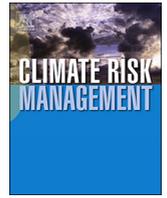


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Rural versus urban perspective on coastal flooding: The insights from the U.S. Mid-Atlantic communities

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1. Introduction

Coastal communities have become increasingly exposed to more frequent and intense tropical storms, hurricanes, accelerated sea level rise (SLR), and related nuisance flooding (Holland and Bruyère, 2014; Knutson et al., 2010; Villarini and Vecchi, 2013; Kim et al., 2014). Accelerating trends of sea level rise have already been observed in many coastal locations, with projections indicating significant inundation of many populated areas (Strauss et al., 2012; Titus et al., 1991). Regardless of the uncertainty of the exact magnitude of SLR (Nicholls and Cazenave, 2010) and the methodological and data challenges present in SLR models and impact scenarios (Horton et al., 2013), it is evident that SLR will have direct and indirect impacts on many coastal communities (Haer et al., 2013). Taking into account the anticipated population growth in the SLR impact assessment, the risk of inundation is projected to affect 4.2 million people under a 0.9 m inundation scenario or 13.1 million people under 1.8 m projections by 2100 (Hauer et al., 2016). Some areas such as the Northeast Atlantic coast and the western Gulf of Mexico are especially vulnerable to SLR and are expected to experience levels higher than the global average across almost all SLR scenarios (Sweet et al., 2017). Accelerated SLR will affect the extent of storm surge and tidal inundation, eventually leading to permanent flooding of low-lying areas and subsequent changes in the built, natural, and social systems (Alexander et al., 2011; Melillo et al., 2014; Parris et al., 2012; Hall et al., 2016). It may also undermine livability in coastal communities (Frey et al., 2010; Nicholls and Cazenave, 2010; Sallenger et al., 2012) and lead to population displacement (Collini, 2008), as many socially vulnerable areas may not be able to afford structural protection or justify public expense for costly interventions (USGCRP, 2014). Changes in the frequency of flood events and resulting damages have already been recorded in many urban areas like Norfolk, Virginia, due to the high level of land subsidence (Ezer et al., 2013; Tompkins and DeConcini, 2014) and in Miami, Florida, due to the inability of the city's gravity-based drainage system to absorb high-intensity rainfall (Wdowinski et al., 2016).

The understanding of coastal hazard risk is rapidly evolving and improving with the increasing number of new simulation models and scenarios offering better resolutions and more accurate impact projections. At the same time, information on response options, their effectiveness in different contexts, and their cost-benefit viability is still limited. Moreover, the understanding of complexities on a household, community, and municipal level and their impact on adaptive and coping capacities and hazard mitigation planning in contemporary coastal settings is still in its infancy. The empirical evidence indicates that homeowners living in high-risk areas often fail to implement measures to minimize their risk of injury, fatality, and property damage and to prevent loss (Peek and Mileti, 2002; Siegrist and Gutscher, 2008). This delay in response likely reflects a lack of personal experience with flooding and may represent a substantial barrier to anticipatory planning for SLR impacts, considering the gradual manifestation and novelty of this hazard (Harvatt et al., 2011). This paper aims to understand the underlying concerns, complexities, and reasoning behind adaptation and hazard mitigation decision-making in response to accelerating coastal flooding in rural versus urban settings. It is grounded in the

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assumption that different levels of urbanization and related cultural, sociodemographic, and economic contexts shape the coping capacity and resilience of different places. According to Scott and Gilbert (2007), urban settings are generally more reliant on the secondary and tertiary economic sectors, more affluent and wealthy, more diverse but with a lower sense of community, and more transient than rural areas. Rural communities are, on the other hand, more dependent on natural resources and physically isolated, and they have limited economic diversification, aging populations, and higher levels of poverty (NCA, 2014). This paper identifies how local contextual factors shape risk perceptions, the level of concern about coastal flooding and its impacts, and consideration of different response options. It evaluates the level of concern with coastal hazards, adaptive and coping responses, attitudes about relocation, data gaps that may affect the propensity to act, and barriers to and opportunities for adaptation via personal, semi-structured interviews with local officials and other stakeholders in coastal Maryland and Virginia.

Coastal flooding discourse in the U.S. The recent coastal disasters of Hurricanes Katrina, Sandy, Harvey, Irma, and Maria accentuated the vulnerability of coastal urban systems and led to an upsurge in awareness of both episodic and chronic flooding in urban systems. At the same time, the paradox of coastal development grounded in the prevailing perceptions of high livability and ensured profits from living in distressed and risky coastal environments has been recognized for many decades (Godschalk et al., 1989). Despite the upsurge in federal programs that address flooding disasters, the policy is still largely fragmented, prevalently reactive, and likely to be amended only after catastrophic events (Birkland, 2001). Local governments often endorse only mandated national regulations and resist any interventions that could curb development in coastal areas, affect tax revenues and economic vitality, and interfere with private property rights (Wilkins, 2011). With the increasing frequency and extent of recurrent flooding, there is a growing need to shift the research attention from acute hazard events to chronic exposures and integrate them into formal risk-reduction policies (Folger, 2016). Moreover, recurrent flooding has been identified as an early indicator of areas that are more likely to face future catastrophic coastal flooding and land loss (Karegar et al., 2017). There is a growing need to build synergies between hazard mitigation mostly focused on non-climatic hazards, risk characterization based on historic trends, and shorter-term planning horizons, and adaptation concerned with gradual but persistent changes, future risk projections, and long-term planning horizons (Higbee, 2014). Even though adaptive activities are increasingly taking place in many communities at different spatial scales and focuses (Vignola et al., 2017), current efforts mostly reflect incremental steps and cautious policy changes that may be inadequate to keep up the pace with accelerated hazards (Kates et al., 2012; Wise et al., 2014). Many existing adaptation practices also reflect fragmented efforts addressing only climate variability and extreme events rather than all dimensions of vulnerability and as such fail to comprehensively address climate change and its associated uncertainties (Vogel et al., 2016).

