

Meeting the Challenges of Sea Level Rise and Extreme Weather: What Professionals in Hampton Roads, Virginia, Need to Get the Job Done

*Shannon E. Cunniff, Director, Coastal Resilience, Environmental Defense Fund
Jordan Davis, College of Charleston; Summer Intern, Environmental Defense Fund*

Executive Summary

In June 2016, Environmental Defense fund conducted a survey of 250 Hampton Roads, Virginia professionals to better understand and overcome the challenges associated with improving Hampton Roads ability to cope with sea level rise and improve its resilience to severe weather events. The respondents were people who identified as being involved with or interested in aspects of the region's community planning, environmental and natural resource protection, and emergency response.

When asked about the region's environmental issues that would be intensified by climate change, results reveal a high degree of consensus that shoreline erosion, stormwater quantity, habitat loss, stormwater quality and nutrient management, management of coastal developments, and shoreline hardening would become more problematic in the future.

The survey also sought to identify priority political, policy, and technical challenges posed by reducing flood risks. The results indicate a compelling need for building regional citizens' knowledge base about current and future flood risks and the benefits and consequences of options to reduce flood risk. Dynamic, user-friendly tools and methods are necessary to engage individuals and enhance their capacity to understand risks, take measures that build their personal resiliency, and to participate meaningfully in planning the region's future. To complement locally relevant, high-resolution models and visualization tools, greater capability to implement advanced community involvement practices would help to build broad support to begin and sustain actions that contribute to the region's economic, social, and environmental resiliency.

The survey also found that greater leadership and commitment on the part of the State of Virginia is needed to improve collaboration across local, state, and federal governments to build cooperation and align actions necessary to create region-wide resiliency.

The survey results are intended to inform ongoing resilience planning efforts by the Commonwealth Center for Recurrent Flooding Resiliency, Hampton Roads Sea Level Rise Preparedness and Resilience Intergovernmental Planning Pilot Project, Coastal Resilience Laboratory and Accelerator Center. Other parties, such as the State of Virginia, federal decision-makers, nonprofit and philanthropic communities, can likewise use the survey findings to determine effective means for assisting the region's evolution towards resiliency.

The survey was conducted and paid for by Environmental Defense Fund through funding provided by the blue moon fund.



Meeting the Challenges of Sea Level Rise and Extreme Weather:

What Professionals in Hampton Roads, Virginia, Need to Get the Job Done

*Shannon E. Cunniff, Director, Coastal Resilience, Environmental Defense Fund
and*

Jordan Davis, College of Charleston and Summer Intern, Environmental Defense Fund

Public Release September 22, 2016

1. Introduction

Worldwide, densely populated and economically productive low-lying coastal areas are experiencing the effects of accelerated sea level rise, erosion and flooding caused by more severe storms. The Hampton Roads area of Virginia ranks among the most threatened areas in the country in terms of populations at risk of flooding from sea level rise and land loss, second only to New Orleans. (McGarry et al., 2014). Hampton Roads' low elevation, relatively flat topography, proximity to the Atlantic Ocean and the Chesapeake Bay and its tributaries, together with its sprawling development and infrastructure make the region especially vulnerable. Parts of the region are already facing flooding from king tides and problematic stormwater drainage. In the next 20 years, the predicted sea level rise of 6 inches will result in flooding that affects 30,000 people in the region; sea level rise flooding will put 42,000 to 85,000 people and five electric power substations at risk in 50 years (based on a conservative 1 – 2.5 feet scenarios) (DHS, 2016). Two of Hampton Roads military bases, Joint Base Langley-Eustis and NAS Oceana Dam Neck in Virginia, are among the nation's bases expected to be most severely affected by sea level rise (Dahl et al., 2016). By 2035, the population at risk of storm surge flooding (i.e., if a Category 3 hurricane hit the region) rises to 787,000 (DHS, 2016), which does not assume any population growth or population density increases in the region even though current forecasts still anticipate a population rise ([Virginia Labor Market Information](#), 2016). Sea level rise and flooding risks may occur sooner and be underestimated (Hansen et al., 2016). No doubt the effects of increased flooding risks and risk perception will progressively affect property values and alter distribution of population growth in the region as has been seen in the most vulnerable areas of Louisiana (Hobor et al., 2014)

Improving coastal storm resiliency ahead of storm events and sea level rise not only save lives, reduces property damage and business losses but will reduce disaster response and recovery costs, perhaps saving \$4 for every \$1 invested (NIBS, 2005). Given all of the scenarios for continued and increased sea level rise, and the extended timeframes for planning and executing major public works projects, efforts

are underway to improve the collective capacity within the region to begin to implement meaningful and cost-effective coastal storm resiliency.

To help improve successful flood hazard mitigation, the Environmental Defense Fund (EDF) set out to determine, via a detailed survey, the views and needs of coastal resiliency planners, designers, engineers, and decision-makers responsible for improving the flooding resiliency of the Hampton Roads region. The survey covered multiple topics such as governance, stakeholder engagement, engineering and financing issues.

These survey results are intended to inform and help the work of the Commonwealth Center for Recurrent Flooding Resiliency¹, Hampton Roads Sea Level Rise Preparedness and Resilience Intergovernmental Planning Pilot Project², Coastal Resilience Laboratory and Accelerator Center³, as well as the contributions of the nonprofit and philanthropic communities to greater assist the region's evolution towards resiliency.

2. Methods

To understand challenges facing efforts to improve Hampton Roads' ability to adapt to climate change, EDF gathered opinions from persons involved with aspects of community planning, environmental and natural resource protection, and emergency response. EDF chose a survey mechanism to rapidly collect information that could be quantified to identify priority issues and needs. EDF designed the survey in consultation with Old Dominion University, the Virginia Institute for Marine Science, the City of Norfolk and others. The survey focused on collecting information relevant to the region's challenges, including environmental issues intensified by climate change and factors effecting efforts to reduce current and future flood risks. Factors included political, policy, and technical aspects, such as:

- Master Planning
- Governance
- Public Engagement
- Access to Information, and
- Research Needs.

The majority of the survey was designed to allow respondents to indicate the degree to which they agreed or disagreed with a statement by selecting from the following choices: strongly agree, agree, disagree, strongly disagree, or not applicable/I don't know (i.e., a Likert-type rating scale that lacks a neutral option). Respondents were encouraged to provide comments to elucidate their strong agreement or disagreement. In addition, two open response style questions were included to elicit

¹ The Commonwealth Center for Recurrent Flooding Resiliency is a joint venture of Old Dominion University, the College of William and Mary Virginia Coastal Policy Center and the Virginia Institute of Marine Science that aims to create a one-stop shop for scientific, socioeconomic, legal, and policy analyses.

² The Hampton Roads Sea Level Rise Preparedness and Resilience Intergovernmental Planning Pilot is a project to advance adaptive planning for sea level rise by unifying, combining and organizing the efforts of federal, state and local agencies with private industries, community efforts, and researchers.

³ The Coastal Resilience Laboratory and Accelerator Center describes itself as a hub to advance technological, organizational and innovation around community revitalization, water management, resilience measurement, as well as port, Naval Station and other water-sector business related resilience challenges.

information on (1) respondents' desired skills, tools, or authorities and (2) innovations they would like to see to enhance building of community resiliency to sea level rise and severe storms.

Using Survey Monkey as the platform for the survey, EDF contacted approximately 250 professionals responsible for aspects of building the region's resiliency to flooding. The survey was open for 21 days from June 6 - 27, 2016, and a financial incentive was offered to encourage participation. The survey, provided in **Appendix A**, took approximately 20 – 30 minutes to complete, depending on the amount of comments provided. Demographic information, such as type of employment and areas of expertise areas, was also collected.

EDF analyzed the survey by compiling responses, determining averages for responses to Likert-style rating statements, categorizing comments, and identifying themes and trends. To measure and reveal degrees of opinions and the amount of consensus, after completion of the survey, each response to a statement was assigned a rating (i.e., one for strongly agree, two for agree, three for disagree, and four for strongly disagree) and an average score was calculated for each statement. Responses of "don't know/not applicable" were not assigned a score and these responses were not included in the calculation of the average. Therefore, scores closest to 1 or 4 represent strongest agreement *among* the respondents; a value close to 1 represents greater consensus among respondents strongly agreeing with the statement whereas a value close to 4 indicates a greater consensus strongly disagreeing with the statement.

