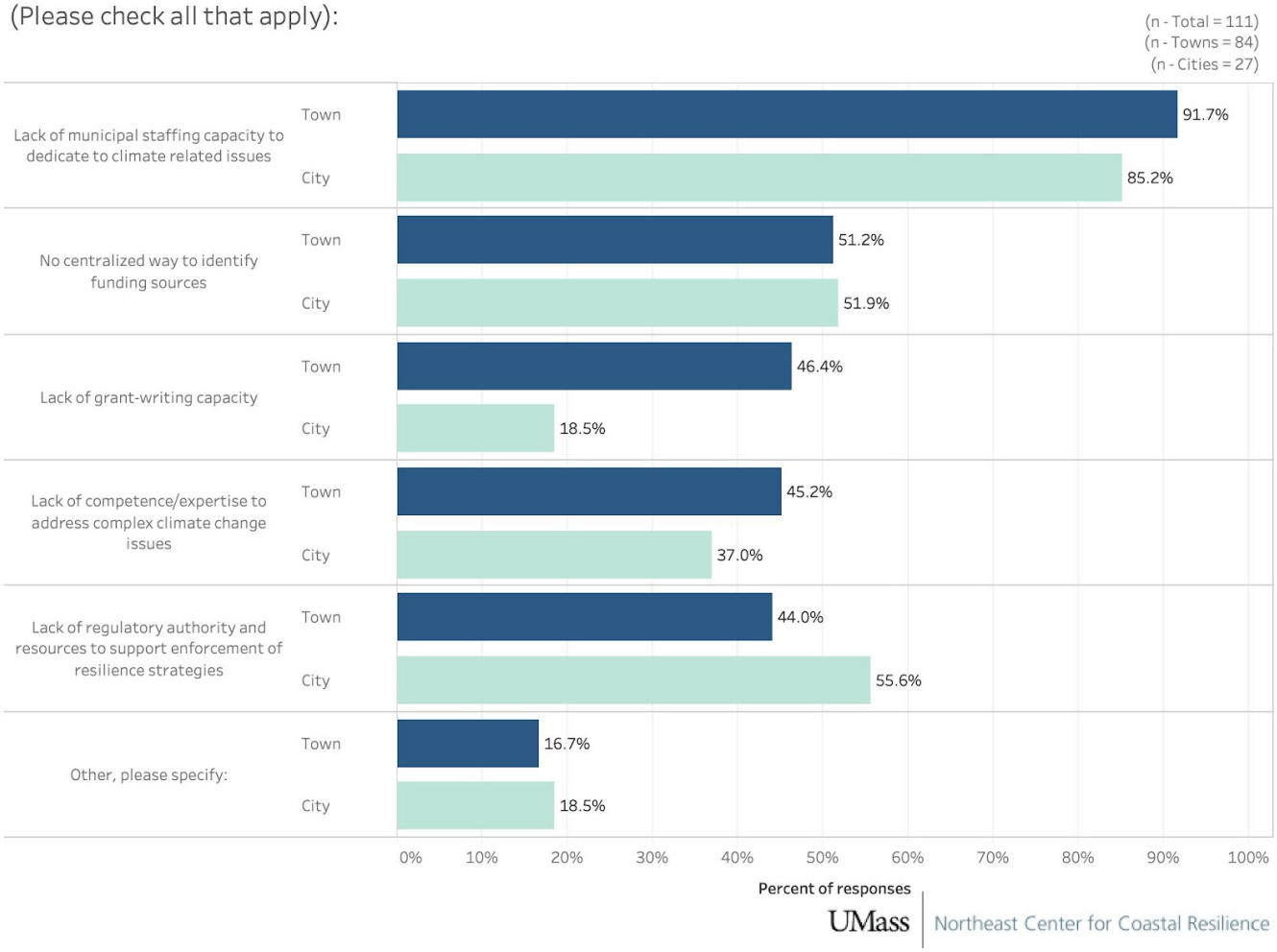
Cities

- In cities, the most frequently reported barriers include staffing constraints (85%); lack of regulatory authority to support enforcement of resilience strategies (56%); lack of a centralized way to identify funds (51%), lack of grant-writing capacity (19%), and lack of expertise to address complex climate change issues (37%). (Figure 33)

- Lack of regulatory authority to support enforcement of resilience strategies is more frequently reported in cities (56%) than in towns (44%). (Figure 33)

- Cities and towns struggled equally with identifying funding sources for resilience projects. (Figure 33)

Figure 33. Municipal resources by towns and cities - Please indicate which of the following barriers complicate, slow, or prevent the implementation of climate change resilience plans in your municipality (Please check all that apply):



"Our Resiliency Committee has spent years writing a Resiliency Plan for our city and our biggest fear is that it will remain as a doorstop. Our Committee is working hard to prevent this. But we need leaders to fund full-time staff dedicated to this effort." *-Coastal city*

"[Our town] is significantly impacted by climate change. Unfortunately we lack the technical expertise and financing to identify and move critical projects forward." *- Coastal town*

"[There is] competition for financial and staff resources between urgent needs and preparing for climate resilience." *- Inland city*

- In specifying "other" responses, respondents indicated the following additional barriers: funding constraints, lack of political or community support, and complicated relationships with private entities. These barriers are each captured elsewhere in this survey (Figure 35). However, these themes arising, spontaneously and unprompted, in qualitative response (some are reported below) underscores the importance of these themes to municipalities.