Some scientific and policy circles advocate new transformational changes as the only way to adequately tackle the emerging climate issues; however, such large-scale, fundamental alterations may not always be possible and acceptable on the ground (Termeer et al., 2017). Vignola et al. (2017) suggest that the best way to mobilize societies to support concrete action is to align the leadership style and performance to the socio-institutional context of place. Bierbaum et al. (2013) found similarities in adaptation approaches across scales and sectors, including the mainstreaming of climate considerations into adaptation plans, pursuing no- and low-regret strategies, and implementation challenges such as lack of funding, institutional constraints, and dealing with future horizons. These latter barriers to adaptation differ between societies and locations based on their mentality, values, risk perceptions, governance processes and structures, and trust in scientific information (Adger et al., 2009) and should be addressed early on in the adaptation process. The adaptation strategies proposed to address coastal hazards mainly include different structural and non-structural measures to protect settlements, accommodate changing conditions, or support relocation away from the shoreline (Nicholls and Tol, 2006; Klein et al., 2007; Karl et al., 2009). The selection of individual strategies depends on the local context like resources, institutional capacities, affluence, and sociocultural determination to continue habitation in a less stable environment. It is often influenced by public and political pressures, regardless of the net benefits and long-term impactfulness of specific measures, often favoring structural defenses over permanent retreat (Abel et al., 2011). Even though the literature on adaptation is growing, very few local governments have developed or implemented climate change or sea level rise adaptation plans (Melillo et al., 2014). In many coastal communities, recurrent flooding is becoming a pervasive problem due to its persistent and accelerating nature (Spanger-Siegfried et al., 2014). As a result, some communities are considering relocating, like the remote villages in Alaska (Bronen 2015), the Kamgar Putala slum in India (Cronin and Guthrie, 2011), and Isle de Jean Charles in Louisiana (Lowland Center, 2015). Many of these efforts are still in the early stage of implementation, and their long-term outcomes are yet to be seen.

2. Methodology

2.1. Conceptual framework

The importance of stakeholders' participation, engagement, and bottom-up approach to decision-making has been well recognized, encouraged, and even mandated in planning and policy-making (Few et al., 2007). The value of stakeholders' perceptions in problem identification and analysis is equally important. Therefore, this paper draws on the knowledge of local stakeholders to identify the location-specific contextual factors that, according to Keeney and McDaniels (2001), often shape adaptation decision-making. Considering many communities have been challenged by environmental changes and instability for centuries and have developed a diverse range of response strategies, their local or traditional knowledge can provide important insights into adaptive processes (Nakashima et al., 2012). This paper further utilizes a case study approach appropriate for exploration of the complex circumstances present in coastal settings that affect or may be affected by adaptation (Füssel, 2007). The conceptual framework used in this paper (Fig. 1) aims to be inclusive and account for the contemporary terminology and concepts utilized in the coastal context such as episodic versus chronic events, different scales, coping capacity, vulnerability, and resilience, all of which shape the threshold

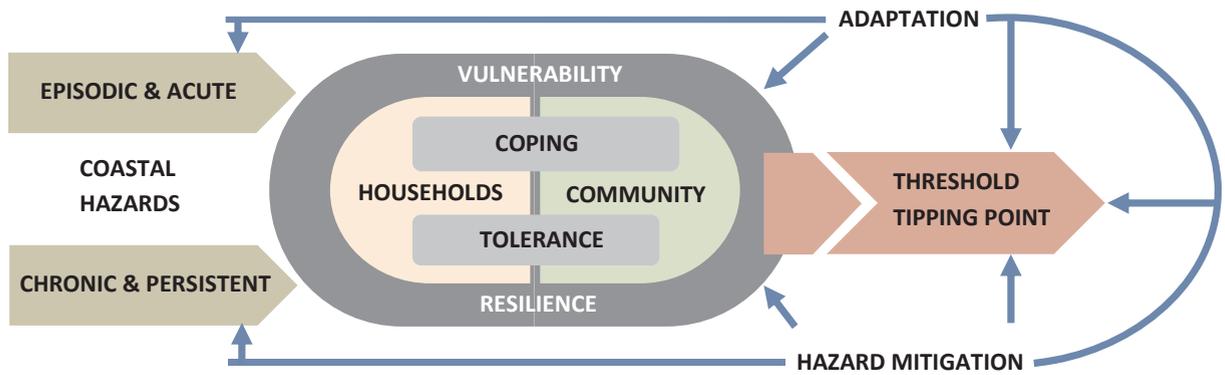


Fig. 1. Transdisciplinary perspective on coastal systems challenged by flooding.

or tipping points of a place.

Adaptation and hazard mitigation interventions may change the coping capacity and tolerance of households and whole communities, as well as affect their vulnerability and resilience. Individually or in synergy, they may also alter the threshold or tipping point after which adaptation outcomes may be undermined by the extent and duration of the hazard exposure. For example, traditional fishing villages may appear inherently more resilient and capable of coping with flooding than urban neighborhoods. Yet, considering their high social vulnerability, subsistence lifestyle, remoteness, and aging infrastructure, their threshold for enduring repetitive impacts and their ability to “bounce back” may be lower than those of their urban counterparts, who have better access to support services and assistance. Therefore, adaptation planning should account for critical biophysical, behavioral, and institutional thresholds and coping ranges and identify tolerance levels beyond which circumstances in households or communities would become unacceptable and result in strategies that would modify these endpoints (Willows et al., 2003; Buijs et al., 2018).