While responses could be analyzed by the type of organization or expertise of the individual, this level of analysis was not conducted as sample sizes would be too small to draw well-founded conclusions. Rather than establishing an arbitrary percentile to represent top responses, EDF chose to select these based on natural groupings and breaks in the data.

3. Question-Specific Results and Discussion

3.1 Survey

A total of 59 individuals responded to the survey for a response rate of approximately 23.6%, assuming the survey reached 250 persons. Of these 59 respondents, 42 provided information regarding their profession and expertise; nine respondents chose "other" as their profession and none of those specified their field of expertise. These data demonstrate the survey obtained input from the desired professional population involved with aspects of building community resiliency to storms and sea level rise: 66.7% of respondents were involved in aspects of coastal resilience/hazard mitigation, 47.6% in coastal zone management, 42.9% in community development, 40.5% in disaster emergency preparedness and/or response, 21.4% in other areas (percentages add up to over 100 as respondents were allowed to select more than one response) (**Figure 1**). Noteworthy is the lack of respondents in state government positions. The population notified of the survey included approximately 10 representatives of state agencies. While this could be an artifact of sampling, it may also be indicative of low state engagement in the region and its coastal resiliency efforts.

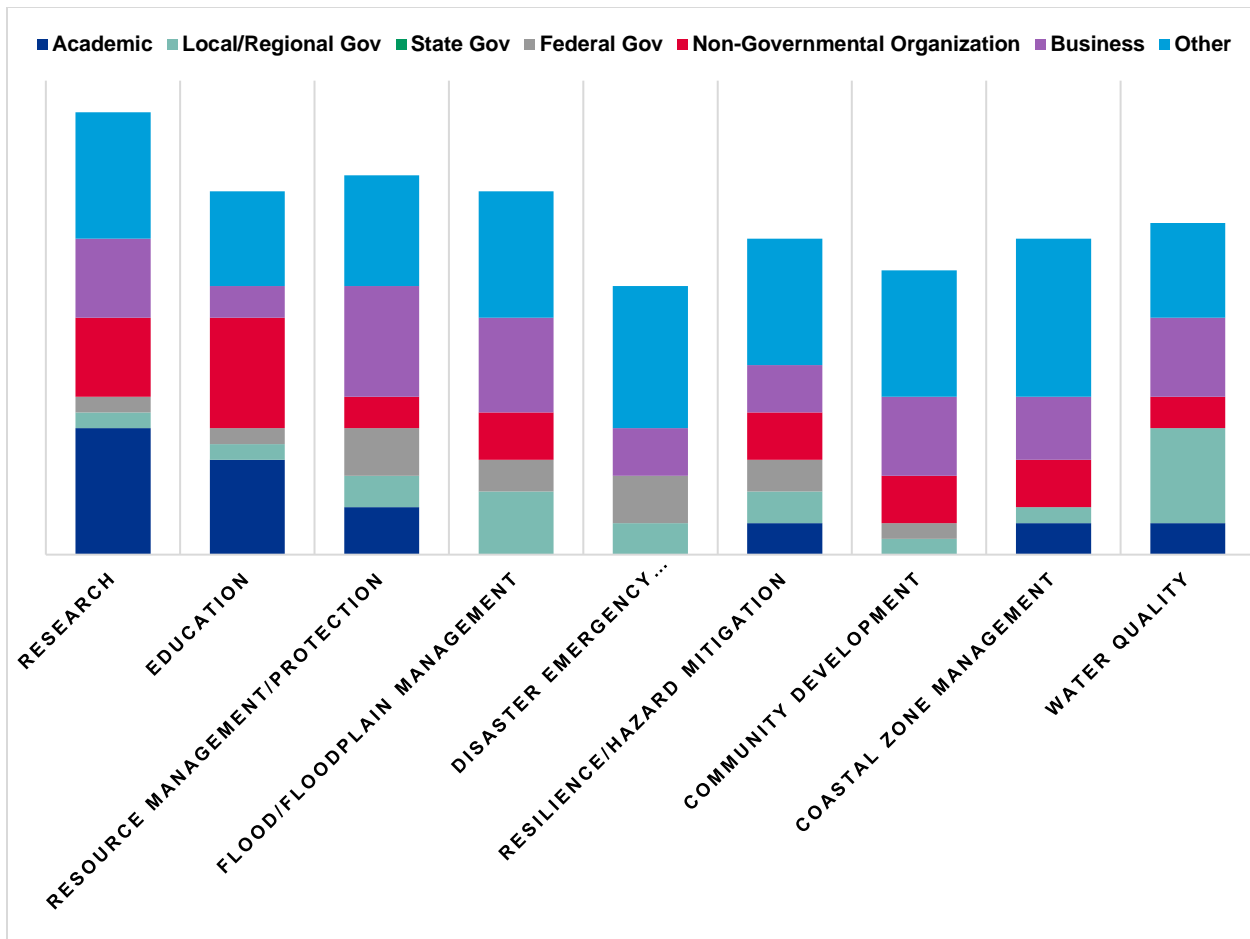


Figure 1: An overview of survey respondents. The majority of respondents' self-identified areas of employment and expertise. Participants could identify multiple areas of expertise. Full text description of expertise area is provided in Appendix A.

3.2 Environmental Issues Most Exacerbated by Climate Change

Respondents were asked to select up to five of 19 environmental issues, including "other", that they believed would be most exacerbated by sea level rise and more severe storm events (**Figure 2**). Responses clustered around six choices providing a clear indication of a high degree of consensus around which environmental issues are expected to be more problematic in the future: (1) Shoreline erosion, (2) stormwater quantity, (3) habitat loss, (4) stormwater quality and nutrient management; (5) management of coastal developments and (6) shoreline hardening.

