A peer-reviewed version of this preprint was published in PeerJ on 4 May 2020.

View the peer-reviewed version (peerj.com/articles/9044), which is the preferred citable publication unless you specifically need to cite this preprint.

Carpenter AT. 2020. Public priorities on locally-driven sea level rise planning on the East Coast of the United States. PeerJ 8:e9044 https://doi.org/10.7717/peerj.9044

Public priorities on locally-driven sea level rise planning on the East Coast of the United States

Adam T Carpenter Corresp. 1, 2

1 Water Policy and Leadership, American Water Works Association, Washington, District of Columbia, United States

2 Environmental Science and Policy, George Mason University, Fairfax, Virginia, United States

Corresponding Author: Adam T Carpenter
Email address: acarpen8@masonlive.gmu.edu

Sea Level Rise poses a substantial concern to communities worldwide. Increased inundation, storm surge, salt water intrusion, and other impacts create challenges which will require considerable planning to address. Recognizing the broad and differing scope of sea level rise issues and the variability of policy options to address them, local planning frameworks are necessary in addition to tools and resources available from state and federal governments. To help assess priorities and preferences on sea level rise planning, a survey of 503 persons affiliated with coastal communities on the East Coast of the United States was conducted in December 2017. This survey studied key aspects locally-driven sea level rise plans, including planning priorities, funding options, methods to resolve conflict, and potential responses. Six key findings address these and other concerns to provide the foundation of a locally driven framework for public officials.

Public priorities on locally-driven sea level rise planning on the East Coast of the United States

Adam T. Carpenter[1,2]

[1] Water Policy and Leadership, American Water Works Association, Washington, District of Columbia, USA
[2] Environmental Science and Policy, George Mason University, Fairfax, Virginia, USA (at the time the study was conducted)

Corresponding Author:
Adam T. Carpenter
1300 I St NW Suite 701W, Washington, District of Columbia 20005, USA
Email address: acarpen8@masonlive.gmu.edu

Abstract

Sea Level Rise poses a substantial concern to communities worldwide. Increased inundation, storm surge, salt water intrusion, and other impacts create challenges which will require considerable planning to address. Recognizing the broad and differing scope of sea level rise issues and the variability of policy options to address them, local planning frameworks are necessary in addition to tools and resources available from state and federal governments. To help assess priorities and preferences on sea level rise planning, a survey of 503 persons affiliated with coastal communities on the East Coast of the United States was conducted in December 2017. This survey studied key aspects locally-driven sea level rise plans, including planning priorities, funding options, methods to resolve conflict, and potential responses. Six key findings address these and other concerns to provide the foundation of a locally driven framework for public officials.

Introduction

Sea Level Rise poses a serious and ongoing set of challenges to coastal communities globally. With global sea level having already increased by about 0.2 m (0.66 ft) over the last century, there is a need to plan and prioritize to eliminate impacts where possible and reduce their harm when they cannot be eliminated (USGCRP, 2018). Several national and multinational bodies project considerable sea level rise by 2100, including U.S. Global Change Research Program with a 0.30-2.5 m increase relative to the year 2000, and the Intergovernmental Panel on Climate Change (IPCC) with a relative change of 0.26-0.98 m increase in 2081-2100 compared to 1986-2005 (USGCRP, 2017; IPCC, 2013).

There are a number of recent activities for assessment and planning for sea level rise and coastal flooding in Eastern U.S. states and elsewhere (Eastern Research Group, 2013; Hinkel *et al.,* 2010; Miller *et al.*, 2012). Among these are risk-assessments that have taken place in several large U.S. cities, as well as a handful of well comprehensive state policies. Table 1 provides information about several examples, including Maryland and California on the state level (although California not an Eastern state, serves as a useful point of reference), and New York and Miami on the local level (California Coastal Commission, 2015; Griffin *et al.*, 2008; New York Academy of Sciences, 2015; Ruvin *et al.*, 2014). On the opposite end of the policy spectrum, North Carolina has imposed substantial limits on official sea level rise projections and how those projections can be used (North Carolina General Assembly, 2011; Overton *et al.*, 2015). Other states, such as Virginia, have committed to taking action but are early in developing plans (Commonwealth of Virginia Office of the Governor, 2018).

The federal National Flood Insurance Program (NFIP) also assists in reducing the financial risks related to flooding (Chivers and Flores, 2012). Within that program, the Community Rating System (CRS) is a mechanism that encourages floodplain management activities in exchange for reduced premiums for NFIP policies for homes and businesses (FEMA, 2017). A variety of community-level toolkits and example processes to address sea level rise or broader climate change concerns have been proposed (Auermiuller and Maxwell-Doyle, 2013; Marcy *et. al.*, 2012; Martin *et al.*, 2011; May and Plummer, 2011; Mittermaier, 2016; Moser *et al.*, 2010). Practices such as building codes, elevation standards, and insurance are pieces of the planning puzzle, but do not by themselves represent comprehensive planning (Eastern Research Group, 2013).

Not fully addressed in these programs and discussions, however, is an understanding of public priorities and preferences to assist in developing locally driven sea level rise plans. Building sea-level rise policies around local priorities and preferences is not a guarantee for successful protection, as many technical and economic barriers are likely to exist to implementation (Moser *et al.,* 2010). However, such an approach has the benefit of being informed by the community and therefore necessarily having some degree of built-in support, helping to strive towards resilience. This study identifies a series of priorities and preferences of those who live in, work in, or regularly visit coastal communities on the East Coast of the United States, and develops six key findings for consideration by public officials in developing locally-driven sea level rise plans.