2.2. Study locations

Both of the case study locations evaluated in this paper are located along the Mid-Atlantic coast (Fig. 2), which is facing a significantly greater relative SLR of 1.75–4.42 mm/year than the observed global SLR of 1.77 mm/year due to localized land subsidence (Williams et al., 2009). More intense storm surge, wave activity, and tidal inundation will drive erosion and likely change the shoreline contours, displace barrier islands, and instigate inland migration (Gutierrez et al., 2009). Balancing development needs

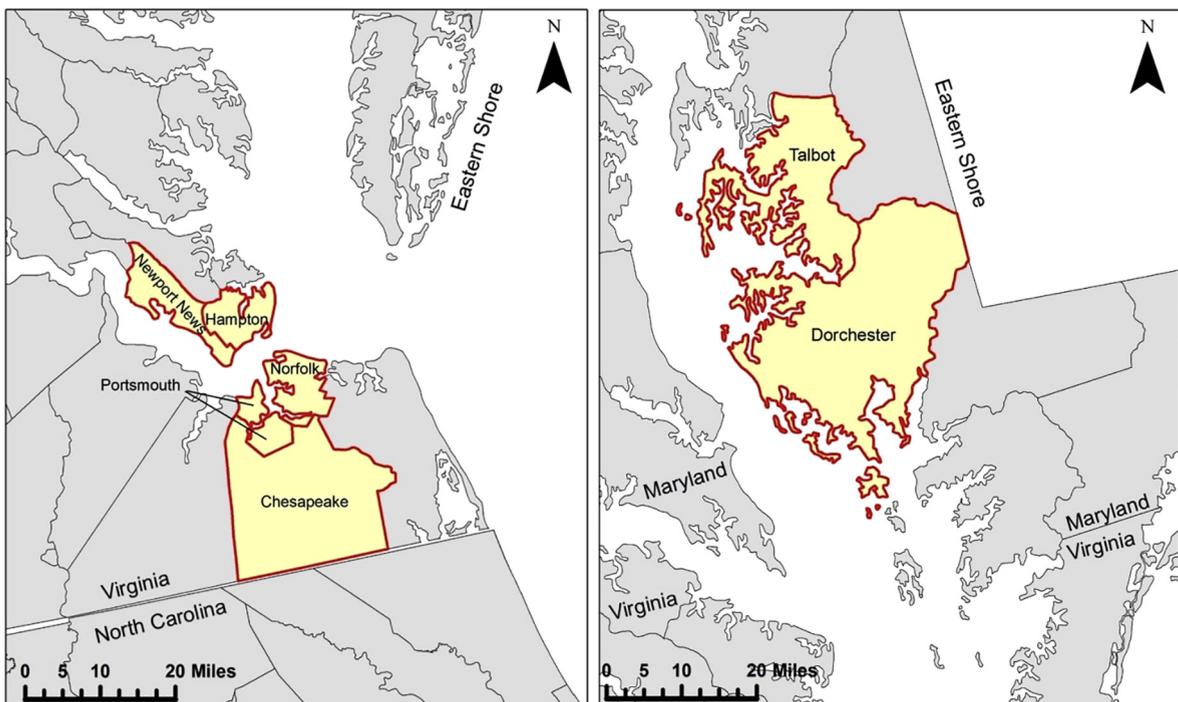


Fig. 2. Case study locations on the Eastern Shore and in the Hampton Roads area.



Fig. 3. Recurrent flooding in Norfolk, Virginia (photo credit: Mary-Carson Stiff and Skip Stiles, Wetlands Watch).

with those vital for ecosystem protection may be even more challenging in this region, considering that the Mid-Atlantic counties are among the most urbanized and densely populated areas in the U.S. (Gill et al., 2009). The rural case studies include Dorchester and Talbot Counties on the Eastern Shore in Maryland, while the urban context is represented by cities in Hampton Roads, Virginia (Chesapeake, Hampton, Newport News, Norfolk, and Portsmouth).

Eastern Shore. This area will experience SLR-driven problems related to higher storm surges and tides, especially in the low-lying coastal fringes. According to Boesch et al. (2013), the relative SLR projections for Maryland range from 0.82 m (2.7 feet) during this century for a low greenhouse gas emissions scenario to 1.04 m (3.4 feet) under a higher greenhouse gas emissions scenario, with a general estimate of 2.1 feet by 2050 for planning purposes. The SLR will propagate the tidal wave deeper up into the bay, resulting in an overall increase in tidal amplitude on the Maryland side, especially in the upper bay and the river heads influenced by tidal fluctuations (up to 0.2 m or 0.66 feet) (Zhong et al., 2008). Such tidal forcing in the upper bay and its tributaries will further exacerbate flood events driven by the southern winds and other weather-driven disturbances (Boesch et al., 2013). Both Annapolis and Baltimore in Maryland have already been experiencing a significant increase of more than 920% in the number of flood days since 1960 (NOAA, 2014). Even though the Eastern Shore is also at high risk of tropical storms and hurricanes, recurrent flooding has been their primary concern (ESLC, 2016).