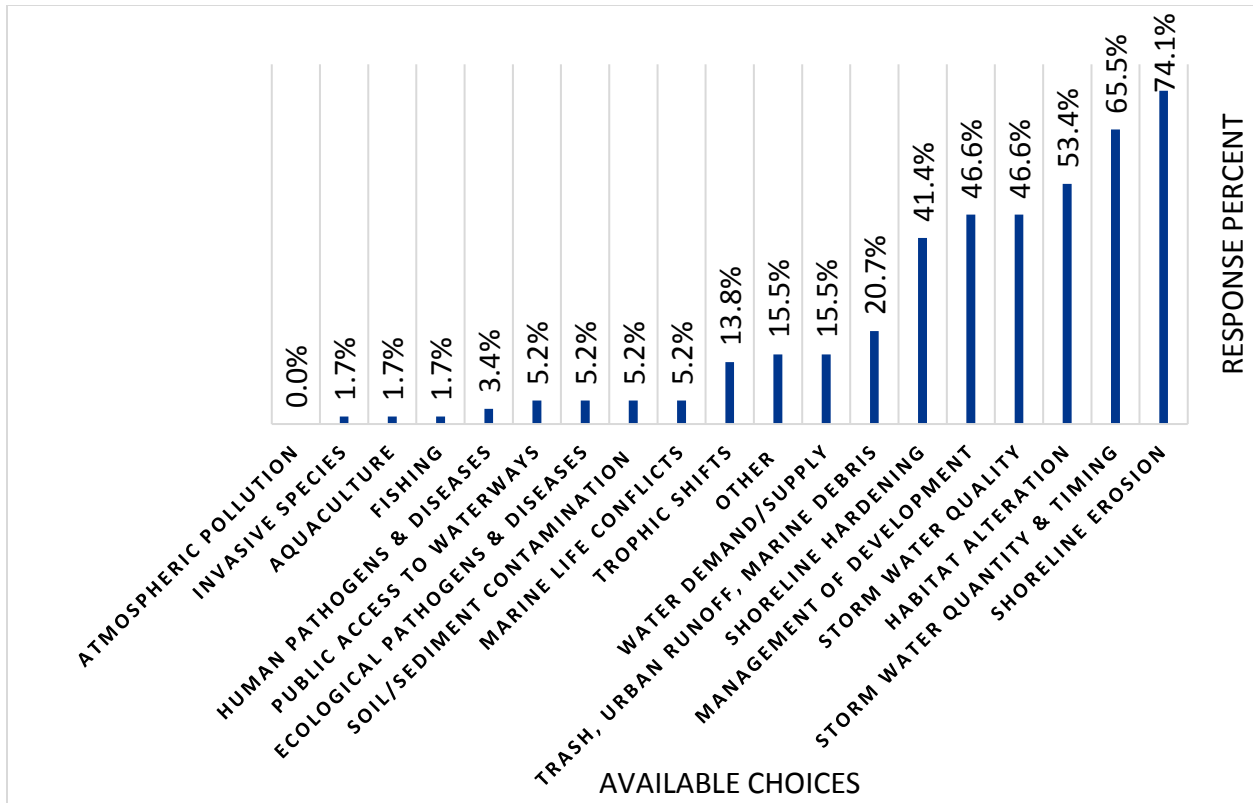


Figure 2: Environmental issues identified as being most exacerbated by sea level rise and more severe storm events; the titles are summaries of the top issues. Respondents were asked to choose their top five.

The links between these issues are well established (Dugan et al., 2011; O’Meara, et al., 2015). For example, there is evidence that bulkheads and sea walls can increase erosion and accelerate habitat alteration and loss (Bozek and Burdick, 2005; NRC, 2007; Dugan et al., 2008; Dugan et al., 2011; Sutton-Grier et al., 2015) and increased coastal development and increased shoreline erosion can be expected to increase demand for structural shoreline protection measures.

Fortunately, measures exist that can simultaneously address aspects of these challenges. The addition of green infrastructure and new low-impact designs can reduce the impacts of coastal developments on storm water quantity and quality (Kim et al., 2015). Actions to support broader adoption of these measures seem warranted. Advancing development and acceptance of alternative means to improve shore protection compatible with or restoring natural habitats, such as living shorelines and other natural infrastructure approaches, would appear to be a priority for the region.

3.3 Key Challenges to Reducing Risks from Sea Level Rise and Storm Damages

Participants were asked to choose five from among 28 major challenges that they face to reduce risks from sea level rise and storm damages. Respondents' selections reflect considerable agreement (**Figure 3**).

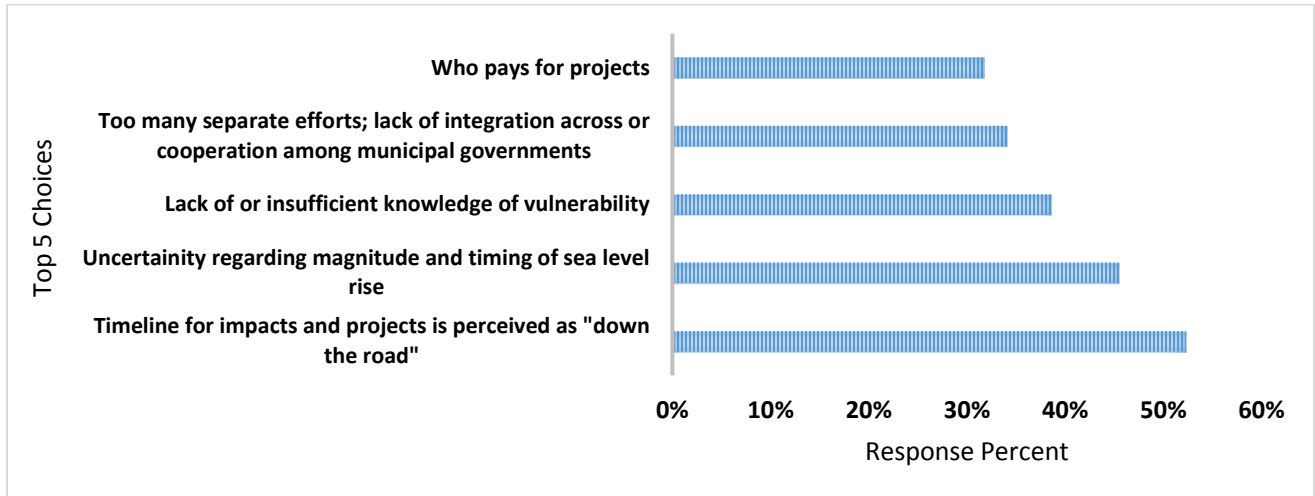


Figure 3: The top five challenges to reducing Hampton Road's risks from sea level rise and storm damages by percent of respondents. Respondents choose 5 out of the 28 choices offered. Other choices received less than 30% response rate. Refer to Appendix A to see the full list of choices offered.

The identified top challenge relates to the perception that sea level rise flooding risks are an issue to be dealt with in the future. Yet building resilience to coastal flooding risks takes time. Community master planning, new zoning, improved building codes, and major public works projects, for example, take decades to bring about meaningful community-wide improvements in resiliency. Ideally building resilience to flood risks should be done ahead of disasters to lessen their impact and cost. Until the public are aware of current flood risks (i.e., the third highest ranked challenge) and perceive threats of sea level rise and increased flooding as a pressing problem, it will be difficult to build the necessary support for setting in motion and sustaining these and other resilience measures. To overcome this major hurdle to effectuating resilience, innovative grassroots education campaigns will be necessary.

Compounding the situation is the second highest ranked challenge -- uncertainty regarding the amount and timing of sea level rise. Agencies and public officials are struggling to choose which measures to invest in and when. Typically flood risk reduction planning used probabilities based on historic flooding. These patterns can no longer be the sole basis of forecasting flood risk and evaluating the cost and benefits of projects. New paradigms are needed to provide public officials and taxpayers with assurance that investments are sound. In the absence of certainty, property owners, planners and decision makers can make "no-regrets" decisions that improve resiliency to reasonably foreseeable flood risks and apply principles of flood-adaptive design and adaptive management. Strengthened public awareness and involvement would help create and sustain greater public support for actions to build resiliency and shore up leaders' confidence in making decisions about investments.

Closely related to these challenges is the fifth ranked challenge -- who pays for projects. Communities perceiving no immediate benefits (e.g., because sea level rise is a problem for the future) may object to

any investment in planning and will be unwilling to pay, approve additional taxes, or support bonds. Participatory planning methods offer significant opportunity for overcoming these challenges. Both involve a strong two way education component where citizens and experts learn from each other and together design plans that simultaneously address multiple issues.

Those surveyed also indicated that there were too many separate efforts that lacked integration. This indicates that while some obstacles have been overcome to begin flood resiliency projects, those surveyed are not convinced that the separate projects make sense or combine to build over the long term a resilient region. Respondents see value in having a region-wide resilience plan to guide and coordinate actions, establish priorities, and contribute to long-term sustainability of the region.

3.4 Innovations Needed

The survey's opened ended question about the innovations needed to implement timely and effective community resilience elicited 21 responses. After categorizing all the comments based on content, seven themes emerged with four garnering 80% of the comments. The four most desired innovations are those that would:

- (1) Improve coordination across the region's governmental agencies
 - Comments reflected a need to bring all levels of government together and create a collaborative system. Additionally, increased coordination at the regional level to better address flooding. Comments also expressed the need for a common and leading entity to facilitate coordination between different regions and governments.
- (2) Advance risk assessment modeling and analytic technologies
 - Comments indicated that improvements in modeling and analysis, as well as improvements in user-friendly interfaces would increase not only the information available but its utility for stakeholders and government officials to explore the effects of climate change on specific properties, infrastructure, and the region. These improvements would also facilitate comparison of the performance of risk management solutions including use of natural infrastructure.
- (3) Expand options for reducing risk
 - Comments reflected interest in improving buyout programs and improving understanding of design, construction, and maintenance requirements of restoring risk reducing natural infrastructure features.
- (4) Enhance the cost-effectiveness of risk reduction
 - Comments about cost emphasized the desire for improved tools to quantify and monetize the myriad costs and benefits, including ecosystem services, of risk reduction solutions. This would facilitate comparison of various measures and combination of measures and aid demonstration of how measures also address other community interests and needs.