Materials & Methods

Between December 20 and December 22, 2017, a survey of was conducted of 503 individuals who live in, work in, and/or regularly visit a coastal community on the East Coast of the United States. The study was reviewed by the George Mason University Institutional Review Board and approved (IRBNet 1168842-1), and the execution of the survey was conducted by Survata

(survey administrator). Written consent was obtained electronically from all participants, and no personally identifiable information was collected.

The survey administrator reached out to potential respondents from their survey pool from states along the U.S. East Coast. All respondents were required to first read and agree to the information on the consent form prior to proceeding to the screening question. Respondents were then asked for their affiliation, if any, with U.S. Coastal Communities. Only those respondents who self-reported that they worked in, lived in, or regularly visited a coastal community on the U.S. East Coast proceeded to the rest of the survey.

The 503 respondents who passed the screening question were presented with 14 technical questions, plus 10 demographic questions. The information gathered includes topics such as relative priorities of other topics in relation to sea level rise, important components for a local plan, preferred funding methods, conflict resolution options, and other facets of planning. Demographics included income, education, ethnicity, political party alignment, self-reported environmentalism, age group, gender, and location. The full text of each question and the scale for each Likert-type response is included in the supplemental materials.

The statistical analysis of Likert-type responses can be controversial, especially the use of parametric tests, meaning that statistical tests and their interpretation had to be chosen carefully (Boone and Boone, 2012; Carifio and Perla, 2008). Because of the controversy around Likert-type data, relationships were established first using non-parametric tests, and parametric tests used only when the sample size was large and the non-parametric test suggests a significant relationship (Clason and Dormody, 1994; Sullivan and Artino, 2013). The use of means and parametric tests is considered by some to be entirely appropriate for larger sample sizes so long as the scale is clearly marked (Carifio and Perla, 2008; Sullivan and Artino, 2013). Others state that comparison of means and the use of parametric tests even in large sample sizes of Likert-type data should be approached cautiously and is sometimes inappropriate (Boone and Boone, 2012; Clason and Dormody, 1994). The analysis of this data takes a hybrid approach by providing descriptive statistics including means, but the means are primarily used to describe the frequencies of responses. Significance of relationships within the data was determined primarily with independent samples Kruskal-Wallis tests, using a significance level of 0.05. Only those relationships found to be significant with those tests and which had large sample sizes were further tested using parametric tests.

There are hundreds of potential correlations between the responses to each question (and each component within each question) and the demographics collected. For most questions, Kruskal-Wallis Tests were used to identify which demographics likely influenced the responses to each component of the question. This results in a series of results indicating whether a particular demographic likely did or likely did not (with $p<0.05$) influence the distribution of the result.

Although these results alone do not indicate how the distribution was impacted. Additional tests, such as Levene's test for equality of variances, followed by t-tests if significant, were required to understand how those distributions were impacted. The influence of various demographics are detailed in the results and the implications included in the discussion section.

Using a combination of the survey and statistical results (both primary questions and demographics), and further informed by the exploratory information on SLR priorities and preferences in Carpenter (2018), six plain-language key findings were constructed (one for each major theme discussed in the survey). These key findings were developed with the intention of use by public officials, and therefore they summarize key information within the study in an action-oriented way. The specific justification for each finding is included in the discussion.

Results

Survey responses

503 respondents completed the survey including the consent form (Q1). 235 respondents reported living in a coastal community, 69 working in a coastal community, and 284 regularly visiting a coastal community (Q2). These add to more than 503 because some respondents had more than one affiliation. There were several significant differences between residents (235) and non-residents (268), as described in the priorities and vulnerability sections.

Respondents were asked to state the importance of ten different key issues (Q3), including both environmental issues (such as preparing for sea level rise or protecting the environment) and non-environmental issues (such as reducing taxes or maintaining roads and other transportation infrastructure), on a Likert-type 1-5 response, with 1 meaning "very unimportant" and 5 meaning "very important". For this and all future questions, the definition of every value in the Likert-type ranking, the full question, and each selection is available in the supplemental materials. This question was designed to assess the relative priority of sea level rise planning compared to both issues which are potentially close proxies for sea level rise planning in the public's mind ("preparing for climate change" and "protecting against future flooding") and those that may have some connection but are probably not directly linked in the public's view (such as "helping people with limited resources" and "growing the economy." Table 2 shows the responses to this question, showing that although "preparing for sea level rise" was one of the lowest ranked issues by both mean (3.68) and percent ranking as 4 or 5 (65.4%), other closely related issues such as "protecting the environment" (4.04 and 75.7%) and "protecting property from natural disasters (3.99 and 75.3%) were ranked more highly.

Survey participants were asked to comment on the importance of various potential components of a local sea level rise plan in a Likert-type 1-5 response (Q4), with 1 meaning "very unimportant" and 5 meaning "very important." This question sought prioritization of sea level rise components recognizing that time and resources are likely to be limited. The responses to the

question, which are detailed in Table 3, include highly ranked activities around preparing to respond when flooding happens, implementing required policies to mitigate future flood damage, and developing maps and tools to assist. On the other end of the spectrum, fewer than half of participants ranked "finding ways to postpone making change until more research is done" highly. Closely related to this question was the following one (Q5), which asked participants to write-in any additional SLR plan components, of which the most common response (20.8% of 120 coded responses) was education.