"We need pre-development and feasibility study funding to compete for VERY competitive large scope grants." *- Inland town*

"The barriers are money and disbelief." *- Coastal city*

"[We need] more direct aid as opposed to grants. There seems to be an entire industry focused on grant applications and much energy is spent on grant applications as opposed to solving actual issues. Staff evaluates risk/reward at every grant opportunity which can be time consuming and detract from daily activities." *- Inland town*

"In order to reach down to rural communities with limited staffing and resources any program must come with administrative and technical support. Without the staffing and expertise available to package the data and explain "why" a certain program will achieve desired outcomes the effort will not be sustained." *- Inland town*

"Permitting and project review take years to get through the multiple permitting agencies. Grants are competitive." *- Coastal town*

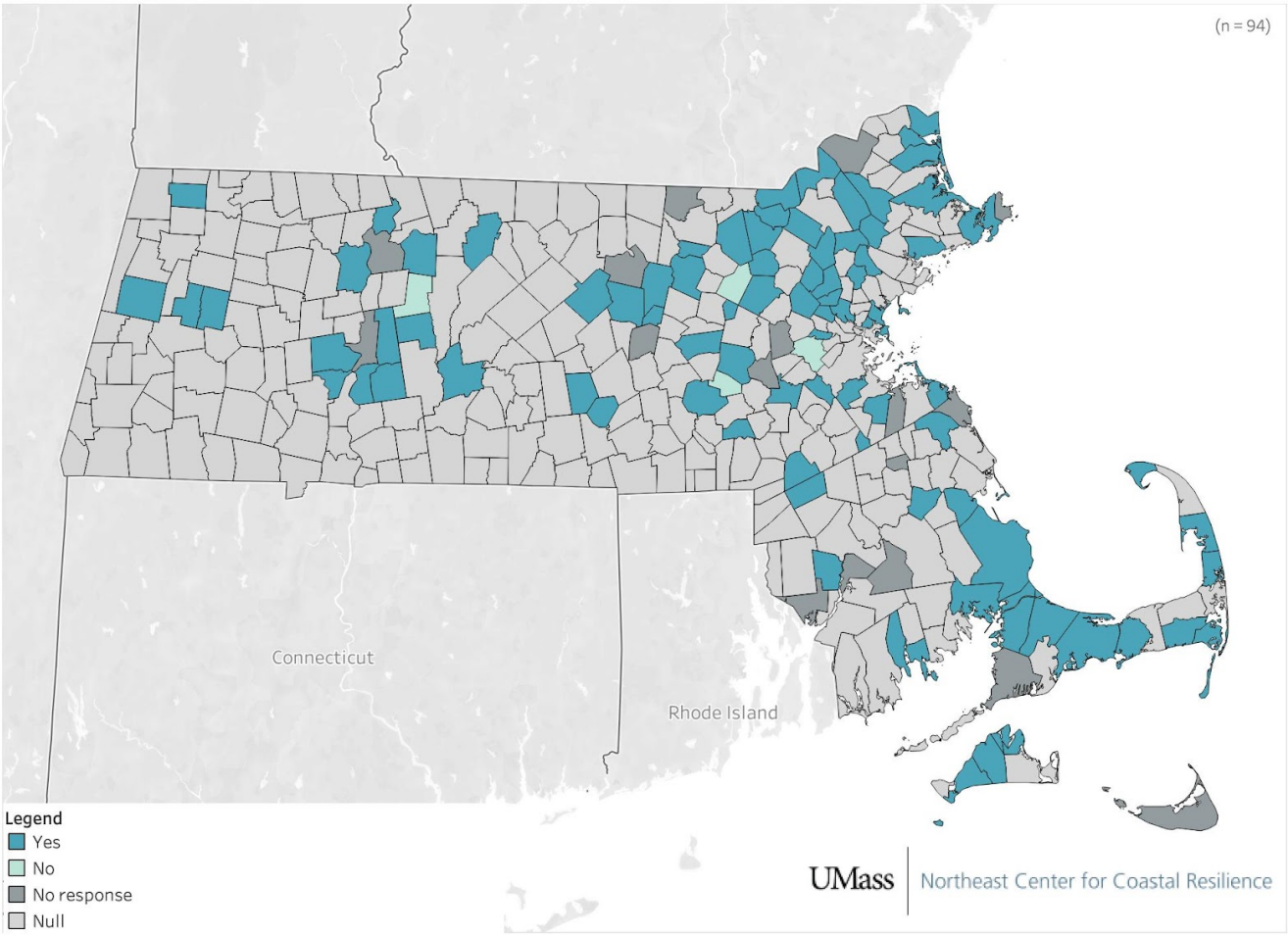
"Our biggest challenge is funding. We have community support with good plans and concepts, but we don't have enough general funds to implement. Grants, like the MVP program, are great but so competitive and rarely fund entire projects from plan to design to construction to operations & maintenance. We would love reliable, consistent state and/or federal funding (similar to Ch 90 funding) to be able to strategically plan and implement mitigation efforts." *- Inland town*

"Lack of grants and other resources (or a lack of knowledge about them or where to find them - or how to access and apply and support the funding of them) for addressing the damage or mitigation of climate related municipal projects. Our beaches are being impacted by erosion and our lakes being infested with invasive species - we have little to no available funding to address these problems without the burden of raising property taxes or requiring private residents to fund any improvements. [...] We have spent thousands on the engineering plans - and yet the plans will collect dust unless there is some way to finance the improvements with grants or state funding." *- Inland town*

Staffing Capacity

A large majority of municipalities (89%) have indicated that climate adaptation and resilience planning are a priority in their planning documents. However, a large percentage of respondents reported that limited staffing capacity hinders the implementation of resilience plans in their municipality (92% of respondents from towns and 85% from cities). (Figures 33 and 34)

Figure 34. Limited municipal staffing capacity - Does limited municipal staffing capacity represent a barrier complicating, slowing, or preventing the implementation of climate change resilience plans?