Comments also reflected that adequate information was available to choose no-regrets measures (i.e., those for which there exists little downside to implementation as they address a current or reasonably foreseeable need) and transitional measures (i.e., those designed to be adapted later after plans or conditions evolve) to immediately begin enhancing resilience.

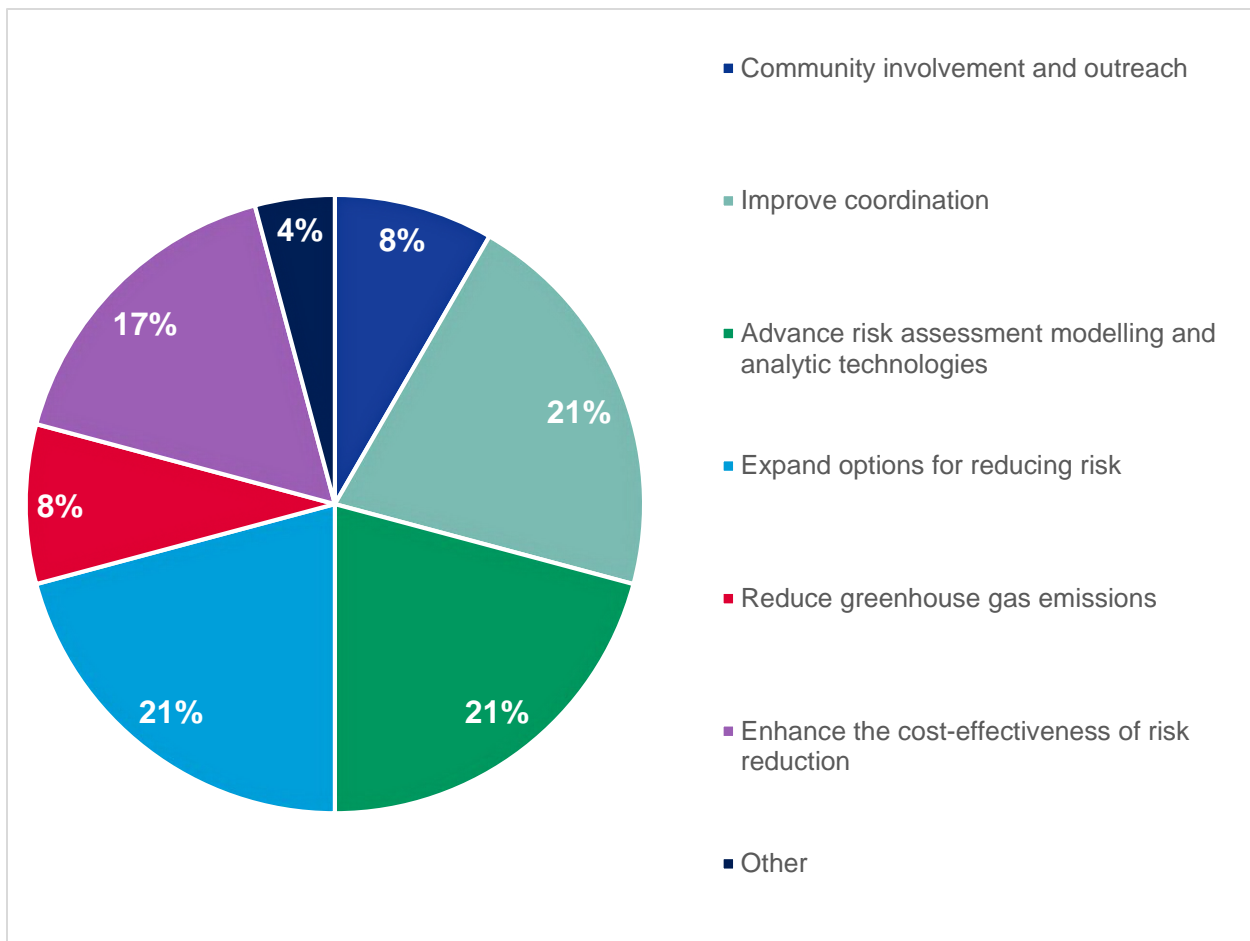


Figure 4: The number of comments in each innovation theme that would make implementing community resilience more effective and timely. Some detailed comments fit into multiple themes and were recorded as such.

3.5 Skills, Tools, and Authorities to Build Community Resiliency

To see if responses were influenced by preceding questions, a similar open-ended question regarding the skills, tools and authorities the respondents desired in order to enhance community resiliency. A total of 35 responded. After categorizing comments based on their content, 6 general themes (and an “other” category) emerged (**Figure 5**):

(1) Unified organization and leadership

- Comments reflect a strong desire for unified organization and leadership with comments including such topics as desiring a one central organization to encourage cooperation between agencies as well as local, state, and federal governments, and serve as a middle ground between community members and those with more leadership and authority.

(2) Planning, mapping tools, and modelling

- The need for flood mapping and other modeling tools to assist development of community plans and improve stakeholder awareness of risks and opportunities to mitigate those hazards emerged as a high priority. Comments reflected an interest in

having a regional planning template that showed how areas, heights, and duration of flooding (from riparian floods and storm surge) coupled with relative sea level rise will affect communities. Of particular interest were methods to better inform citizens about risk and risk reduction methods and build community consensus around a solution set.

- (3) Community engagement
 - Comments reflected the desire to improve the involvement of community members; for example, “I would like to see more programs aimed to inform and engage the public” and “Community representatives (i.e., civic leagues, businesses, [and] professional organizations) and citizens need to get involved more.” Respondents desired ways to get more residents interested in attending meetings and acting as community representatives.
- (4) Greater funding
 - Only five respondents expressed the need for additional funding; this implies that while additional funding may be desirable, other needs are seen as more significant at this time.
- (5) Certainty regarding sea level rise
 - Respondents felt greater certainty about the timing and magnitude of sea level rise would help planning the types and timing of projects
- (6) Quantification of resiliency
 - A few respondents commented that having method to express current resiliency and measure progress would aid efforts to demonstrate need, compare proposed solutions, and document progress.

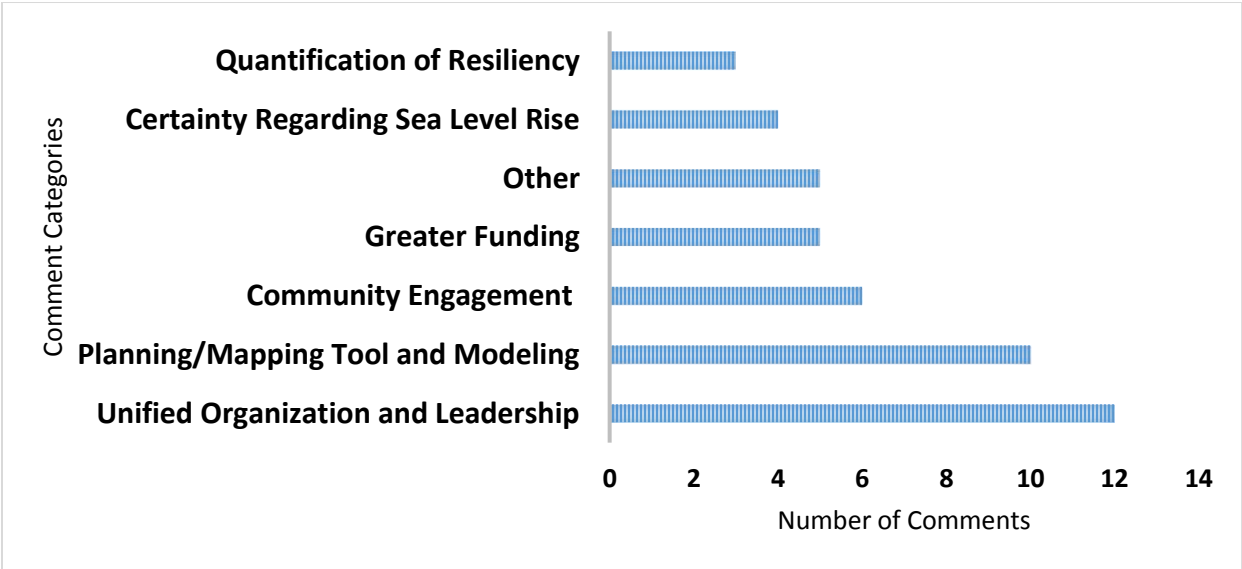


Figure 5: Number of comments received in each theme regarding skills, tools, or authorities respondents wish they had access to in order to increase building of community resiliency to sea level rise and severe storms. Note that some comments fit into more than one category.