Hampton Roads. The Hampton Roads area is highly vulnerable to both extreme weather events and SLR, both of which will be exacerbated by the local land subsidence that will expand the inundation impact zone (McFarlane and Walberg, 2010). Over the last 100 years, Virginia has experienced higher rates of SLR than any other East Coast state, measured at the Sewells Point tide gauge in Norfolk at the centennial rate of 0.44 m (1.45 feet) (USCCSP, 2009). Virginia's coast is highly prone to recurrent flooding, which is expected to worsen in the next 20 to 50 years due to an SLR of approximately 1.5 feet anticipated for this area (Fig. 3; VIMS, 2013). Projected SLR along the Chesapeake Bay will put many vulnerable assets like ports, railways, utilities, roads, military installations, and other critical infrastructure at flood risk (Stiles, 2012). The high vulnerability of this metropolitan area stems from its high population densities and important infrastructure such as Interstate 64, the Hampton Roads Bridge Tunnel, Naval Station Norfolk, Joint Base Langley-Eustis, Naval Weapons Station Yorktown, and Naval Shipyard Norfolk (Governor's Commission on Climate Change, 2008).

2.3. Interviews and analysis

This paper utilizes semi-structured qualitative interviews to record the attitudes, experiences, and perspectives of local stakeholders in different case study locations toward adaptation, hazard mitigation, relocation, and data needs related to coastal flooding. A local key informant helped identify and recruit relevant respondents familiar with both the topic of study and the local context. All of the participants were older than 18 and had a professional or contextual understanding of the local coastal issues. A total of 24 participants from both of the case study locations participated in semi-structured interviews (Virginia Tech's IRB #15-090), with 15 interviews conducted on the Eastern Shore and nine interviews in the Hampton Roads area from May 11 to 21, 2015. Among the participants, there were 13 decision-makers/public officials, two local experts on coastal issues, one local scientist, and eight local residents. Each interview was administered in person by the first author of this paper and lasted approximately 60 min. Each session was audio-recorded and transcribed for accuracy. The main lead questions included the following key themes: perception of coastal hazards/impacts, adaptation and hazard mitigation options, relocation, barriers and opportunities, and data support needs. Transcripts were analyzed using the qualitative data analysis software Nvivo under different parent nodes, one for the Eastern Shore and one for Norfolk, with the child nodes reflecting the aforementioned thematic areas. Each interview was coded and the results analyzed to identify the key concepts and relationships. Considering some participants discussed a theme under different topics or intended questions, some responses were merged and restructured to improve the clarity of the content. For example, many respondents did not differentiate between adaptation and hazard mitigation and rather discussed them as response options to a specific problem like flooding or erosion.

3. Results and discussion

3.1. Coastal hazards and risks

Eastern Shore. The perspectives on the problem differ and range from erosion, flooding, and sea level rise to global climate change. Erosion has been a well-known problem in this area, often described as “washing off” or “collapsing” of banks and silting that restrict navigation and water rescue. Dredging represents only a temporary solution, and channels fill back in quickly. There is no consensus on whether it is caused by the land sinking or the water rising, and people “do not particularly care what the cause is, but look at the problem that needs to be addressed.” The residents are not fully cognizant that erosion is driven by SLR, wave activity, and wind, nor of the cause-effect relationship between the individual problems. The decision-makers have a higher awareness of the ubiquitous connectivity in coastal settings, recognizing, for example, linkages between agricultural runoff, loss of seagrass, increased wave activity, and higher erosion rates. Perceptions of intensity vary as well, with respondents who have lived in the area for longer observing more pronounced changes like “the increase in fury of storms.” The municipalities are facing significant stormwater infrastructure issues, namely the backing up of seawater into the drainage and sewer lines and the inability of the system to deal with heavy rainfall or high tides. The roadside ditches and swales designed for stormwater runoff now serve as tidal intermittent streams. Most respondents remember instances when flooding affected them personally, but they are not fully aware of the indirect impacts of chronic exposure. For example, some coastal school districts have to replace their school bus fleet twice as fast as in other locations due to regular driving over flooded roads that shortens the vehicles’ lifespans.

Evacuation in the Bay Hundred area of Talbot County is complex, considering the topography, dispersed pattern of residential villages and homesteads, and limited number of roadways and bridges that lead further inland. The upper Eastern Shore has many low points and floodable road passages that can severely limit commuting options, especially to and from the remote coastal hamlets. Even though sheltering in place would work best in this context, many large capacity shelters are also floodable and cannot accommodate seasonal visitors. There is also a realization that “we have so many homes, older homes built so close to the water; there is only so much you can do in terms of prevention.” Many respondents had recollections of 13 inhabited islands that used to exist and thrive in the Bay but were eventually consumed by seawater and disappeared. Hazard-driven mobility is still ongoing, and some waterfront neighborhoods have “every second or third home [with a] for sale sign,” with many homes already being abandoned or “half in water and half out.” Many sellers have low expectations of selling the properties, considering how low or close to the water they are, and are aware that “the next person will not buy it” or “I may not have a house to leave to my children.” In some historic communities, older housing is standing on the higher ground, while newer structures can be found in the low-lying locations impacted by flooding. Officials are aware of SLR projections, but the focus is still on episodic events and hazard mitigation rather than the chronic risks and adaptation.