Respondents were asked about their perceived vulnerability to four natural hazards – water surge damage, repeated flooding from high tides, increased flooding from SLR, and other natural disasters (Q6) on a Likert-type question, with 1 meaning "not at all vulnerable" and 5 meaning "exceptionally vulnerable." This question gauged how vulnerable respondents felt about these topics, rather than any objective measure of vulnerability (which would have required data not collected in this study). Table 4 shows the summary statistics for this question. Overall, respondents found themselves to be the most vulnerable on average to damage from hurricanes and severe storms but also perceived some vulnerability from other hazards.

Respondents were presented with 15 potential protection priorities (which services and places to focus protection on with a SLR plan) (Q7). These included a wide range of options, including various types utilities and related infrastructure (drinking water, electric power, sewer/wastewater and others, as well as individual homes, places of cultural importance, and others. These results are shown in Table 5. Although many essential services and others were highly ranked, drinking water was the only to exceed 80% of respondents ranking highly. Electric power, Roads and highways, homes and residences, and sewer/wastewater were all at greater than 70% ranking as 4 or 5. When respondents were asked to identify other priorities not listed (Q8), those with more than five responses include medical facilities / hospitals (11 responses), educational facilities/school (10), and animal shelters / zoos (7).

To help better understand how local sea level rise plans can be developed, funded, and administered, respondents were asked about their preferences on whether the responsibility for preparing for future flooding and sea level rise should be entirely public sector, entirely private sector, or somewhere between (Q9). The distribution of these responses is shown in Figure 1. In this case, over 60% of respondents (303) selected "equal mix of public and private sectors" and of the remaining, more selected "mostly public sector" (115) than any other choice.

Recognizing that funding can be a significant challenge for implementation of any community-wide project, whether or not related to SLR, respondents were asked about the usefulness of various funding mechanisms in their communities (Q10), going from "not at all useful" (1) to "exceptionally useful" (5). Recognizing that the actual funding need and availability will vary considerably based upon other aspects of the SLR plan, this question focused on how useful

various funding mechanisms are, rather than the actual funding amounts. Ten options were available, including voting on methods to pay for highest priorities, increasing various forms of taxes, and others. The summary of these responses can be seen in Table 6. Although no funding mechanism had greater than 60% of respondents rank it in one of the top two rankings, "hold public meetings to identify highest priorities and vote on methods to pay for them" was the closest, obtaining 59.2% of responses ranking as 4 or 5. On the opposite end, all forms of increased local taxes received a ranking of 4 or 5 by fewer than one third of respondents. Respondents were also given the opportunity to describe other mechanisms (Q11). Notable amongst these are responses that can be categorized as "governmental action / funding" (6), "improved information" (6), and "donations / fundraising" (6).

Recognizing that there are tradeoffs (including cost, complexity, and level of protection) to all forms of hazard mitigation, respondents were asked to indicate the desired level of protection (which could also be interpreted as tolerance for failure of those protections) from the cumulative protections of their SLR plan. Respondents were asked from ranges as frequent as failing less than 1 in every 10 years all the way up to failing less than one in every 1,000 years, and they were asked both about minor flooding and major flooding. Table 7 shows the distribution of responses, including a general preference for failure less than 1 in 100 years, although considerable distribution across the choices, with protections generally desired to be stronger for addressing major flooding than for minor flooding.

Some of the decisions that will need to be made in developing and implementing a local sea level rise plan will probably be controversial. For this reason, respondents were asked to rate how helpful eight different methods to resolve conflict locally are likely to be, with 1 meaning "not at all helpful" and 5 being "exceptionally helpful" (Q13). Of the methods, the most favorable was considered to be discussions with preparedness experts about improving protection against floods. Discussions with scientists and increasing educational efforts were also high on the list. Table 8 shows these results. Respondents were also asked to write in any other methods that may be effective for resolving conflict (Q14). The most common responses coded to "community meetings" with eight, over 25% of all of the write-ins for this question.

The last two primary questions were around the perceived appropriateness of various adaptation responses that could be undertaken, first from a list (Q15) and for any additional write-ins (Q16). In Q15, the responses ranged from "very inappropriate" (1) to "neither appropriate nor inappropriate" (3) and finally to "very appropriate" (5). Of a list of ten adaptation options, including a wide range of choices such as early warning tools, raising elevations on new construction (and/or existing construction), and harden public infrastructure, all options had medians above three (neutral) except for "increase cost of insuring high-risk areas" with a median of 3, and "don't provide assistance for areas at highest risk" with a median of 2. Table 9 shows all of these responses.

There was limited participation in identifying other potential adaptation measures (n=21 respondents with a total of 26 responses). Of those that did respond, six coded to "improve public infrastructure" which is very similar to one of the responses in the previous question.

Part of the survey was the collection of a series of pieces of demographic information self-reported by each respondent. These included a household income range, self-rated level of environmentalism, job title, level of education, ethnicity, political affiliation, age range (Q24, gender (Q25), location/state (Q26). Respondents were also asked to provide any feedback of concerns about the survey (Q23), for which the most common responses (other than responses indicating no feedback) were either something positive about the survey (17) or concerns about sea level rise itself (11) or the wording of the survey (7).

The primary use of the demographic information was to analyze similarities and differences in priorities across demographics, presented in the statistical analysis below. Therefore, the demographic information is not presented in full here but is available in the supplemental materials. Overall, although some of the distributions are not perfectly representative of the underlying population, they are diverse enough to represent a substantial number of viewpoints.