3.6 Resiliency Visioning and Planning

Respondents were asked to react to 10 statements regarding different aspects of resiliency visioning and planning. Respondents demonstrated fairly consistent opinions (summarized in **Table 1**). The majority of professionals working on Hampton Roads resilience felt they understood what coastal resilience means, that they know solutions to cope with sea level rise and more flooding, but they lack a unifying vision that integrates near- and long-term resilience issues. Respondents felt that residents, particularly those that may be especially vulnerable to disasters (i.e., those currently living in floodplains, minority or elderly communities, or people with disabilities) are not particularly aware of the risks they face. Respondents desire a common set of future sea level rise scenarios to improve decision-making and help outreach to the public about current and future risks.

Table 1: The top statements, of 10 choices, respondents agreed and disagreed with, based on the average score. Statements are presented in order of most agree/disagree to least agree/disagree. Average scores are provided in parentheses; a (4) would indicate unanimous strong disagreement and (1) unanimous strong agreement.

Agree	Disagree
I have a clear understanding of what coastal resilience means. (1.48)	In general, residents in communities of color in the Hampton Roads area have a good understanding of their risks from sea level rise and more severe storms. (3.15)
A common set of future sea level rise scenarios would improve decision-making. (1.82)	<p>In general vulnerable members (e.g., elderly, persons with disabilities, poor, etc.) of the Hampton Roads areas have an understanding of sea level rise and flooding risks. (3.13)</p> <p>The Hampton Roads region has a clear unifying vision that integrates near- and long-term resilience issues while solving other community challenges. (3.13)</p>
Agencies know the solutions for coping with sea level rise and more flooding, but don't have the political support (authority and funding) to implement them. (2.23)	In general, residents of neighborhoods in the Hampton Roads area existing in the 500 year floodplain have a good understanding of how sea level rise and more frequent severe storms events will affect them. (3.15)

Less consensus existed regarding, “Agencies know the solutions for coping with sea level rise and more flooding, but don't have the political support (authority and funding) to implement them”. However comments offered by those that agreed and disagreed with the statement reflected they agreed that agencies lack of political support to implement solutions. Some that disagreed with this statement indicated that no solutions exist and that agencies do not yet have a good handle on solutions. This may reflect a dissatisfaction or discomfort with solutions being discussed.

3.7 Governance

When provided with 11 statements about governance issues, respondents demonstrated very consistent opinions highlighting the need for greater leadership and alignment across all levels of government (**Table 2**). Comments illustrate this theme; for example, one respondent noted, “There must be a unified plan that extends from the Federal, to State and to local government plans”. Comments also indicated a strong desire for support from the State of Virginia and federal agencies and a belief that resiliency planning is far more than a local issue. While funding might be expected to be a priority need, improvements in state policies and practices to ensure local agencies have the authorities they need to undertake actions that improve resiliency is seen as a larger issue.

Virginia is a Dillon rule state where local jurisdictions are intentionally limited to implementing actions for which they have expressed authority by the State legislature. Comments offered reflect the chilling effect the Dillon rule has had on local agency actions or willingness to take actions to build resilience. Other comments reflect frustration over the lack of state leadership and engagement in building Virginia’s coastal resiliency. The strong level of agreement regarding governance issues strongly points to the need for designation of a leadership team responsible for: aligning federal, state, and local agencies priorities and actions; ensuring coordination across jurisdictions; changing state policies and practices to support local action; and harmonizing funding from multiple sources.

Table 2: Top three statements relevant to governance presented in order from strongest agreement/disagreement to least (average scores in parentheses); a (4) would indicate unanimous strong disagreement; a (1) unanimous strong agreement.

Agree	Disagree
Narrow thinking and turf issues lead to reduced effectiveness of resiliency planning, redundant efforts and inefficient use of funding. (1.72)	The region's political leaders know that voters support and want action to enhance coastal resiliency. (2.96)
Changes in state policies and practices are needed to ensure effective coastal resiliency. (1.78)	Federal agencies are aligned and effectively support Hampton's Road's resilience work. (2.84)
Agencies could do more to implement resiliency faster if they had clearer lines of responsibility. (1.90)	Coastal resiliency planning is a local issue, best addressed by each jurisdiction. (2.81)

3.8 Solutions

EDF presented seven statements about knowledge of solution types and tradeoffs (**Appendix A**). Respondents demonstrated congruent opinions regarding the need for more information about solutions. Respondents feel that the region’s most vulnerable residents lack understanding of risk reduction solutions and the tradeoffs involved in choosing one over another (**Figure 6**). Comments also reflect a lack of awareness of risk and solutions to reduce risk and a need to correct this situation. For example, “Most people don’t know they are in the 500 year floodplain, let alone what that means with regard to sea level rise” and “Cities need to do more outreach and take action to empower their citizens”. The respondents also believe that the general public, particularly the most vulnerable, lack basic understanding of the environmental, economic, or social costs and benefits of potential solutions.

This means that the region will need a concerted effort to educate the public to help inform their tradeoff analysis.

Table 3: Average scores for responses to statements about knowledge about solutions for lessening flood risks; values closest to (4) indicate greater strong disagreement.

Statements
A clear set of measurable environmental, social, and institutional objectives exists with which to create viable solutions to build resilience. (2.83)
In general the public understands the contribution of natural infrastructure (i.e., beaches, dunes, oyster reefs, maritime forests) to risk reduction and resiliency. (2.98)
In general, the public understands the co-benefits of natural infrastructure beyond flood risk reduction. (2.98)
Neighborhoods currently experiencing flooding episodes have an understanding of the kinds of solutions that can help them reduce the risks of flooding and storm damage. (3.02)
Neighborhoods of color have an understanding of the array of solutions for reducing their current and future risks of flooding and storm damage. (3.17)
Neighborhoods in the 500 year floodplain have an understanding of the array of solutions for reducing their growing risk from flooding & storm damage. (3.19)
In general, the public understands the biological, physical and economic consequences of structural features such as sea walls, levees, and bulkheads. (3.20)

A sophisticated survey of the public is necessary to ascertain whether these perceptions are correct. If a public survey bears out these findings, methods to enhance community involvement, improve the penetration of information into these communities, and to verify the effectiveness of education, would be highly beneficial.

3.9 Information and Skills

Presented seven statements, respondents’ choices reflect general agreement about improvements that would build the region’s capacity to address resilience (**Table 4**).

Table 4: Statements respondents addressed with corresponding rating average (shown in parentheses); a (4) would indicate unanimous strong disagreement and (1) unanimous strong agreement.

Agree	Disagree
Quantification of ecosystem services is important for making sustainable resiliency decisions for the region. (1.92)	Real estate and development professionals understand sea level rise and storm surge vulnerabilities/risks. (3.00)
It is possible to quantify the risk reduction benefits of natural infrastructure. (1.98)	Governmental agencies fully understand the concerns of all stakeholders. (2.87)
More detailed information and case studies on successful floodplain management and buyout programs would bolster willingness to implement actions. (2.02)	Real estate and development professionals understand the effectiveness and limitations of risk reduction features, including natural defenses like dunes and wetlands. (2.83)
I fully understand how to implement new participatory design practices (a.k.a. community-based participatory research and crowd co-design) to enhance community involvement. (2.43)	

Information to quantify risk reduction and other ecosystem services would aid efforts to assess a range of benefits and evaluate tradeoffs to aid selection of solutions that work best for community values and needs. Other responses address the need for more information regarding options for reducing risk and building resiliency. Respondents’ comments provide supporting evidence: “The public tends to think structural features are the only way to solve flooding”; “Most people have no idea of the economic consequence of bulkheads, sea walls, etc., most think they are the only solutions”, and “They [the public] do not understand the cost, liability, and environmental impacts and often solely focus on the physical protection of their structures that would buy them more time/preserve value”.