The respondents from the Eastern Shore also discussed the importance of local mentality in decision-making. The residents have the mentality of staying in place and facing the storm, especially those who have been living there for generations (been-heres) versus the “come-heres” who moved to the area upon their retirement or are part-time/seasonal residents. The population center is further inland, and some residents are skeptical that the local officials would be supportive of providing assistance to remote satellite villages in a time of need. At the same time, the local officials believe that people living there can take care of themselves and deal with most disturbances. Many local residents are indeed proud of their self-sufficiency and are intentionally building capacities to support each other, for example, by identifying community resources and skills that would help them cope with challenging situations like flooding. Yet, they may still need resources and technical input for larger interventions (e.g., emergency generators and public infrastructure upgrades). As one participant stated, “We are not expecting a lot of help from the outside, but you still eventually need water and power.” This social cohesion and unified support is not ubiquitous in all coastal villages, and some have a very different narrative: “people there, they do not keep together in the need”; “they are [a] much more divided community”; and “locals are in the middle of the land-war.”

A significant portion of coastal housing was constructed as summer weekend homes and was not designed for year-round habitation. Consequently, as many seasonal homeowners move in permanently upon their retirement, they strain the water supply, septic system, and services. Officials are concerned that extending and upgrading these services will attract more development and increase the flood risk. Many communities are experiencing a substantial outflux of young people to the mainland due to the lack of economic opportunities, decreased enrollment in schools, and closure of stores and services, prompting residents to commute greater distances for basic necessities. This trend is leaving a growing aging population without support from their nuclear families and increasingly dependent on commuting for sustenance. People living in this area are realistic about their situation and historically experienced displacement and loss due to storms many times—all of which is a part of local knowledge. There is a pervasive dependency on state and federal funding for most flood response measures. To obtain grant money, localities have to be creative to incorporate flood-control benefits into other community projects, such as efforts to secure clean water or improve stormwater runoff. There is a sentiment that all constituents should bear the cost of adaptation and everybody should contribute, including the property owners. Even though many cite Hurricane Sandy as a wakeup call, “they literally need to have their feet wet to see what is happening,” and it is going to take a few more major events over a short period of time for people to become concerned. People are doing their own risk assessment based on limited information and grounded in their previous hazard experiences. One resident noted, “At our age of nearly 70, we expect to have 20 more years here, and things will not change during those 20 years to the point where we cannot live in our house. Therefore, we have put worrying about that on reserve.” Many respondents stated that “it is risky everywhere,” and each area has its own hazard challenges to deal with. Many are expecting they will have to do more to prepare for flooding, like changing their routines or doing retrofits, and are content with that considering the benefits of living in coastal locations.

Hampton Roads. This area is very prone to flooding from “the sea, from the sky, and the stormwater system.” The topography is flat and rainfall has no means to leave the area due to reverse flooding through the storm drain system, which cannot handle the increasing volume of water. Flooding events occur more frequently and cover more area, showing up in neighborhoods that never used to flood. If an estate becomes a repetitive loss property (any insurable building with two or more insurance claims of more than \$1,000 paid by the National Flood Insurance Program; FEMA, n.d.), “the reality of a long-term existence there is very questionable.” Tide gates and valves help but only during low-profile events, while pumping the water out is also not viable considering the distances needed for effective removal. Currently there is “no solution [for] how to deal with the sheer amount of water that is coming up through drains,” and it is challenging to plan evacuation and sheltering options considering the ever-changing risk. Moving to higher ground is not a permanent solution due to accessibility issues. Each municipality has its own unique circumstances that dictate their exposure and adaptation possibilities. The City of Chesapeake covers 360 square miles and has 55 square miles of 1-year floodplain, while Norfolk spreads over 50 square miles altogether. The Virginia Beach risk is driven by ocean-based hazards, while in other townships it is influenced by the complex networks of waterways and bay-specific conditions. As to recurrent flooding, the respondents accentuated the need for more transparency and a full disclosure of repetitive flood damages: whether a property has been damaged by flooding in the past, to what extent, and how many times. People want to know, but local officials are legally not allowed to share that information. If prospective home buyers come from inland locations and are not familiar with coastal hazards, do not know how to ask the question, and are not aware of the issue, the only way they will find out about flooding is when they start experiencing it, which is often too late. “There is no database, no information, and no legal protections for this type of flooding and incentives for homeowners to be honest about it,” something that could be resolved with a more transparent “buyer beware” system. Participants also noted that presenting scientific data and future projections is not as effective and does not get as much of a response as simple, personalized stories of flooding incidents, especially when communicating to the general public. In-person communication is more impactful than online and social media outreach efforts. Participants also suggested that the timeframe of risk communication to the general public should be scaled down to a more relevant timeframe, such as the duration of a home mortgage or an average person’s life milestones and financial capacity. Individuals who never experienced flooding, renters and those in transition, generally pay less attention to risk information and do not engage in flood-prevention activities.