Statistical analysis

There were several key differences between those respondents who are residents of coastal communities and those who are not (i.e. those who either worked in or regularly visited a coastal community but were not also residents). Of the 503 respondents, 235 lived in coastal communities and 268 did not. 65 potential differences (all of the subcategories of each primary question) between these two groups were first screened using Mann-Whitney U (nonparametric) tests. The five relationships which were found to be significant were further tested using independent sample t-tests – all five of these relationships were found to be significant for both tests. The following five statements are provided first with the Mann-Whitney U p-value, followed by the t-test p-value.

- Residents perceived their communities to be more vulnerable to hurricanes and severe storms (3.57) than non-residents perceived (3.16) the communities they worked in or regularly visited to be ($p=.001$ / $p<.001$).
- Residents perceived their vulnerability to repeated flooding from high tides (3.10) to be greater than non-residents (2.70) perceived the communities they were associated with ($p=.001$ / $p<.001$).
- Residents perceived their vulnerability to increased flooding if sea level rises in the future (3.40) as higher than non-residents (2.70) perceived the coastal communities they were affiliated with ($p<.001$ / $p<.001$).
- Residents placed higher priority on the importance of electric power for sea level rise plans (4.34) than non-residents (4.13) placed on electric power ($p=.016$ / $p=.012$).

- Beaches and similar coastal areas were given a higher priority by residents (3.91) than non-residents (3.62) (p=.008 / p=.004).

As there were five statistically significant differences between coastal residents and non-residents out of 65 relationships (7.7% of relationships), there are important differences between the two groups but the overall difference in priorities and preferences was modest overall.

Some demographics correlated with changes in the distribution of responses for some or all components of primary questions. Overall, the self-reported level of environmentalism predicted the largest number of changes to the distribution of primary question responses, with 62% of components to questions likely influenced by this demographic. The preferred funding mixture (public, private, or equal mix) was the second most powerful predictor, coming in at 32% of components to primary questions. Gender and Age were each 29%. Notably, ethnicity, education, and income all influenced less than 10% of question components, and political party only 12%. A summary of these results is shown in Table 10. The component tables showing the P value of every test on each component of each question are found in the supplemental materials.

Key findings

Six key findings were developed as described in the methods section. The justification for each finding is included in the discussion. The key findings were:

Finding 1 on relative priority: "Officials are likely to gain better engagement with the public if they make a strong connection between planning for sea level rise and other high priority issues like the environment, infrastructure/utilities, and the economy."

Finding 2 on planning components: "Officials should consider building sea level rise plans that integrate response planning and preparedness with mandatory policies to reduce future damage. Maps and tools, educational resources, and voluntary protections were also popular, but inaction to wait for more research was not popular."

Finding 3 on protection priorities: "Officials should consider the protection of essential utility and transportation services as some of the highest priorities for protection in sea level rise plans. Residents also rate the protection of individual homes and of government facilities very highly."

Finding 4 on funding priorities: "Funding may be one of the largest challenges of sea level rise planning. Officials should consider public meetings to discuss how to pay for priorities, should use state and federal funds when available, and should work with the insurance industry on risk reduction measures. Officials should avoid cutting other programs and should proceed cautiously with taxes."

Finding 5 on conflict resolution: "To help prevent and resolve conflict, officials should consider bringing in both preparedness experts and scientists familiar with flooding and sea level rise to talk with the community and use the media to help educate the community about the issue. Avoid making adaptation measures optional to avoid conflict."

Finding 6 on adaptation responses: "Public officials should consider a variety of adaptation responses. Early warning systems, natural and artificial barriers, and hardening infrastructure are among the items respondents generally found to be appropriate. Even some potentially controversial adaptation, such as preventing new development in vulnerable areas were generally viewed as appropriate. Officials should avoid cutting off assistance from high risk areas."

Discussion

Key findings

The six key findings of this study were developed based upon the study's findings and were written in plain language to be of maximum utility for public officials.

For relative priority (finding 1), respondents ranked preparation for sea level rise relatively low on the list of other issues, indicating that in many instances they may not fully engage unless they make connections to other issues that are higher priorities, such as the environment or the economy. Although concerning that the public ranked sea level rise lower than most other priorities, the long-term and somewhat abstract nature of sea level rise may put it in the back of people's minds. Additional study on this phenomenon could yield additional insights, as the reasoning for respondent's answers is not known from this study alone.

For planning components (finding 2), a wide variety of components, such as response plans, mandatory mitigation policies, and maps and tools were popular for respondents, hence the relatively large number of suggestions for public officials to consider. The only option considerably lower than the rest was waiting to take action until additional research is done, which was not a popular choice. How and where to incorporate sea level rise planning (whether in a stand-alone plan, incorporated into other plans, or through some other means) is likely to be a very local decision.

For protection priorities (finding 3), drinking water and electric power were both ranked with a median and mode of 5 (exceptionally high priority), making utilities key candidates for adaptation measures. However, it is also possible that officials will have a difficult time prioritizing certain areas and services over others, as most items polled were identified as high priorities, and many services are likely to be highly interdependent on each other.

For funding priorities (finding 4), the preferred method to identify funding was to hold public meetings. Although this may indeed be useful, it also poses the challenge that the identified

funding sources (for example, using federal and state funds, which also ranked highly) may not be available when and in the quantities desired. Local methods to raise funding (e.g., taxes) were potentially controversial and may pose challenges in gaining support.

For conflict resolution (finding 5), both discussions with preparedness experts and scientists were amongst the most popular choices, but a number of other means to prevent or resolve conflict (such as starting with measures that have the greatest public support, holding public meetings, and others) had similar levels of popularity, meaning that a number of conflict resolution methods may be acceptable to the public in sea level rise planning.