Respondents felt that developers and real estate professionals need to understand both risks and risk reduction measures. This indicates a desire for these professionals to exercise more responsibility for designing more resilient communities and for informing homeowners and buyers of the risks and solutions for mitigating risks to encourage action that will help sustain property values.

Responses also indicate a strong interest in building regional capacity to implement floodplain management, including targeted buyout programs, to lessen risks and build resiliency. Training that provides detailed information on how other communities successfully implemented buyouts and strengthened floodplain management through zoning, open space acquisition, and building codes would help the region -- from political leaders and agency staff to citizens – accelerate adoption of practices, lower risks, and reduce insurance costs.

3.10 Research and Development Priorities

Questions about R&D needs focused on six themes: (1) risk perception, (2) risk, (3) relocation, (4) multiple lines of defense (MLOD) strategies, (5) building stakeholder and political support, and (6) policy, financing, and legal issues. Respondents had a list of four to eight topical choices, in addition to “other”, from which to identify a priority research topic. In every category, except building stakeholder and political support, a majority formed indicating fairly large agreement on informational and tool needs (**Table 5**). Focusing research funding on these priorities first would appear the best course of action to accelerate resilience efforts by providing important detailed region-specific data. These research needs will provide data and tools that help build stakeholder support for changes that enhance resiliency, can improve community member understanding of risks and facilitate stakeholder comparisons of possible solutions.

Table 5: Top R&D priorities by theme with the corresponding response percent.

Theme	Top R&D Priority	Response Percent
Risk Perception	Comparison of flood modeling results to actual community member understanding of and personal estimates of flood impact to property.	65.2%
Risk	Development of tools to compare changes in flood damages from various mitigation options.	58.7%
Relocation	Identifying primary concerns about and test possible solutions for relocation to guide creation of relocation policies and programs.	51.1%
MLOD Strategies	Development of local engineering and ecological criteria for coastal wetland restoration.	77.3%
Stakeholder and Political Support	Development and testing of messages regarding value and benefits of MLOD strategies that include natural infrastructure; <i>and</i> In-depth assessment of regional industries and businesses that will directly benefit from a climate change adaptation economy.	44.4% (tied)
Policy, Financing, & Legal Issues	Explore and develop new financing mechanisms for coastal resiliency.	66.7%

The R&D needs for building stakeholder and political support for resilience address effective messaging but respondents primarily clustered into one of two groups. One focused on building a positive message about how businesses can directly benefit from climate change actions. The other on developing and testing messages to build support for resilience strategies that rely on a comprehensive strategy that employs natural defenses, engineered structures, new building codes, zoning and buyouts. Together with early warning and evacuation, these measures will reduce the negative consequences of extreme weather and sea level rise. Over three-quarters of the respondents felt that the development of local engineering and ecological criteria to guide coastal wetland restoration would advance its use in an MLOD strategy.

4.0 Discussion

The survey results clearly indicate that efforts are underway to consider how to address impacts expected from further sea level rise and more frequent intense weather events. Responses, particularly explanatory comments, reveal apprehension regarding public's lack of awareness of or concern about current and future risks and the implications for taking timely actions to mitigate these increasing risks. Expressions of grassroots concern about risks and need for actions to reduce community vulnerability are widely viewed as necessary to generate greater government interest, action and funding especially at the state and local level. The federal government, through the military, is actively exploring what climate change means for the region due to its concerns about the effect of climate change on the continuity of its operations. The US Army Corps of Engineers has already presented ideas for reducing the area's vulnerability (USACE, 2015). Valuable new information on the region's flood risks was released after this survey took place (Hall, 2016). The region's largest city, Norfolk, with support from the Rockefeller Foundation, has led the region's local governments by creating its [resilience strategy](#) (Norfolk, 2015). These, and other studies, together with on-the-ground experience, are improving the knowledge base necessary for planning and coping with flood risks. Yet even Norfolk's [website](#) dedicated to flooding awareness and flood mitigation lacks information on *growing* flood risks. This could be intentional and stemming from a lack of confidence in sea level projections, indicating the lack of an overarching vision for building resilience to climate change that unifies agencies and creates consistent communications.

Respondent's generally agreed that the most physically and economically vulnerable populations were unaware of their current and future risks and of the range of solutions to mitigate those risks; these opinions should be borne out by surveys of community members. Yet, respondents did not place especially high priority on innovations to improve community involvement and outreach. More emphasis was placed on better predictive modelling and mapping tools to present flood risk information. Progress on the identified R&D priorities will improve data and information available to community members to understanding of risks and comparison of solutions. That alone will be insufficient. Concerted efforts to translate findings in a manner relevant to homeowners and businesses and improved community outreach and engagement tactics will be necessary.

Responses to multiple questions indicate that participants clearly feel that the region would benefit from creation of a unifying vision and strategy for building the region's resilience. Survey responses noted community "turfiness" as a problematic and overwhelmingly supported a regional approach to resiliency. Civic pride and competition among the region's communities stymies cooperation and adoption of ideas from one another. Building resilience to disasters will require individual actions and the cooperation of local, state, and federal agencies as well as the involvement of the NGO and academic communities. Respondents reflected frustration with what they perceived as insufficient State attention to the threats posed by sea level rise to the state's economy. Because Virginia is governed by the Dillon rule^[1], the state legislature is critical to establishing appropriate governance to help bring the region together and providing the necessary authorities for local actions to implement meaningful

^[1] Virginia's Dillon Rule intentionally restricts local jurisdictions from taking actions when the state has not expressly given them authority and responsibility. The rule makes it difficult for local jurisdictions to zone or re-zone properties or to create special tax districts to pay for projects, and is often cited as the reason for poor implementation of regional plans.

actions to move the communities of Hampton Roads to a sustainable future. Respondents also noted some frustration with the number of uncoordinated studies and meetings happening across the region.

There would appear to be support for designation of a leadership team lead by the state and comprised of representatives of federal and local government that was charged to:

- Develop a vision for the region's future inspires the public and builds confidence in the continuing viability of the region.
- Provide focus to align federal, state, and local agencies priorities, policies, and actions.
- Identify and support additional authorities to implement the vision.
- Leverage funding and harmonize investments.
- Ensure coordination across jurisdictions.

At a minimum such a governance structure would facilitate collaboration across federal, state, and local agencies. By filling a current leadership void, it would provide a strong voice necessary to represent the region by sending clear messages to political leaders, investors, as well as the public.

Respondents indicated they knew what needed to be done while they also noted that they did not have a good understanding of all the stakeholders' interests. This disconnect, if perpetuated, does not bode well for building public and political support for action and could result in poorly conceived projects. Philanthropic institutions and NGOs may be well suited to bridge this gap by creating neutral spaces and processes that effectively provide safe ways to educate public and explore ideas that enthuse the public. NGOs, especially when partnered with the academic community, can help translate scientific and engineering information to build awareness and understanding of risks and solutions. Similarly NGOs are well-suited to working with communities to create innovative ideas and to mobilize community members to influence decision-making.

Respondents noted that when stakeholders had knowledge about flood reduction measures they were primarily familiar only with traditional structural approaches (e.g., seawalls, bulkheads, and levees) and not aware of the environmental, cost, and quality of life tradeoffs associated with these structures. They believe the public generally lacks understanding of how restoring and maintaining natural infrastructure -- such as wetlands, unobstructed floodplains, oyster reefs, and sand dunes -- can reduce risk and enhance the region's resilience. To build a more resilient region, community outreach is needed to inform the public about all available options, their limits, how they complement one another, their life cycle costs, and how to maintain their functionality. An understanding that no single measure protects against all conditions is critical for the public to support multiple strategies to reduce vulnerabilities.