Everybody has a story to share: “A woman living on the north shore has a million-dollar house and put it on the market four to five years ago. In the meantime, she had two expensive flood claims. The house sits on the slab. The city continues to tax it at a million dollars a year. She cannot sell it. And that conversation is happening daily now.” Each case is unique and requires a customized approach to address issues like historic preservation or structural determinants. The flood insurance premium can sometimes serve as an indicator of risk when no other information is available, but that information is only disclosed during the closing on a property and the actual premium is revealed after the contract is signed: “For some, the insurance premium increased six times and house value decreased 50 percent.” The basement space has to be completely eliminated, often resulting in the loss of living and storage space, which affects the total value of the house. One participant noted that society needs a paradigm change in which it will start looking at coastal real estate not as an investment opportunity and asset but rather as a liability and risk. Other issues are related to accessibility to and from critical facilities, daycares, schools, and places of work. Many policies are designed to manage functions under normal circumstances but may not work for the conditions of chronic flooding: “This is an uncharted territory. There are things we haven’t even thought of yet that’s just going to continue to add [to] and compound this issue.” The process to obtain funding for interventions takes time and often spans different levels of government. There is also a concern with competition for funding from other states, which will likely intensify as impacts accelerate. The arguments as to why municipalities need funds should be very strong and grounded in economic realities, as well as clearly define the broader implications of action versus inaction for national security and revenues. Further, the municipalities in Hampton Roads are all socio-economically co-dependent and interconnected. As such, they pay attention to what others are doing and are under peer-pressure to act consistently with other regional efforts, while at the same time trying to preserve their autonomy and identity. People who lived next to water for generations are comfortable with flooding but do not expect it will occur as frequently and be as severe as they have experienced in recent years. Residents are increasingly noticing flooding and demand more action from the local government. In addition, they are realizing how this affects them on a more profound level, for example in inability to sell their house or commute to work. Coping capacity varies within the region and depends on the type of home construction and the history of exposure. If flooding caused minor damage and inconvenience, residents can endure more than if their home is on a slab and every time they have to replace drywall, appliances, and furniture: “The latter group gets more frustrated quicker.”

3.2. Adaptation and hazard mitigation responses

Eastern Shore. Strategies employed in this area include property abandonment and demolition; elevation; shoreline hardening; setbacks; rainwater harvesting; construction of swales, jetties, or bulkheads; reconstruction of wetlands, living shorelines, and sediment dredging. The State is increasingly supporting anticipatory planning on long-term horizons, and that is often driving local governments to be more proactive, especially considering their dependency on state resources for capital projects and large investments. Although there is a shift among federal and state institutions to recognize the important role of community participation in disaster response, they are still reluctant to fully support the concept of self-sufficiency and sheltering in place versus evacuating out of harm’s way. The County provides the majority of services and capital improvements for satellite villages. Therefore, there is a chain of dependency on resources and support that may influence adaptation planning in this area. The adaptation plans are mostly written by consultants, often without the appropriate stakeholders’ input, and as such fail to capture the local complexities and contextual aspects vital for an effective response.

Hampton Roads. The local officials are aware of the emerging coastal problems and are committed to solve them despite their

complexity. The general public, on the other hand, wants quick fixes and more immediate tangible solutions. The formal mentality shifted from considering only hard measures like a seawall or floodgates to a more integrated approach including installing pumps, raising water profile, freeboard requirements, retreat, transfer of development rights with density bonuses, living shorelines, taxes, road elevation, setbacks, and new building codes. Some people want to learn what they can do on their own to reduce the risk of flooding, such as elevation, installation of flood vents, hurricane straps, roof clips, hurricane shutters, and small-scale tide dams. Several localities prefer acquisition over elevation considering it does not address the issue of accessibility to and from the structure during secondary emergencies, especially for properties with two or more repetitive flood-loss claims. A few places advocate development of acquired properties albeit at a higher standard instead of converting them into green space to avoid the “Swiss-cheese effect” and possible neighborhood decline. Respondents stressed the importance of holistic assessment of individual interventions and their unintentional impacts on the localities. One participant noted, *“There are great regulations and we are tackling and enforcing them. But, in 10 years from now, most of what we are doing now may even be impractical; it may be ineffective. And nobody likes to hear that.”* Some residents are willing to take legal action against the flood-warning signs and similar measures in their neighborhood due to concerns with the resale potential and real estate value of their home. Chronic flooding represents a greater concern than storm surge, but many officials still use the term “hazard mitigation” instead of “adaptation.” There is general recognition that we need a mixture of options and a one-size-fits-all approach will not be adequate to deal with chronic flooding.

3.3. Relocation

Eastern Shore. Relocation is “*certainly not a common consideration and we would probably get a very strong pushback against that. It may be something we do need to address.*” People who may have to consider relocation, who are located in vulnerability hotspots, will likely be of lower income. Attitudes toward relocation vary: Some see their home as an emotional investment and do not want to give up on it, while others are more willing to consider moving. The loss of residents who have other living options readily available would be harmful for those who would have to stay. They would “*leave the community weaker by going*” and “*less economically viable.*” Residents would want to know how much compensation they would receive under the different scenarios, how the relocation process would be managed, and what else would be considered for participation in the program. One respondent suggested, “*It does not make a whole lot of sense to talk about retreat because it turns so many people off. And it’s going to happen by itself anyway.*” For many owners of waterfront property, having a home there is likely the largest and/or final investment they will make in their life, so they may be interested in resale rather than other options that may not give them a return on their investment, especially considering that flooding is not so frequent yet. The local governments highly depend on the revenues generated from income taxes and not property taxes, which are capped off. Thus, the major contributors are the wealthy homeowners and permanent residents, and they prefer to live close to the water. The amount of money needed to relocate all high-risk properties would be enormous, especially considering that the historic and vacation homes were not designed to withstand major retrofits or physical transfer elsewhere. Spontaneous relocations from coastal areas are already happening in many areas, with residents moving to larger neighboring towns that offer more amenities, better health care, proximity to hospitals, nursing home options, and better access to public services. This trend is common among younger people in search of economic opportunities, as well as older residents who are not able to take care of their properties and deal with extensive commuting.