- 14% of respondents from towns and 22% from cities reported that they have one or more full-time staff members dedicated completely to climate resilience planning.

- 82% of respondents from towns and 85% from cities indicated that they have one or more staff members who allocate only some of their time to climate planning.

- 4% of municipalities reported that they have only volunteers or unpaid interns (and no paid staff members) working on climate resilience planning. Other municipalities have a mix of part-time staff members and volunteers.

- Because of self-selection discussed in the introduction, staffing capacity may be even lower in municipalities that have not completed the survey.

- In qualitative responses to open-ended questions, municipalities often expressed the need for additional staffing to support climate resilience planning.

"We would like to have a full time climate planner but do not have the resources to dedicate a full time position to this effort yet." *- Inland city*

"We lack the staffing to actively pursue these efforts diligently. There are a number of staff working on various elements of climate resiliency, but only in addition to their other responsibilities. Towns should develop a climate office that oversees all climate related initiatives at some point in the future. This is a critical issue that needs immediate action." *- Coastal town*

"We have insufficient resources to fund climate change resilience implementation following planning stages. [We have] limited staffing capacity and limited grant-writing expertise." *- Coastal town*

"[Our city] has some 40 volunteer Boards, Commissions and Committees that provide valuable expertise, time and energy to doing the work of the city. However, this only goes so far no matter how well-motivated these citizens are. Increased staffing is a top priority." *- Coastal city*

6.2 COORDINATION AND GOVERNANCE CONSTRAINTS

- Overall, the top coordination and governance barriers reported by municipalities were insufficient resources to mobilize broad community support (63%), difficulties changing by-laws and regulations (47%), difficulty identifying and prioritizing action steps (41%), and coordination issues both regionally (41%) and internally (40%).

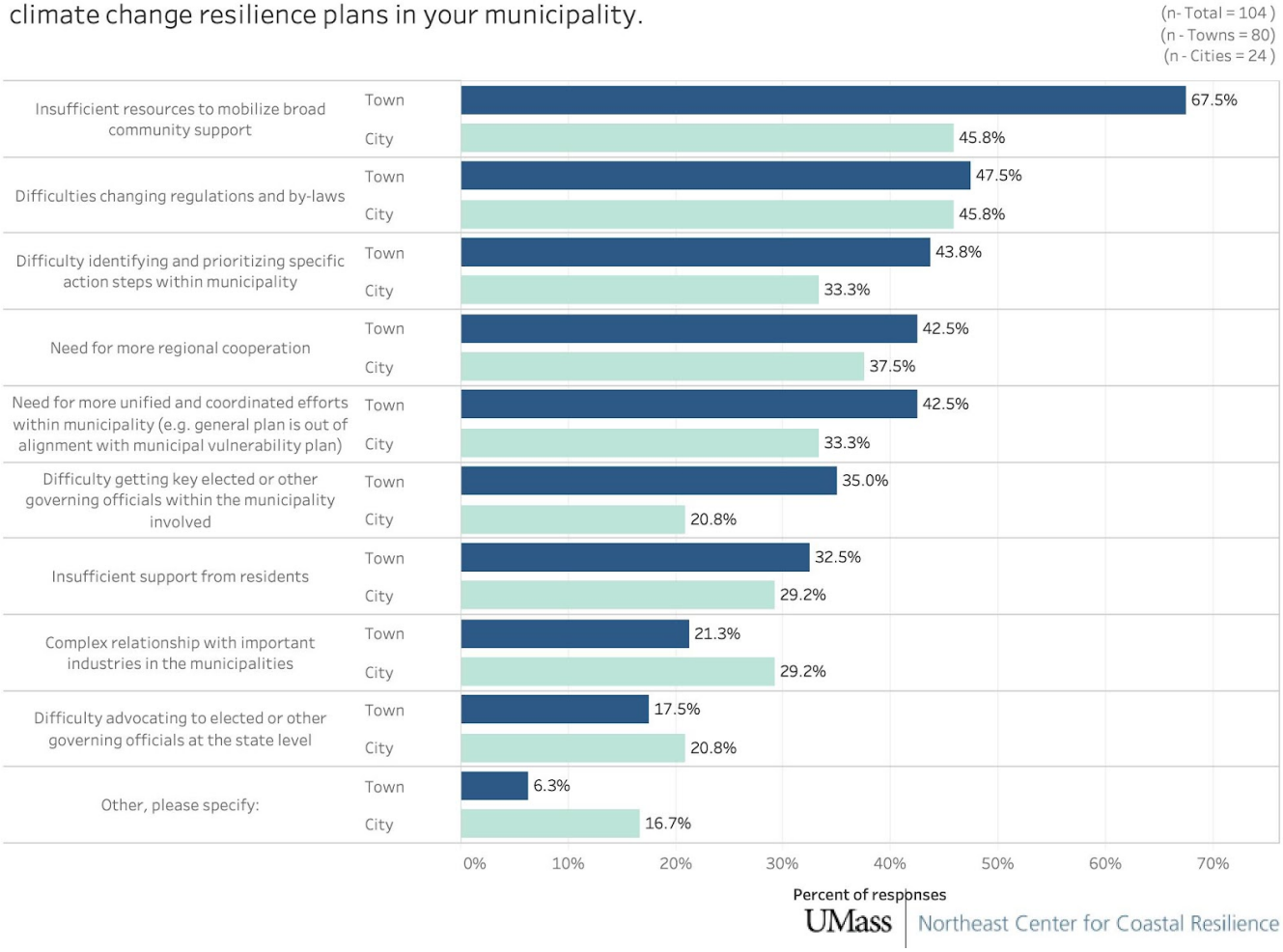
- In towns, respondents were markedly more likely than in cities to identify insufficient resources to mobilize broad community support as a barrier to resilience planning (68% of towns and 46% of cities). They were also more likely to report difficulties in identifying and prioritizing action steps (44%); getting

key elected and other governing officials on-board (35%); and both internal and regional coordination issues (43%). (Figure 35)