Scientists at the Virginia Institute for Marine Science (VIMS) are largely responsible for developing the designs for and use of living shorelines to attenuate waves, reduce erosion and improve water quality in the region. The survey responses indicate that more work is necessary to advance broader acceptance of living shorelines potential to enhance the region's ability to cope with sea level rise and more frequent, intense storms. Collaboration between VIMS, Old Dominion University, and Virginia Tech, and other local experts could accelerate the desired development of regional guidelines for design of natural infrastructure. Likewise multi-disciplinary teams, formed with experts from the region's universities, could develop regional methods to quantify the risk reduction and other ecosystem services provided by natural and built infrastructure to more fully inform public opinion and decision-making.

5.0 Conclusion

The survey findings indicate a compelling need for building regional citizens' knowledge base to enhance their capacity to take measures that build their personal resiliency and to participate meaningfully in planning the region's future. Locally accurate data on current and likely future flood risk is a first step but by itself will be insufficient. Information must be meaningful to property owners, residents and businesses so that they understand the locations, height and duration of floods, and recognize the economic and other impacts of flooding (e.g., effects on emergency services) to themselves and the region. Dynamic, user-friendly flood impact visualization tools together with the development of methods for comparing environmental, economic, and social characteristics of alternative solutions will provide more digestible and actionable information for agency managers and the general public. Far more effective methods of reaching into communities and involving stakeholders will likewise be critical for building public understanding and support for actions to manage risks and build vibrant and resilient communities. Addressing these issues will facilitate public engagement and informed decision-making about which risks are acceptable, which solutions are suitable, and the advantages of taking action before crippling disaster strikes. While these tools are being developed, greater state leadership and commitment and improved systems of collaboration across governmental bodies can be created and fine-tuned. Addressing each of these needs will be crucial for successfully building Hampton Roads into a more economically, socially, and environmentally sustainable and resilient region.

References

- Bozek, C. M., and Burdick, D. M. (2005). Impacts of seawalls on saltmarsh plant communities in the Great Bay Estuary, New Hampshire USA. *Wetlands Ecology and Management*, 13(5), 553-568.
- Dahl, K., Caldas, A., Spanger-Siegfried, E., and Udvardy, S., 2016, The US Military on the Front Lines of Rising Seas: Union of Concerned Scientists.
- Dugan, J. E., Airoidi, L., Chapman, M. G., Walker, S. J., Schlacher, T., Wolanski, E., and McLusky, D. (2011). Estuarine and coastal structures: environmental effects, a focus on shore and nearshore structures. *Treatise on Estuarine and Coastal Science*, 8, 17-41.
- Dugan, J. E., Hubbard, D. M., Rodil, I. F., Revell, D. L., and Schroeter, S. (2008). Ecological effects of coastal armoring on sandy beaches. *Marine Ecology*, 29(s1), 160-170.
- Hall, J. A., S. Gill, J. Obeysekera, W. Sweet, K. Knuuti, and J. Marburger, 2016, Regional Sea Level Scenarios for Coastal Risk Management: Managing the Uncertainty of Future Sea Level Change and Extreme Water Levels for Department of Defense Coastal Sites Worldwide. Defense of Defense: Alexandria, Virginia, Strategic Environmental Research and Development Program, 224 pgs.
- Hansen, J., Sato, M., Hearty, P., Ruedy, R., Kelley, M., Masson-Delmotte, V., Russel, G., Tselioudis, G., Cao, J., Rignot, E., Velicogna, I., Tormey, B., Donovan, B., Kandiano, E., Schuckmann, K. v., Kharecha, P., Legrande, A. N., Bauer, M., and Lo, K.-W., 2016, Ice melt, sea level rise and

superstorms: evidence from paleoclimate data, climate modeling, and modern observations that 2°C global warming could be dangerous: *Atmos. Chem. Phys.*, v. 16, p. 3761-3812.

Hobor, G., Plyer, A., and Horwitz, B., 2014, *The Coastal Index: the problem and possibility of our coast: The Data Center.*

Kim, G., Miller, P. A., and Nowak, D. J., 2015, *Assessing urban vacant land ecosystem services: Urban vacant land as green infrastructure in the City of Roanoke, Virginia: Urban Forestry & Urban Greening*, v. 14, no. 3, p. 519-526.

McGarry, J., Kovarik, B., and Tyson, R., 2014, *Safe Coast Virginia: Climate change threats and practical solutions for coastal Virginia: Chesapeake Climate Action Network.*

National Research Council. (2007). *Mitigating shore erosion along sheltered coasts.* Washington, D.C.: National Academies Press.

NIBS, 2005, *Natural Hazard Mitigation Saves: An independent study to assess the future savings from mitigation activities: National Institute of Building Sciences.*

Norfolk, 2015, *Coastal Resilience Strategy Norfolk, Virginia, Department of Public Works*, p. 14.

O'Meara, T., Thompson, S. P., and Piehler, M. F. (2015). Effects of shoreline hardening on nitrogen processing in estuarine marshes of the US mid-Atlantic coast. *Wetlands Ecology and Management*, 23(3), 385-394.

Sutton-Grier, A. E., Wowk, K., and Bamford, H. (2015). Future of our coasts: the potential for natural and hybrid infrastructure to enhance the resilience of our coastal communities, economies and ecosystems. *Environmental Science and Policy*, 51, 137-148.

USACE, 2015, *North Atlantic Comprehensive Coastal Study, Department of the Army, Washington, DC*, 116 pgs.

Virginia Labor Market Information, 2016.

http://bi.virginialmi.com/rdPage.aspx?rdReport=lmitools_demographics&tabsDemographics=tpnlPopulationChange&rdNoShowWait=True&rdWaitCaption>Loading. Retrieved August 3, 2016

Appendix A: Summary of Hampton Roads Flood Resilience Survey Questions

Question 1: Hampton Roads faces many issues, now and in the future. Which environmental issues will be most exacerbated by sea level rise and more severe storm events? (Pick up to 5)

Answer Options
Shoreline erosion
Storm water quantity and timing (including riverine flooding and heavy precipitation events)
Storm water quantity, nutrient management, nutrient loading
Habitat alteration or loss
Invasive species
Soil/sediment contamination (e.g. inorganic pollutants such as heavy metals and persistent pollutants)
Atmospheric pollution
Trash, urban runoff, marine debris
Marine life conflicts
Public access to waterways
Human pathogens and diseases
Ecological pathogens and diseases
Water demand, ground water supply
Fishing—overfishing, habitat damage, bycatch
Trophic shifts (changes in species composition due to shifting ranges)
Aquaculture
Management of development
Installation of additional structural shoreline protection measures
Other (please specify)

Question 2: Please react to each statement pertinent to resiliency visioning and planning by selecting either strongly agree, agree, disagree, strongly disagree, or not applicable/I don't know.

Statements
I have a clear understanding of what coastal resilience means.
Agencies know the solutions for coping with sea level rise and more flooding, but don't have the political support (authority and funding) to implement them.
The Hampton Roads region has a clear unifying vision that integrates near- and long-term resilience issues while solving other community challenges.
In general, residents of neighborhoods in the Hampton Roads area currently experiencing flooding episodes have a good understanding of sea level rise and increased flooding risks.
In general, residents of neighborhoods in the Hampton Roads area existing in the 500 year floodplain have a good understanding of how sea level rise and more frequent severe storms events will affect them.
In general, residents in communities of color in the Hampton Roads area have a good understanding of their risks from sea level rise and more severe storms.
In general vulnerable members (e.g., elderly, persons with disabilities, poor, etc.) of the Hampton Roads areas have an understanding of sea level rise and flooding risks.
Government-sponsored public meetings result in meaningful opportunities for the public to influence flood and sea level rise resiliency plans.
There is insufficient local control and authority to implement and enforce existing plans.
A common set of future sea level rise scenarios would improve decision-making.

Question 3: Please react to these statements about governance by selecting either strongly agree, agree, disagree, strongly disagree, or not applicable/I don't know.