In relocation, it would be important to preserve community cohesion and determine whether residents should move together or be dispersed to different locations. It may be too complex to simultaneously uproot an entire community and relocate it somewhere else, and it is more likely that communities will start dwindling away “*house by house, family by family.*” People who are long-term residents and have lived in their area for generations have deeper attachments to the community and have a stronger sense of belonging. Another concern is related to community identity, especially in remote communities on Deal Islands, Tilghman, and St. Michael, where residents have been embedded so deeply into the local culture and setting that it would be difficult to replicate their way of life anywhere else, “*even just a few miles away.*” They may also feel apprehension about relocating to larger population centers due to discomfort with more diverse demographic landscapes and urban culture. It may not be financially possible to acquire all high-risk coastal properties, and the government may not have enough resources to give everybody in need the pre-storm value of their house, even if residents want to relocate. The compensation received for a small rural coastal home may not be enough to purchase a replacement home in a larger town. Officials will have to be very creative in finding alternative funding mechanisms to accrue funds for the future, for example, a fee that will feed into the relocation program. The older respondents noted that relocation was considered a normal practice in the past and many families were prompted to move multiple times, especially in Eastern Shore area without any form of assistance.

Hampton Roads. “*We have no policy on that now, but it is a topic; it is being discussed. It is a very complicated issue we still know little about. What are the legal obligations of municipalities? What incentives can be offered under what conditions? For how long does it make sense to provide services in areas with repetitive flooding?*” The information on relocation is limited and context specific, often referring to riverine conditions that are significantly different than coastal ones. And then how do you decide to whom to offer it, especially when you know that everybody would want to participate? Many officials prefer relocation over elevation, as it represents a long-term solution. The localities may be more supportive of this possibility if they would have developable land away from the coast and would preserve their tax base. Spontaneous retreat from the coast may happen as “*a product of market price and cost,*” with financial disincentives like higher taxes and insurance rates driving people away from the shoreline. However, if houses cannot sell, that will depreciate the values of whole neighborhoods, and eventually the whole area. Some municipalities are already actively considering pursuing buyouts and trying to identify high-risk properties with multiple claims, preparing applications for federal grants, and finding the regulatory mechanisms to facilitate this process among eligible properties. Some homeowners have already approached

officials asking about this possibility. Other communities do not use acquisition because they want to keep residents living in these neighborhoods and avoid a layout with patchy vacant lots. Acquiring individual lots is also not preferred because there is not enough “linear capability” to convert that space into a park or viable public space. Moreover, buyouts are costly for municipalities: They have to offer a fair market value, pay for the moving costs, demolish the structure, and then maintain the property at their own cost.

“*The transition from living there to not living there*” will not be an easy process, especially considering that both local and federal governments do not have the resources to buy out everybody. The number of repetitive loss properties increased multifold in the last few years, yet localities are capable of acquiring only a few properties annually. The localities may have to rely on the property owners and the private sector to carry the cost of relocation. There is also an issue of scale and strategic planning for relocation, which is closely related to the tipping point in the neighborhood when a number of properties seek buyout and the rest are anxious about their future: “*Nobody wants to be the last person in the floodplain, but how do you do that? How do you afford to buy out [and] do everyone at once?*” Another concern is that buyouts would cause tensions in the community between those who would be able to leave and those left behind. The discourse on relocation brought up many important questions, such as what would be the legal challenges associated with a large-scale effort; who should bear the burden of this process; what should be done with acquired properties; and where should people go. One respondent proposed that the smaller municipalities with limited areas of higher elevation could make a partnership with a neighboring municipality that has more land and start making investments there, but that would be “*pretty radical.*” There are many places around the U.S. that are experiencing population loss and “*would love to get [a] bunch of people moving in,*” and maybe this is an opportunity to reverse some of the development mistakes of building right on the coast. Homes that are sitting on a slab in rural areas may be eligible for physical relocation within the property lines or to another inland location. In older urban areas, this is not feasible considering the age of the structures and lack of available space. Some localities have a significant proportion of economically disadvantaged households that are not represented well in the policy process: either those who lived there for generations and are not required to have flood insurance tied to their mortgage, or those who cannot afford to pay for the insurance. They experience repetitive flooding but are not eligible for federal assistance and are not part of the claim records that often serve as an indicator of buyout needs. Relocation may augment social justice issues, considering that many flood-prone areas include minority neighborhoods that already feel they are being underserved by the city.

3.4. Barriers and opportunities

Eastern Shore. People have a hard time understanding the issues of sea level rise and climate change, especially when their perceptions are grounded in past experiences and the history of place rather than current knowledge and science. Some people do not believe in the information and climate change and will resist doing anything they are told to do. They just hope the problem will go away on its own. Economic incentives and financial support are very important in rural counties, but the federal programs prioritize densely populated urban areas. The fiscal structure of localities is based on the size of the community and the revenues generated from the people who live there. They are under pressure to maintain the status quo or not do anything that would prevent people from buying homes and hurting their economic base. It is also very difficult to talk to constituents because all they want to know is “*When should I sell my house?*” and “*What is the impact on my property value?*” Officials are often unaware of challenges in the remote communities that often lack political representation and visibility. Many local governments are composed of only one or two staff members who are in charge of everything and have limited capacity to deal with irregular problems and long-range planning. As for implementation opportunities for adaptation strategies, the small rural scale is actually advantageous, as it represents a more manageable environment for testing different strategies.

Hampton Roads. There is a misconception that the hazard exposure is the homeowners’ fault since they built or bought on the shoreline when they knew or should have known the risk, but in reality, many people bought homes or inherited them when issues with flooding did not exist. The changes are now so rapid that it is difficult to accept that they are here to stay. Older people are hoping that conditions will not deteriorate over the next 15 to 20 years during their lifetime. There is a concern with liabilities and legal connotations of what can be done to prevent flooding. For example, once the municipality provides utility services, they cannot “unprovide” them. The private sector is more flexible and has more options to stop providing services that are not sustainable anymore. Further, each local municipality has its unique governance system and organization, with different divisions of responsibilities related to flood protection. The institutions are not designed to operate under rapidly changing conditions, and it is difficult to accept that coastal contours “*are not static anymore.*” Also, there is a possible conflict of interest between continually investing revenues in the same repetitively flooded parcels versus funding other community improvements and development.