- Cities were more likely than towns to report the following barriers to climate resilience planning: complex relationships with industries (30%); and difficulty advocating at the state level (21%). (Figure 35)

- In specifying "other" responses, municipalities indicated difficulty coordinating with utility providers, a lack of consistency in performance standards across departments, long timelines for permitting and project review, exaggerated cost estimates of projects, disagreement among governing officials, difficulty coordinating with the state, limitations of all-volunteer boards, difficulty coordinating with property owners, and having not made enough progress in climate resilience planning to know what the barriers are. (Figure 35)

Figure 35. Coordination and governance by towns and cities - Please indicate which of the following barriers related to coordination and governance complicate, slow, or prevent the implementation of climate change resilience plans in your municipality.



This section of the survey received numerous comments from respondents, we report a few below, organized by theme.

- Insufficient community support:

"There appears to be little public support in the community for climate resiliency actions." *- Inland town*

"There are some small communities without much capacity that have a strong volunteer base that want to do a lot but the public [is] largely uninformed." *- Inland town*

"Mayor is on board but some councilors don't understand the return on investment." *- Coastal city*

- Difficulties changing regulations and bylaws:

"Generally we are concerned that building codes cannot be updated beyond state code requirements." *- Inland city*

"[There are] political issues involved in proposing and achieving approval for changes to zoning and other policies that would facilitate implementation of proactive resiliency planning. Resistance to the idea of limiting development in high hazard areas, future retreat, etc." *- Coastal city*

- Need for unified and coordinated efforts within the municipality:

"We lack the staffing to actively pursue these efforts diligently. There are a number of staff working on various elements of climate resiliency, but only in addition to their other responsibilities. Towns should develop a climate office that oversees all climate related initiatives at some point in the future. This is a critical issue that needs immediate action." *- Coastal town*

"We need ALL departments to be FORCED to base ALL decisions with climate change in mind. Our Resiliency Plan has a lot of great ideas but we have no means to implement it. We need laws to force us to do so and we need a Resiliency Coordinator to assist us all and to enforce Departments to comply. At least pass an ordinance that all Departments must prove that adapting to climate change is now necessary. Prove it." *- Coastal city*

- Need for more regional coordination:

"[A barrier to resilience planning is that] we do not have municipal control over power or telecommunications networks." *- Coastal city*

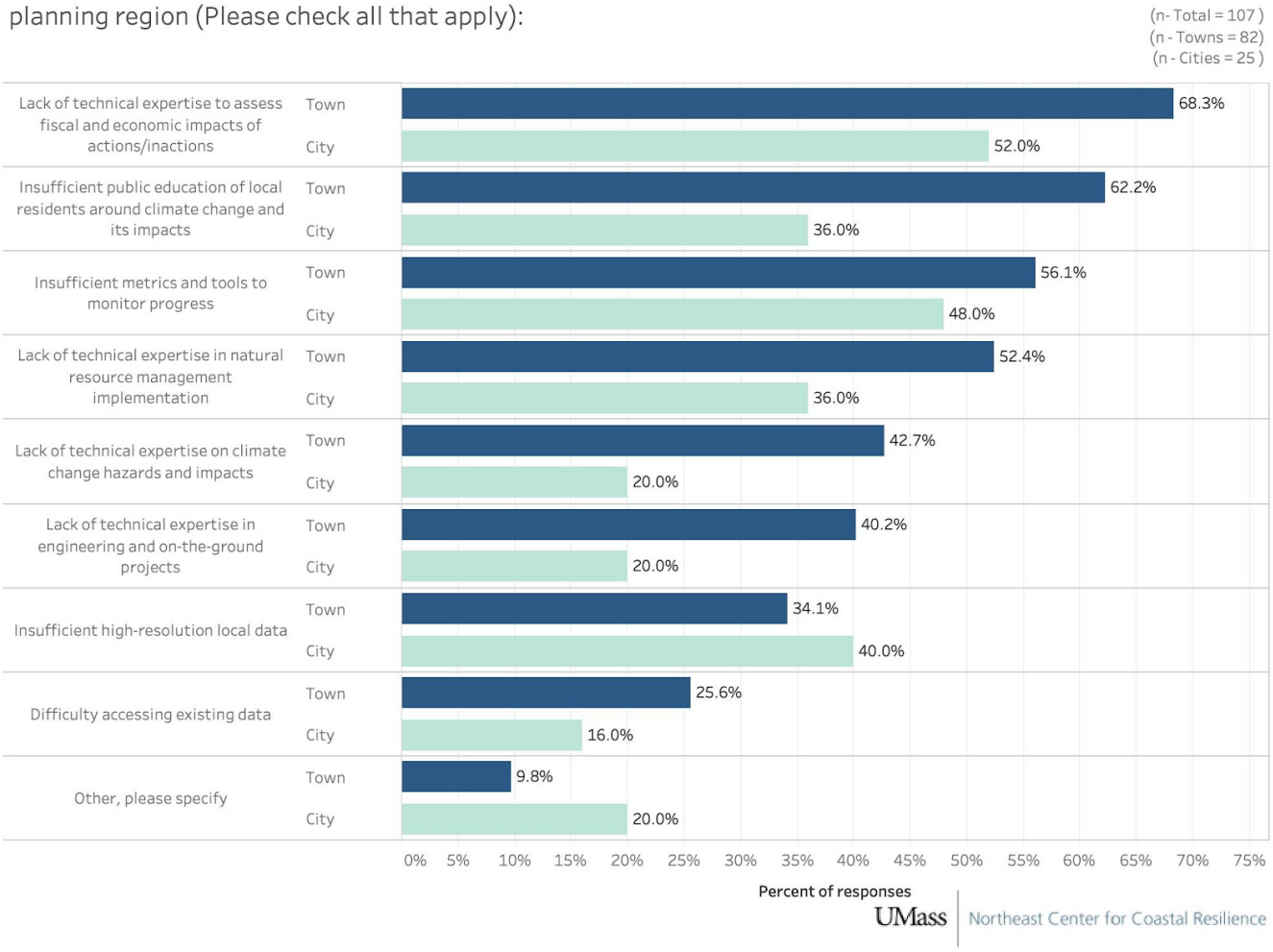
"There has to be a better way, regionally, we could address these issues. The work could be easier if teams of people worked on items like this more systematically and regionally. We never have time to put heads together and come up with better ways to accomplish these tasks. Instead, town by town, our small crews go out with insufficient equipment doing it over and over, rather than solve it once for many years. "