Finally, for adaptation responses (finding 6), most of the surveyed adaptation measures were generally considered acceptable by the respondents. This included several measures that were expected to be controversial, such as preventing new development and removing existing development from vulnerable areas over time, were also generally acceptable. The only clearly unacceptable response of those studied was not providing assistance for areas at highest risk.

Impact of demographics

As mentioned in the results section, many demographics, such as income, education, and ethnicity had little impact on the distribution of responses for most components of most questions. Rather, the perceived level of environmentalism, preferred (public/private/mixture) funding sources, gender, and age impacted the most components of the questions. Although involving a diverse group of stakeholders across all demographics is essential to full engagement of a community, assuring a solid mixture of individuals affiliated with those demographics that have the greatest influence could be especially important in local sea level rise planning. By assuring, for example, that groups with differing viewpoints on environmental matters are represented in the process, there is greater potential for building buy-in through the process rather than ending in conflict.

Conclusions

Developing a locally-driven sea level rise plan is likely to be a challenging process, involving technical expertise, policy tradeoffs, and considerable community input. The six key findings and related information from this study can be used by public officials on the East Coast of the United States and elsewhere to better engage the public on this difficult but necessary process, by better understanding the general priorities and preferences of others affiliated with these coastal communities.

Much additional work can be done to further advance these issues. First, similar studies could be conducted elsewhere the in United States (for example, in Gulf states or on the West Coast) or in

nearly any country that has one or more coastal regions. Additional study can help to validate the usefulness of these key findings with policy makers, through discussions or by utilizing them in public processes and evaluating their effectiveness. Although the pathway to coastal resilience through sea level rise planning will likely be difficult, through the development of tools and resources such as this study, public officials can better understand how to get started and some strategies for success.

Acknowledgements

I would like to thank all the members of my dissertation committee who provided valuable guidance and advice during the development and execution of this research: Dr. Dann Sklarew, Dr. Sharon deMonsabert, Dr. Robert Jonas, Dr. Barry Liner, and Dr. Paul Schopf.

References

Auermuller, L, and M. Maxwell-Doyle. 2013. *Getting to Resilience. A New Jersey Community Planning Tool.* http://www.prepareyourcommunitynj.org/

Boone, H.N., and D.A. Boone. 2012. *Analyzing Likert Data.* Journal of Extension, 50:2:2TOT2. https://joe.org/joe/2012april/tt2.php

California Coastal Commission. 2015. *SLR Policy Guidance.* https://www.coastal.ca.gov/climate/slrguidance.html

Carifio, J., and R. Perla. 2008. *Resolving the 50-year debate around using and misusing Likert scales.* Medical Education, 42:12:1150-1152. https://doi.org/10.1111/j.1365-2923.2008.03172.x

Clason, D.L., and T.J. Dormody. *Analyzing Data Measured by Individual Likert-Type Items.* Journal of Agricultural Education, 35:4:31-35. https://doi.org/10.5032/jae.1994.04031

Carpenter, A.T. Dec 2018. *Exploration of Local Sea Level Rise Planning Public Perceptions.* Journal of Mason Graduate Research, 6:1:1-37. https://doi.org/10.13021/G8jmgr.v6i1.2382

Carpenter, A.T. May 2019. *A Framework for Locally Driven Sea Level Rise Policy and Action. A dissertation submitted to the graduate faculty of George Mason University in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy.* https://pqdtopen.proquest.com/pubnum/10749005.html

Chivers, J., N.E. Flores. 2002. *Market Failure in Information: The National Flood Insurance Program.* Land Economics, 78:4:515-521. https://doi.org/10.2307/3146850

Commonwealth of Virginia Office of the Governor. 2018. *EO 24 – Increasing Virginia's Resilience to Sea Level Rise and Natural Hazards.* https://www.governor.virginia.gov/media/governorvirginiagov/executive-actions/ED-24-Increasing-Virginias-Resilience-To-Sea-Level-Rise-And-Natural-Hazards.pdf

Eastern Research Group, Inc. 2013. *What Will Adaptation Cost? An Economic Framework for Coastal Community Infrastructure.* https://coast.noaa.gov/data/digitalcoast/pdf/adaptation-report.pdf

Federal Emergency Management Agency [FEMA]. 2017. *National Flood Insurance Program Community Rating System Coordinator's Manual.* FEMA Report FIA-15/2017. https://www.fema.gov/media-library-data/1493905477815-d794671adeed5beab6a6304d8ba0b207/633300_2017_CRS_Coordinators_Manual_508.pdf

Griffin, J., R. Hall, D. Halligan, Z. Johnson, J. Dubow, K. Colburn, G. Flora, B. Dougherty, K. Ebi, and K. Dow. 2008. *Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change. Phase 1: Sea-level rise and coastal storms.* https://dnr.maryland.gov/ccs/Publication/Comprehensive_Strategy.pdf

Hinkel, J., R.J. Nicholls, A.T. Vafeidis, R.S. Tol, T. Avagianou. *Assessing risk of and adaptation to sea-level rise in the European Union: an application of DIVA.* Mitigation and Adaptation Strategies for Global Change, 15:7:703-719. https://doi.org/10.1007/s11027-010-9237-y

Intergovernmental Panel on Climate Change (IPCC). 2013. *Climate Change 2013: The Physical Science Basis, Summary for Policymakers.* http://www.climatechange2013.org/images/report/WG1AR5_SPM_FINAL.pdf