Statements
Agencies could do more to implement resiliency faster if they had clearer lines of responsibility.
To achieve comprehensive coastal resilience, a single state-based entity is needed to unify state agencies and articulate a clear statement of priorities that focuses development and implementation actions.
Coastal resiliency planning is a local issue, best addressed by each jurisdiction.
Coastal resiliency planning is a state and federal issue, best addressed on a larger scale.
Local governments can do more with existing authorities to improve coastal resiliency.
Changes in state policies and practices are needed to ensure effective coastal resiliency.
Narrow thinking and turf issues lead to reduced effectiveness of resiliency planning, redundant efforts and inefficient use of funding.
DoD's Joint Land Use Studies will serve to identify and unify regional resilience priorities, and provide the best means to continue community development and economic growth and enhance the region's resiliency.
Federal agencies are aligned and effectively support Hampton's Road's resilience work.
The region's political leaders know that voters support and want action to enhance coastal resiliency.
My agency/organization has authority, skills, and tools to implement measures to enhance local or regional resiliency.

Question 4: Please react to these statements about solutions by selecting either strongly agree, agree, disagree, strongly disagree, or not applicable/I don't know.

Statements
A clear set of measurable environmental, social, and institutional objectives exists with which to create viable solutions to build resilience.
Neighborhoods currently experiencing flooding episodes have an understanding of the kinds of solutions that can help them reduce the risks of flooding and storm damage.
Neighborhoods in the 500 year floodplain have an understanding of the array of solutions for reducing their growing risk from flooding & storm damage.
Neighborhoods of color have an understanding of the array of solutions for reducing their current and future risks of flooding and storm damage.
In general, the public understands the biological, physical and economic consequences of structural features such as sea walls, levees, and bulkheads.
In general the public understands the contribution of natural infrastructure (i.e., beaches, dunes, oyster reefs, maritime forests) to risk reduction and resiliency.
In general, the public understands the co-benefits of natural infrastructure beyond flood risk reduction.

Question 5: Please react to statement about information and skills by selecting either strongly agree, agree, disagree, strongly disagree, or not applicable/I don't know.

Statements
I fully understand how to implement new participatory design practices (a.k.a. community-based participatory research and crowd co-design) to enhance community involvement.
It is possible to quantify the risk reduction benefits of natural infrastructure.
More detailed information and case studies on successful floodplain management and buyout programs would bolster willingness to implement actions.
Governmental agencies fully understand the concerns of all stakeholders.
Real estate and development professionals understand sea level rise and storm surge vulnerabilities/risks.
Real estate and development professionals understand the effectiveness and limitations of risk reduction features, including natural defenses like dunes and wetlands.
Quantification of ecosystem services is important for making sustainable resiliency decisions for the region.

Question 6: What are the skills, tools, or authorities you wish you had access to enhance building of community resiliency to sea level rise and severe storms? (Open-ended question)

Question 7: The key challenges to reducing risks from sea level rise and storm damages are (pick your top 5)

Answer Options
Lack of or insufficient knowledge of vulnerability
Lack of concern
Uncertainty regarding magnitude and timing of sea level rise
Religious or cultural beliefs
Conflicting future sea level rise scenarios for Hampton Roads
Timeline for impacts and projects is perceived as "down the road"
Inability to excite and unify stakeholders around solutions
Lack of solutions; lack of known solutions
Lack of agreement on priority projects to implement
Lack of planning
Lack of authority
Too many separate efforts; lack of integration across or cooperation among municipal governments
Lack of state leadership
Concern over role of government
Current or continuing development in the coastal zone
Property values, jobs, tax base and other economic concerns
Other more pressing societal needs
Inflexible rules or rule interpretation
Insufficient local authority (e.g., Dillon rule)
High cost of land and solutions
Who pays for projects
Lack of incentives to each impacts and costs of household/business relocation
Slow speed of buyouts after disasters
Aesthetics of solutions
Focus on traditional structural solutions
Concerns over impacts of projects on quality of life
I don't know.
Other (<i>Add another challenge or provide additional comments on the key challenges you chose</i>)

Question 8: Help identify the top research and development (R&D) priorities that will improve resiliency planning and design: Risk Perception (Pick 2)

Answer Options
Develop understanding of how households perceive their flood and severe storm risks
Develop understanding of how businesses perceive their flood and severe storm risks
Compare flood modeling results to actual community member understanding of and personal estimates of impact of flood to their property
Test effectiveness of various risk information messages on risk perception
Study effects of insurance premium increases on local and state economy
Other (<i>please specify</i>)

**Question 9: Help identify the top R&D priorities that will help improve resiliency planning and design:
Risk (Pick 2)**

Answer Options
Development of tools that use flood/surge models to calculate flood depths, durations, and damages from various storm events.
Development of tools to compare changes in flood damages from various mitigation options (e.g., relocation, house elevation, bulkheads, sea walls, dunes, wetlands, etc.)
Development of tools that evaluate the longevity and effectiveness of flooding and storm defensive measures (both engineered and natural infrastructure).
Development of models to evaluate sea level rise shifts in wetlands distribution and implications for bay health.
Study of economic effects of business interruptions from flooding events.
Other (<i>please specify</i>)

**Question 10: Help identify top R&D priorities that will improve resiliency planning and design:
Relocation (Pick 2)**

Answer Options
Identify explicit factors that motivate low- and middle-income households in coastal areas vulnerable to sea level rise, storm surge, erosion, and environmental quality degradation to relocate to safer locations.
Identify the primary concerns about and test possible solutions for relocation to guide creation of meaningful, fair, and culturally sensitive relocation policies and programs.
Understand the motivations for staying by households at risk of flooding.
For economically vulnerable communities, identify factors that ensure individual needs and socio-cultural and economic aspects can be addressed if relocations are ever pursued.
Explore new relocation financial support strategies.
Other (<i>please specify</i>)

**Question 11: Help identify top R&D priorities that will improve resiliency planning and design:
Multiple lines of defense adaptation strategies. (Pick 2)**

Answer Options
Ascertain migration of wetlands under various sea level rise scenarios.
Develop local engineering and ecological criteria for restoring coastal wetlands that balance enhancing risk reduction with retaining other ecosystem services (e.g., water quality, fisheries/shellfish improvement, bird habitat).
Test methods of oyster reef construction to improve water attenuation and recovery.
Create regional methods for quantifying and comparing impacts and ecosystem services of various adaptation strategies.
Other (<i>please specify</i>)

Question 12: Help identify top R&D priorities that will improve resiliency planning and design: Data for building stakeholder & political support. (Pick 3)

Answer Options
In-depth assessment of regional industries and businesses that will be impacted by climate change.
In-depth assessment of regional industries and businesses that will directly benefit from a climate change adaptation economy.
Evaluate effectiveness of techniques to connect and involve disadvantaged communities.
Determine how local risk, insurance premiums, and environmental amenities affect property values.
Develop and test message effectiveness regarding maintenance and building dunes as a part of a resilience strategy.
Develop and test message effectiveness the build support for improved pre-disaster planning as a means to secure and target disaster funding to build greater resilience.
Develop and test messages about Hampton Road's communities' vulnerability and economic importance to enhance state leadership and funding.
Develop and test messages regarding value and benefits of multiple lines of defense strategies that include natural infrastructure.
Other (please specify)

Question 13: Help identify the top R&D priorities that will help improve resiliency planning and design: Policy, financing, legal issues. (Pick 3)

Answer Options
Gather case studies and evaluate effect of Dillon Rule on local efforts to reduce risks from flooding, storms and sea level rise; identify unused flexibilities and authorities provided by the state.
Identify new authorities needed for local government officials to improve resilience.
Generate ideas for incentives to encourage orderly retreat from the coast in high risk areas.
Explore benefits of parametric insurance for the state or local communities.
Develop and evaluate policies that address the contemporary socio-economic and cultural needs of coastal citizens.
Explore and develop new financing mechanisms for coastal resiliency.
Other (please specify)

Question 14: What innovations would make implementing community resilience more effective and timely? (Open-ended question)

Question 15: About you—what kind of work do you do? (Pick any and all that apply)

Answer Options	Answer Options
Research	Academic
Education	Local/Regional Government
Resource management/resource protection	State Government
Flood/Floodplain management	Federal Government
Disaster emergency preparedness and/or response	Non-Governmental Organization
Resilience/Hazard mitigation	Business
Community development	
Coastal zone management	
Water quality	
Other (Please specify)	N/A