- Inland town

6.3 DATA AND INFORMATION CONSTRAINTS

Lack of or difficulty accessing data and information may represent ulterior barriers that complicate, slow or prevent the implementation of resilience strategies. (Figure 36)

Figure 36. Data and Information by towns and cities - Please indicate which of the following barriers complicate, slow, or prevent the implementation of climate change resilience plans in your municipality or planning region (Please check all that apply):



- The most frequently reported barrier to the implementation of climate resilience plans is the lack of technical expertise to assess fiscal/economic impacts of actions/inactions (68% of towns respondents and 52% of city respondents). (Figure 36)

- In towns, compared to cities, respondents more frequently reported barriers related to data and information (e.g., lack of technical expertise, insufficient public education of local residents, etc.). One exception is the lack of high-resolution local data, selected as a barrier by 40% of city respondents. (Figure 36)

- In towns, more than 40% of respondents reported also the following barriers: insufficient public education of local residents around climate change and its impacts (62%), insufficient metrics and tools to monitor support (56%), lack of technical expertise in natural resource management implementation (52%), lack of technical expertise in climate hazards and impacts (43%), and lack of technical expertise in engineering and on-the-ground projects (40%). (Figure 36)

- In cities, more than 30% of respondents reported also the following barriers: insufficient metrics and tools to monitor progress (48%), insufficient high-resolutions local data (40%), lack of technical expertise in natural resource management and implementation (36%), and insufficient public education of local residents around climate change and its impacts (36%). (Figure 36)

- In specifying "other" answers, municipalities reported limited staff time, funding issues, difficulty prioritizing competing needs, lack of transportation data, and the need to monitor climate mitigation efforts in order to mobilize support for climate resilience.

"[There is] no time at a small municipality without planning [resources], and staff, to even look for some of this [data], never mind process or use." *- Inland town*

"Any information that will help municipalities be able to implement climate resilience practices as quickly as possible will be helpful. So knowing there is a place to look for these resources and experts to ask, rather than spending lots of time researching solutions, will be very very helpful indeed. Case studies on where and how it's been implemented so we can go see these systems will also be helpful." *- Inland city*

"More [trainings/webinars] on department-specific considerations. What should a building inspector, a forester, a procurement officer, engineers, health inspector, etc., know about how their work may change as a result of climate change? What are their specific roles in supporting climate action? " *- Coastal city*

Numerous municipalities in our survey are MVP communities. The **Municipal Vulnerability Preparedness grant program (MVP)**[8] is perceived as very helpful by the survey respondents. The program "provides support for cities and towns in Massachusetts to begin the process of planning for climate change resiliency and implementing priority projects. The state awards communities with funding to complete vulnerability assessments and develop action-oriented resiliency plans. Communities who complete the MVP program become certified as an MVP community and are eligible for MVP Action Grant funding and other opportunities." Some municipalities provided suggestions to expand or improve the MVP program with emphasis on **data acquisition and knowledge sharing**:

"A challenge is lack of State funding for feasibility studies and designs. The Municipal Vulnerability Preparedness grant program is competitive, only about a third of all applications were funded in 2020. And the funding is limited for studies (i.e., micro-grid feasibility study, etc.) If MVP or a similar program had more funding for feasibility studies, this would help alleviate some of the data gaps that many municipalities face."

- Inland town

"If there are ways to help communities identify key Best Management Practices's or common items to implement within communities that every community should be instituting - that would be helpful. Ways to easily update our MVP plan with actionable items would be helpful going forward so we can more easily prioritize projects and seek funding to implement them." *- Inland city*

"[In our municipality] the MVP process produced a very broad brush plan. It lacked the specific steps to take which is the next piece we need to do. It would have been helpful if the MVP process forced us to be more specific, or had a phase 2 plan funded to get the community to those more specific and task oriented list from which to choose to seek grant funding for implementation." *- Inland city*

"The MVP planning process should include some baseline items every community should implement if they haven't already. That way all communities can rise up to be more resilient together, rather than some communities getting a head start because they had better consultants and better thought process during their planning exercises. We understand that every community is unique. However, I assume there are some baseline items every community should look into." *- Inland city*

"After our MVP planning process, we realized that we missed lots of details, which other communities had included, and we thought that we should have all been given these ideas during the planning process and we would have included them in our plan, but just hadn't thought about them - which resulted in vague plan with mediocre non-actionable item." *- Inland city*