Marcy, D. A. Allen, W. Sweet, S. Gill, A. Luscher-Aissaoui, E. Myers, and C. Zervas. *Incorporating Sea Level Change Scenarios at the Local Level.* https://coast.noaa.gov/data/digitalcoast/pdf/slcscenarios.pdf

Martin, J., P.L. Fackler, J.D. Nichols, B.C. Lubow, M.J. Eaton, Mc. Runge, B.M. Stith, and C.A. Langtimm. 2011. *Structured decision making as a proactive approach to dealing with sea level rise in Florida.* Climatic Change 107:1-2:185-202. https://doi.org/10.1007/s10584-011-0085-x

May, B., R. Plummer. 2011. *Accommodating the Challenges of Climate Change Adaptation and Governance in Conventional Risk Management: Adaptive Collaborative Risk Management (ACRM).* Ecology and Society, 16:1. https://www.ecologyandsociety.org/vol16/iss1/art47/

Miller, K.L., J.L. Kaminski Leduc, and K.E. McCarthy. 2012. *Sea-Level Rise Adaptation Policy in Various States.* https://www.cga.ct.gov/2012/rpt/2012-R-0418.htm

Mittermaier, P. 7 Nov 2016. *How Low-Lying Cities Can Protect Themselves from Climate Change.* https://www.nature.org/en-us/what-we-do/our-insights/perspectives/how-low-lying-cities-can-protect-themselves-from-climate-change/

Moser, S.C., J.A. Ekstrom, and R.E. Kasperson. 2010. *A framework to diagnose barriers to climate change adaptation.* Proceedings of the National Academy of Sciences of the United States of America, 107:51:22026-22031. https://doi.org/10.1073/pnas.1007887107

New York Academy of Sciences. 2015. *New York City Panel on Climate Change 2015 Report Executive Summary.* Annals of the New York Academy of Sciences, 1336:1:9-17. https://doi.org/10.1111/nyas.12591

North Carolina General Assembly. 6 Apr 2011. *House Bill 819 (2011-2012 Session).* https://www.ncleg.net/gascripts/billlookup/billlookup.pl?Session=2011&BillID=H819

Overton, M, W. Birkemeier, S. Benton, W. Cleary, T. Jarrett, C. Peterson, S. Riggs, S. Rogers, G. Rudolph, and E. Sciaudone. *North Carolina Sea Level Rise Assessment Report.* North Carolina Coastal Resource Commission Science Panel. https://files.nc.gov/ncdeq/Coastal%20Management/documents/PDF/Science%20Panel/2015%20NC%20SLR%20Assessment-FINAL%20REPORT%20Jan%2028%202016.pdf

Ruvin, H., J. Murley, D. Enfield, S. Fain, T.W. Fair, J. Gonzalez, and A. Milian. 2014. *Sea Level Rise Task Force Report and Recommendations.* https://www.miamidade.gov/planning/library/reports/sea-level-rise-report-recommendations.pdf

Sullivan, G.M., A.R. Artino. 2013. *Analyzing and Interpreting Data from Likert-Type Scales.* Journal of Graduate Medical Education, 5:4:541-542. https://doi.org/10.4300/JGME-5-4-18.

United States Global Research Program [USGCRP]. 2017. *Climate Science Special Report: Fourth National Climate Assessment, Volume 1.* Washington, DC: U.S. Global Change Research Program. https://doi.org/10.7930/J0J964J6

517 USGCRP. 2018. *Impacts, Risks, and Adaptation in the United States: Fourth National Climate*
518 *Assessment, Volume II.* Washington DC: U.S. Global Change Research Program.
519 https://doi.org/10.7930/NCA4.2018

Figure 1

Response distribution for preferred funding and responsibility for sea level rise planning (Carpenter 2019)

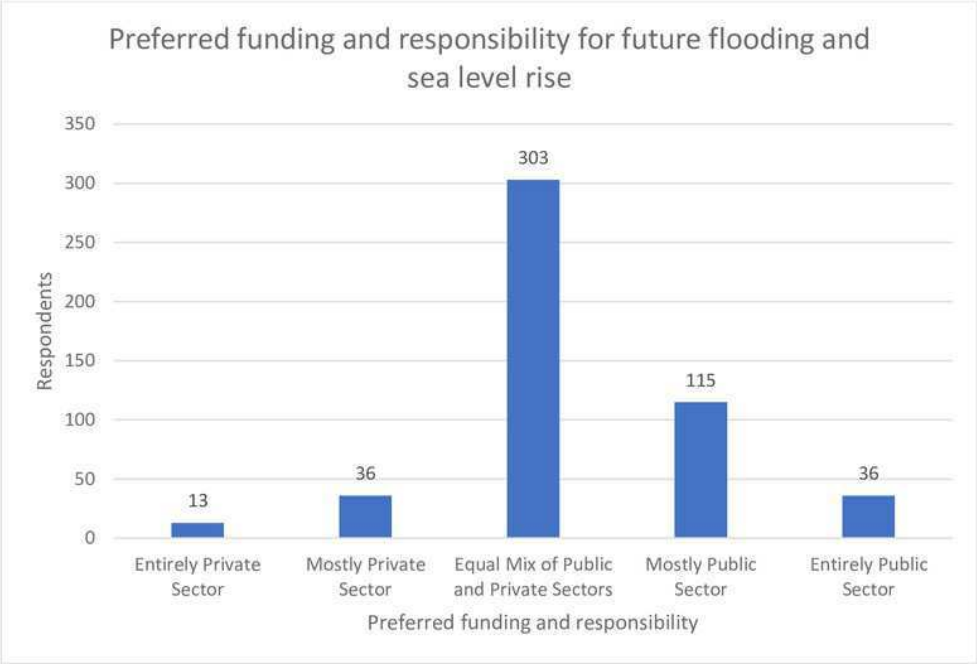

Table 1(on next page)