[8] Municipal Vulnerability Preparedness program webpage: https://www.mass.gov/municipal-vulnerability-preparedness-mvp-program

7. INFORMATION AND DATA NEEDS

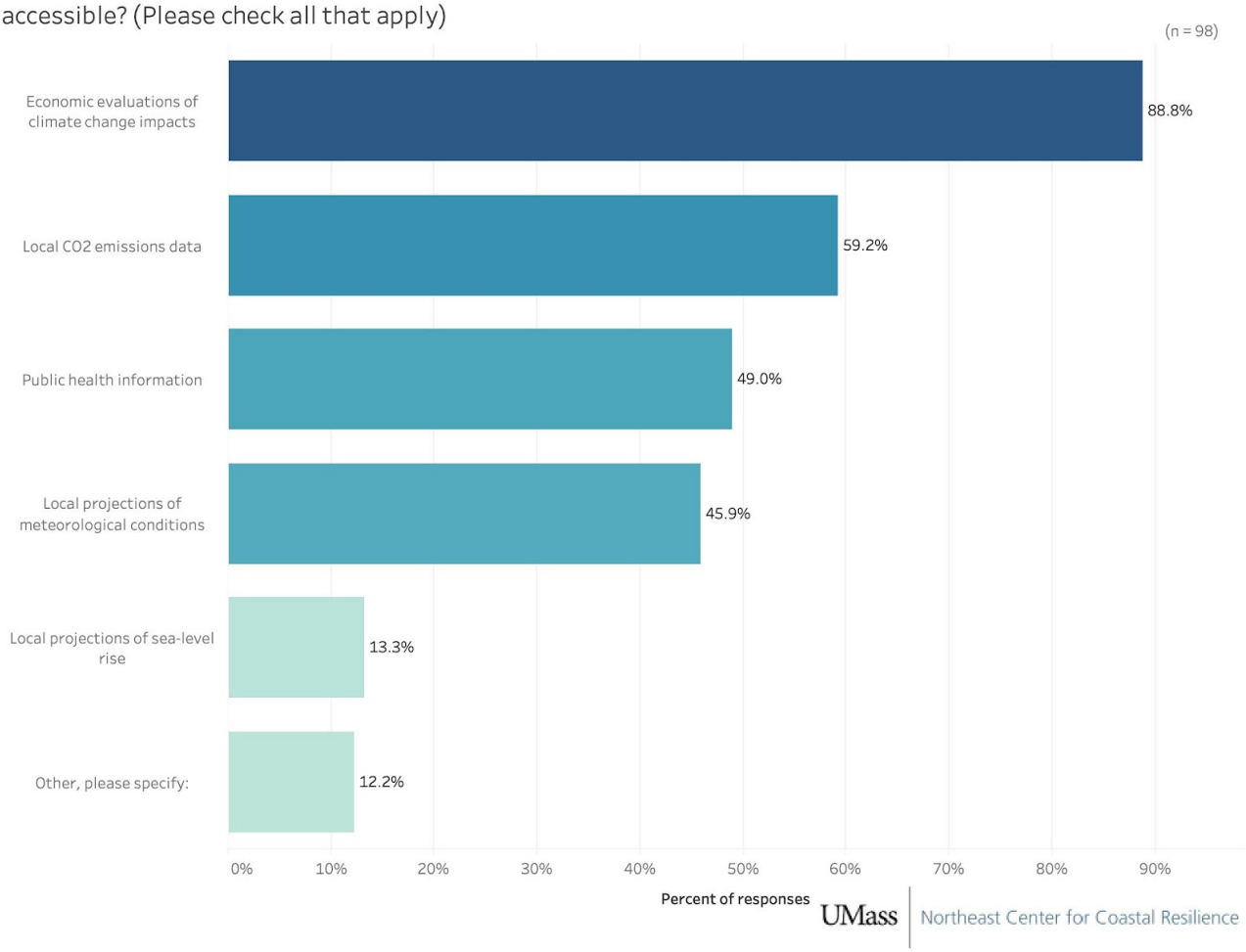
This section explores the date needs of municipalities and the resources considered most helpful to accelerate the implementation of resilience strategies.

Data needed but not easily accessible

- Economic valuations of climate change impacts (89%) and local CO2 emissions data (59%) are the two types of data most frequently indicated as "needed but not easily accessible" (Figure Q32). It is worth emphasizing that these data are crucial for climate adaptation planning and for monitoring progress in climate mitigation (i.e. actions that reduce emissions of greenhouse gases). (Figure 37)

- Data considered needed but not easily accessible include also: public health information (49%), local projections of meteorological conditions (45%), and sea level rise (13%). (Figure 37)

Figure 37. Data needs - What specific types of data does your municipality need that is not currently easily accessible? (Please check all that apply)

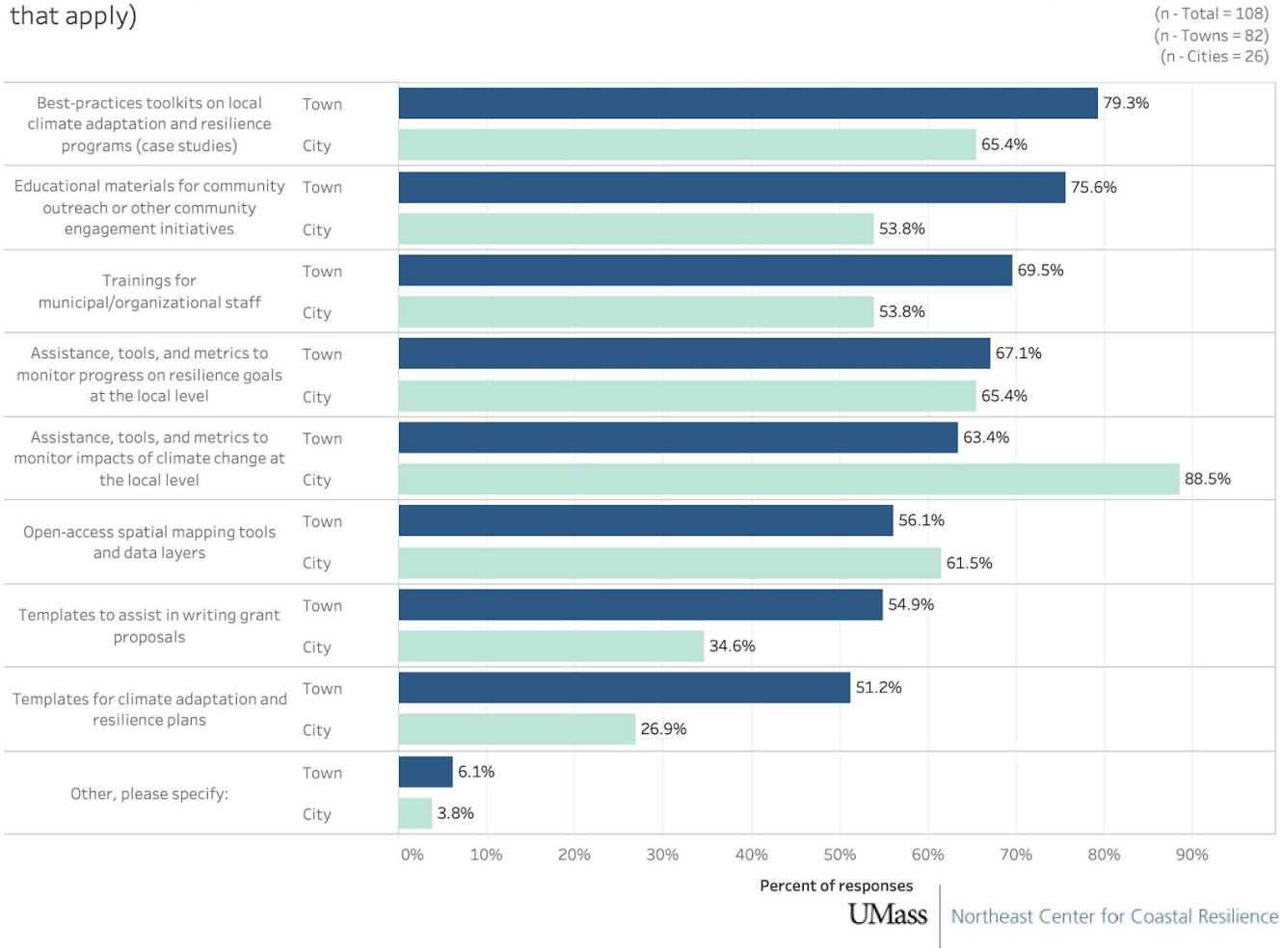


- In specifying "other" data needs, respondents reported: road drainage best-practices, flood modeling, projected stormwater and rainfall data, and transportation and vehicle emissions. They also expressed difficulty allocating limited staffing to locating data when there were so many pressing issues.

Most helpful resources to make progress in climate adaptation and resilience

The resources considered most helpful to municipalities to make progress on their climate adaptation strategies differ somewhat between towns and cities. (Figure 38)

Figure 38. Most helpful resources by towns and cities - What kind of information and data resources would be most helpful to your organization to make progress on climate adaptation and resilience? (Please check all that apply)



Towns

- In towns, respondents most frequently selected "best practices toolkits on local climate adaptation and resilience programs (case studies)" (79%). (Figure 38)

- Additional resources considered helpful by town respondents appear connected to education and outreach. They include educational materials for community outreach or other community engagement activities (76%); training for municipal staff (70%); and assistance tools and metrics to monitor progress of resilience goals at the local level (67%). (Figure 38)

Cities

- In cities, respondents most frequently selected as most helpful resources "assistance, tools, and metrics to monitor impacts of climate change at the local level" (89%). (Figure 38)

- Resources considered most helpful by cities seem to focus on monitoring, progress indicators, and data visualization. They include assistance tools and metrics to monitor progress of resilience goals at the local level (65%); best practices toolkits on local climate adaptation and resilience programs (case studies) (65%); and open access spatial mapping tools and data layers (62%). (Figure 38)

The nexus between climate resilience and climate mitigation

Several municipalities highlighted the importance of integrating resilience planning with mitigation strategies, also in term of data collection.

"[There is] lack of data on transportation, GHG emissions, use of fossil fuels in our community, to measure and prediction actions towards net-zero; ***it is impossible to separate carbon reduction from climate resiliency with our work, and in the public eye****."* *- Inland city*

"The Climate Resiliency Committee and Select Board adopted town rules to require that all municipal departments must reduce greenhouse gas emissions by 25% by 2025, 50% by 2030, 75% by 2035 and 100% by 2040." *- Coastal town*

"I believe there is a significant psychological impact on us all, even when the climate emergency is only "hitting the fan" in other states and countries. It would be very empowering and therapeutic to work on local and regional zero carbon infrastructure. More PV farms, more E-cars, and heat pump systems for homes."

- Inland town

"I am afraid the term "resilience planning" sounds like surrendering to climate change. Like say, building big seawalls against rising oceans. I want to get to zero and then negative-carbon; resiliently or otherwise."