Summary of selected states with SLR policies (Carpenter, 2019)

Table 1. Summary of selected states with SLR policies (Carpenter, 2019)

State	**Key Policy**
California	State planning guidance to municipalities
Maryland	Strict limits on state involvement in SLR areas
North Carolina	Projections limited to 30 years in the future
Virginia	Executive order organizing state agencies

Table 2(on next page)

Key issues surveyed sorted by mean score (Carpenter, 2019)

Table 2. Key issues surveyed sorted by mean score (Carpenter, 2019)

Issue	Mean	Median	Mode	Standard Deviation	Number (Percent) Ranking 4 or 5
Protecting the environment	4.04	4	5	1.255	381 (75.7%)
Maintaining roads and other transportation infrastructure	4.04	4	5	1.220	392 (77.9%)
Maintaining utilities and related infrastructure	4.01	4	5	1.200	385 (76.5%)
Growing the economy	4.00	4	5	1.198	375 (74.5%)
Protecting against future flooding	3.99	4	5	1.248	375 (74.5%)
Protecting property from natural disasters	3.99	4	5	1.242	379 (75.3%)
Helping people with limited resources	3.90	4	5	1.226	368 (73.2%)
Reducing taxes	3.77	4	5	1.255	331 (65.8%)
Preparing for sea level rise	3.68	4	4	1.274	329 (65.4%)
Preparing for climate change	3.68	4	5	1.302	318 (63.2%)

Table 3(on next page)

Sea level rise components surveyed sorted by mean score (Carpenter, 2019)

Table 3. Sea level rise components surveyed sorted by mean score (Carpenter, 2019)

Component	Mean	Median	Mode	Standard Deviation	Number (Percent) Ranking 4 or 5
Preparing to respond and/or evacuate when flooding happens	4.11	5	5	1.192	392 (77.9%)
Implementing required policies to reduce future flood damage	3.98	4	5	1.171	369 (73.4%)
Developing maps and tools to learn where flooding will and won't likely cause damage	3.96	4	5	1.132	369 (73.4%)
Educating the community on the causes of flooding and sea level rise	3.88	4	5	1.209	355 (70.6%)
Building physical barriers (sea walls, levies, dunes, etc.) to protect against flooding	3.87	4	5	1.247	357 (71.0%)
Calculating the most cost-effective places and things to protect	3.85	4	5	1.182	350 (69.6%)
Working in the community to implement voluntary protections	3.82	4	4	1.123	350 (69.6%)
Finding ways to postpone making changes until more research is done	3.27	3	3	1.262	218 (43.3%)

Table 4(on next page)

Summary statistics for community vulnerability surveyed sorted by mean score (Carpenter, 2019)

Table 4. Summary statistics for community vulnerability surveyed sorted by mean score (Carpenter, 2019)

Vulnerability Type	Mean	Median	Mode	Standard Deviation	Number (Percent) Ranking 1 or 2	Number (Percent) Ranking 4 or 5
Water surge damage from hurricanes and severe storms	3.35	3	4	1.261	137 (27.2%)	248 (49.3%)
Increased flooding if sea level rises in the future	3.17	3	4	1.299	254 (50.5%)	223 (44.3%)
Other natural disasters	3.12	3	3	1.082	154 (30.6%)	180 (35.8%)
Repeated flooding from high tides	2.89	3	2	1.351	220 (43.7%)	187 (37.2%)

Table 5(on next page)

Summary statistics for protection priorities (Carpenter, 2019)

Table 5. Summary statistics for protection priorities (Carpenter, 2019)

Priority for Protection	Mean	Median	Mode	Std. Dev.	Number (Percent) Ranking 4 or 5
Drinking water	4.30	5	5	0.994	413 (82.1%)
Electric power	4.23	5	5	0.957	399 (79.3%)
Roads and highways	4.07	4	4	0.899	386 (76.7%)
Homes and residences	4.07	4	5	1.020	380 (75.5%)
Sewer / wastewater	3.97	4	5	1.085	352 (70.0%)
Government facilities	3.90	4	5	1.042	343 (68.2%)
Natural gas / heating fuel	3.85	4	4	1.089	337 (67.0%)
Beaches and similar coastal amenities	3.75	4	4	1.120	319 (63.4%)
Natural wetlands, wildlife areas	3.71	4	4	1.192	318 (63.2%)
Stormwater and green infrastructure	3.69	4	4	1.036	313 (62.2%)
Businesses, offices, shops	3.67	4	4	1.059	300 (59.6%)
Public transit	3.62	4	4	1.180	296 (58.8%)
Places of cultural importance	3.47	4	3	1.076	254 (50.5%)
Parks and public spaces	3.43	3	3	1.120	241 (47.9%)
Houses of worship	3.31	3	3	1.254	234 (46.5%)

Table 6(on next page)

Summary of responses to funding mechanisms (Carpenter, 2019)

Table 6. Summary of responses to funding mechanisms (Carpenter, 2019)

Funding Methodology	**Mean**	**Median**	**Mode**	**Standard Deviation**	**Number (Percent) Ranking 4 or 5**
Hold public meetings to identify highest priorities and vote on methods to pay for them	3.64	4	4	1.101	298 (59.2%)
Minimize the use of local taxes but utilize state/federal money when available	3.56	4	4	1.088	275 (54.7%)
Encourage insurance companies to require upgrades on homes/businesses to reduce risks as a condition of insurance	3.41	3	3 & 4 (Tied)	1.167	248 (49.3%)
Set policies to encourage individuals / businesses to pay for their own protection to minimize local government costs	3.27	3	4	1.211	230 (45.7%)
Increase funding by raising local fees for beaches and other amenities	3.05	3	3	1.216	189 (37.6%)
Use only money already used for protection (no change)	2.96	3	3	1.297	175 (34.8%)
Increase funding by raising local sales taxes	2.83	3	3	1.256	161 (32.0%)
Increase funding by raising local property taxes	2.76	3	2	1.290	149 (29.6%)
Increase funding by raising local income taxes	2.69	3	3	1.294	137 (27.2%)
Increase funding for protection by cutting other local programs and services	2.62	3	1	1.396	140 (27.8%)

Table 7 (on next page)

Distribution of responses on protection strength (Carpenter, 2019)

1 Table 7. Distribution of responses on protection strength (Carpenter, 2019)
2

Potential Failure Rate	Major Flooding		Minor Flooding	
	Total	Percent	Total	Percent
Fails less than 0.1% of years (1 in 1,000 years average)	58	11.5%	35	7.0%
Fails less than 0.2% of years (1 in 500 years average)	92	18.3%	61	12.1%
Fails less than 1% of years (1 in 100 years average)	180	35.8%	168	33.4%
Fails less than 2.5% of years (1 in 50 years average)	98	19.5%	126	25.0%
Fails less than 10% of years (1 in 10 years average)	75	14.9%	113	22.5%

Table 8(on next page)

Summary of methods to resolving conflict by mean score (Carpenter, 2019)

Table 8. Summary of methods to resolving conflict by mean score (Carpenter, 2019)

Conflict Resolution Methodology	Mean	Median	Mode	Std. Dev.	Number (Percent) Ranking 4 or 5
Discuss with preparedness experts about ways to improve protection against floods	3.85	4	4	1.044	336 (66.8%)
Discuss with scientists about the chances and locations of future flooding	3.80	4	5	1.107	317 (63.0%)
Increase educational efforts through the media about the risks and impacts of flooding	3.80	4	4	1.082	324 (64.4%)
Start with measures that have the greatest public support	3.75	4	4	1.044	317 (63.0%)
Perform cost and benefit analysis on various ways to move forward	3.70	4	4	1.012	303 (60.2%)
Hold public meetings to identify ways to resolve conflicts	3.61	4	4	1.083	284 (56.5%)
Hold votes on options to resolve disputes	3.47	4	4	1.132	259 (51.5%)
Make some measures optional for individual homes and businesses	3.34	3	3	1.200	238 (47.3%)

Table 9(on next page)

Summary of appropriateness of responses to flooding and SLR by mean score (Carpenter, 2019)

Table 9. Summary of appropriateness of responses to flooding and SLR by mean score (Carpenter, 2019)

Response for Gauging Appropriateness	Mean	Median	Mode	Std. Dev.	Number (Percent) Ranking 4 or 5
Develop and enhance early warning systems to notify residents about upcoming floods	4.20	4	5	0.943	401 (79.7%)
Develop and enhance natural physical barriers (such as wetlands or sand dunes)	4.17	4	5	0.937	397 (78.9%)
Harden public infrastructure (roads, utilities, etc.) against damage	4.13	4	5	0.896	390 (77.5%)
Develop and enhance man-made physical barriers (sea walls, levies, etc.)	4.07	4	4	0.967	393 (78.1%)
Require new structures to be built at higher elevations	4.07	4	5	0.970	382 (75.9%)
Prevent new development on the most vulnerable areas	4.00	4	5	1.091	360 (71.6%)
Raise the elevation of existing structures	3.73	4	4	1.025	308 (61.2%)
Remove existing development from the most vulnerable areas over time	3.50	4	4	1.182	271 (53.9%)
Increase cost of insuring high-risk areas	3.42	3	3	1.183	247 (49.1%)
Don't provide assistance for areas at highest risk	2.52	2	1	1.419	140 (27.8%)

Table 10(on next page)

Overall influence of each demographic on survey sub-questions by question category (Carpenter, 2019)

Table 10. Overall influence of each demographic on survey sub-questions by question category (Carpenter, 2019)

Overall Influence by Percentage	**Vulnerability**	**Funding**	**Responses**	**Conflict Resolution**	**Priorities**	**Issues**	**Components**	**Total**
Environmentalist	100%	90%	50%	100%	60%	20%	38%	**62%**
Funding mixture	25%	50%	70%	13%	47%	0%	13%	**34%**
Gender	0%	10%	60%	13%	0%	50%	75%	**29%**
Age	100%	60%	50%	13%	7%	10%	13%	**29%**
Work coastal	75%	40%	0%	0%	20%	10%	0%	**17%**
State	75%	20%	0%	13%	27%	0%	0%	**15%**
Political party	0%	30%	10%	13%	7%	20%	0%	**12%**
Live coastal	75%	0%	0%	0%	13%	0%	0%	**8%**
Visit coastal	75%	0%	0%	13%	7%	0%	0%	**8%**
Ethnicity	25%	10%	0%	13%	0%	10%	0%	**6%**
Education	0%	0%	0%	0%	0%	30%	0%	**5%**
Income	0%	10%	0%	0%	0%	0%	0%	**2%**
Total	**46%**	**27%**	**20%**	**16%**	**16%**	**13%**	**11%**	**19%**