- Inland town

8. THE PERSPECTIVE OF PLANNING AGENCIES

In addition to municipalities, 10 planning agencies completed the survey. Their answers about hazards and impacts experienced by local municipalities supported the results obtained from municipal respondents. In addition, respondents from planning agencies provided insights about ways to improve planning and regulatory process and opportunities to enhance regional coordination efforts. A selection of their observations and suggestions is presented below by theme.

Resource Constraints

"We can assist municipalities but most of them lack the staffing and resources to address climate resilience projects and grant writing."

"Our region struggles with the lack of relevant adaptation solutions for rural communities with very small budgets."

"Some of the tougher issues are finding the resources to do the needed work, and the political challenge of making big investments now, in problems that are not yet pressing."

"Funding that does exist is restrictive in such a way that it makes it difficult to use on basic infrastructure updates that would address climate change."

"Our planning agency would like to dedicate resources (i.e. assessed needs, developed plans or programs) to increase the climate resilience capacity of vulnerable groups but we do not have funding."

"Most of our municipalities have identified and prioritized action steps through the MVP process but implementing them is the challenge."

"There often are not up to date general/master plans for our municipalities. Also, climate adaptation is not a priority in our region outside of the MVP process so it is difficult to incorporate the MVP findings into other planning efforts. Lastly, there is no funding to support climate adaptation. Funding (or competing priorities for limited local funding) is the largest barrier."

Regulatory and permitting challenges

"Permitting is time-consuming and expensive and ought to be streamlined for climate resilience projects."

"State environmental permitting regulations are a significant time/expense barrier to implementing Nature-based Solutions in our region. Culvert replacements in our region cost $1M + and this is not sustainable either. We have a high need for these projects and the engineering and permitting costs need to be reduced."

"I hear a strong desire for the funding and regulations around infrastructure improvements to be easier. Namely, many of our communities would like to upsize their culvert and storm water infrastructure but find the permitting timelines to be too long, the stream crossing standards to be too costly, and the funding sources too restrictive to get projects moving forward within the timeframe they need."

"State regulations (i.e. wetlands protection act) are not keeping pace with climate change and efforts to update them are not moving fast enough."

Concerns about human migration

"We have seen in-migration of climate refugees and will likely continue to have substantial in-migration from coastal areas, which is resulting in increased developmental pressure, loss of open space and threats to drinking water supplies and quality."

"(Rural) communities are just beginning to express concern about climate-related migration and the impact that this will have on the character of their small towns. This fear could lead to restrictive growth controls and poor long-term zoning decisions."

Data needs and coordination

"Data is limited (some simply don't exist) and often not broken down to a small enough scale to be meaningful."

"If we had more resources to differentiate which underserved communities are suffering most from the effects or future effects of climate change in the region I think that would help with the work we do in a major way."

"[...] up to date flood data is more available for coasts, while inland communities, especially smaller communities, continue to use floodplain maps from the 70s and 80s that no longer reflect their current flood impacts. It can be difficult then for communities to properly prepare for a future of greater flood damage in unexpected places."

"I think a platform for sharing strategies, and better access to funding (or more assistance with accessing that funding) are two of the most important ways to help our communities with climate resilience right now. Many towns know what the issues are but need support in implementing the strategies."

APPENDICES

A1. LIST OF MUNICIPALITIES IN THE SURVEY SAMPLE

1	Avon
2	Acton
3	Amherst
4	Arlington
5	Ashland
6	Athol
7	Auburn
8	Ayer
9	Barnstable
10	Berkley
11	Beverly
12	Bourne
13	Boxford
14	Boylston
15	Braintree
16	Burlington
17	Carlisle
18	Chatham
19	Chelmsford
20	Chelsea
21	Chilmark
22	Clinton
23	Cohasset

24	Concord
25	Dedham
26	Deerfield
27	Dighton
28	Dover
29	Dracut
30	Eastham
31	Easthampton
32	Fairhaven
33	Falmouth
34	Foxborough
35	Framingham
36	Gill
37	Gloucester
38	Granby
39	Hadley
40	Halifax
41	Harvard
42	Harwich
43	Haverhill
44	Hinsdale
45	Hopkinton
46	Hull
47	Ipswich
48	Kingston
49	Lakeville
50	Lancaster
51	Leicester

52	Leominster
53	Lexington
54	Lowell
55	Lynnfield
56	Mansfield
57	Marlborough
58	Maynard
59	Medford
60	Medway
61	Methuen
62	Middleton
63	Milton
64	Montague
65	Nahant
66	Nantucket
67	Natick
68	New Bedford
69	Newbury
70	Newburyport
71	Newton
72	North Adams
73	North Andover
74	North Reading
75	Northampton
76	Norwell
77	Oak Buffs
78	Pelham
79	Pepperell

80	Peru
81	Pittsfield
82	Plymouth
83	Princeton
84	Provincetown
85	Revere
86	Rockport
87	Salisbury
88	Sandwich
89	Scituate
90	Shutesbury
91	South Hadley
92	Sterling
93	Swansea
94	Tewksbury
95	Tisbury
96	Wakefield
97	Ware
98	Wareham
99	Watertown
100	Wellfleet
101	Wendell
102	West Tisbury
103	Westford
104	Weston
105	Weymouth
106	Whitman
107	Wilmington

108	Winchester
109	Winthrop
110	Woburn
111	Yarmouth

A2. LIST OF PLANNING AGENCIES IN THE SURVEY SAMPLE

1	Berkshire Regional Planning Commission
2	Cape Cod Commission
3	Central Massachusetts Regional Planning Commission
4	Franklin Regional Council of Governments
5	Martha's Vineyard Commission
6	Merrimack Valley Planning Commission
7	Metropolitan Area Planning Council
8	Northern Middlesex Council of Governments
9	Old Colony Planning Council
10	Pioneer Valley Planning Commission