3.5. Data, Information, and support needs

Eastern Shore. Regional collaboration is very important, especially considering the “*impacts are not isolated and solutions are not done in [a] vacuum.*” More accessible and affordable technology and tools help localities to generate customized maps and risk assessments, to strengthen intra- and inter-state collaboration, and to efficiently disseminate risk information and warnings. Residents are more likely to engage in the issue and act upon the information when officials visit and discuss the issues in person, showing that they personally care about the community. Thus, simple messages and face-to-face communication still work the best. Officials should mobilize unsuspecting resources like the retired community, who are available during the day to participate in outreach efforts. Efforts not conducted in consultation with residents are generally not so well received by localities.

Hampton Roads. There is a need for crowdsourcing so that residents do not have to rely only on the localities for information but can inform each other about the changes around them via, for example, instant streaming or real-time pictures of conditions. There is

also a demand for more transparency and full disclosure of repetitive damages and flood claims to protect buyers and break the cycle of buying and reselling problematic properties. Localities would also benefit from more granular, downscaled, accurate, and consistent data that shows uncertainty, as well as from tools that would support analysis of different response options in various contexts developed in consultation with the end-users to ensure that they are answering their questions and providing the information they need. All respondents reported that face-to-face dialogue on flood risk is the most effective outreach approach. Simpler information is better, especially if supported by specific information on what people should do under which circumstances.

4. Discussion and policy recommendations

The interviews indicate that many coastal communities are becoming increasingly concerned with the impacts of chronic flooding on their social and community fabric. The respondents were cognizant that simple solutions implemented today may cause unintended environmental and socioeconomic problems in the future. For example, the living shorelines and wetlands restoration may increase the population of mosquitos and ticks and increase the need for pesticide applications, both of which were considered highly undesirable by local residents. Respondents also expressed concern with social justice implications, not only regarding who will be affected but also who will be protected and given priority in support and funding assistance. The local officials noted that their constituents have difficulty accepting change and the fact that things are permanently getting worse. As for relocation, the discourse mostly revolves around the character of the process—whether it should be done on an individual or collective basis and whether it should be managed or spontaneous. To enable retreat, [Abel et al. \(2011, p. 285\)](#) suggest that “*public and private benefits, costs, risks, uncertainties, responsibilities and liabilities of coastal development need to be reassigned, so those who benefit from coastal development and enjoy living there pay the costs.*” Such a paradigm shift, even though clearly necessary, may be difficult to achieve, considering that whole economies, governance and social structures, and cultural determinations are constructed around the unrestricted right to live along the shores. In both locations, respondents expressed concern with resale potential and property values and with too many unknowns that may discourage officials to manage this issue and instead leave it to resolve on its own. The interviews also highlight the importance of location-specific trends in vulnerability to coastal hazards. For example, some areas in the case study locations experienced a significant influx of immigrants from South America who work in the agricultural sector, are not familiar with living in a coastal environment, do not speak English, and are likely to rent the lowest-cost homes, which may be subject to recurrent flooding. Respondents also emphasize the importance of integrating adaptation with other community goals, reflecting locale-based trends, and capitalizing on the people’s heightened awareness of and support for other issues such as environmental and health concerns.

The results contain statements indicating the difficulty to envision the future under different scenarios and to account for the possibility of the worst-case scenario. [Van der Voorn et al. \(2012\)](#) suggest that most people ground their opinions in their past experiences that shape their expectations of future events. Thus, it is important to use suitable methods that will help them broaden their perspectives and account for uncertainty to ensure they do not compromise their ability to adapt in the future ([van der Voorn et al., 2012](#)). Forecasting, foresight, and scenario planning analyses may play an important role in delineating and communicating the possible futures under conditions of high complexity and uncertainty, especially when allowing for stakeholders’ participation in the development process ([Rialland and Wold, 2009](#)). Backcasting is another normative approach that assumes the distant future is inherently unknowable and suggests stakeholders should rather envision a desired future and then work backward to explore what is needed to achieve it ([Wilson et al., 2006](#)). Even though all of these approaches may support adaptation, the combination of two or more approaches and integration of stakeholders’ input may yield more accurate and robust results. For example, the methodology that combines backcasting, adaptive management, and stakeholder engagement approaches may allow users to implement a range of different goals over various temporal scales and ensure that they are achieved over time in an adaptive manner and with public support ([van der Voorn et al., 2017](#)). The observed institutional and governance barriers can be overcome by adaptive planning under the uncertainty of coastal changes, inclusion of the mid-term actions and boundary spanning activities, and a more critical discussion that will span from short-term to long-term horizons ([Buijs et al., 2018](#)). Even though adaptive decision-making is interpreted differently in various disciplines, some of the common threads suggest it should be responsive to changing conditions, reflexive, process-focused, flexible, actionable and implementable, based on continual learning, and result in consensus-building ([Lempert and Groves, 2010](#)).

As for the rural-versus-urban dichotomy, in urban settings circumstances are quite different: Even though metropolitan areas tend to have more partnerships and collaboration on issues of coastal flooding, they also include more diverse participants coming from different sectors with various priorities and perspectives, which often hinders achieving consensus on how to move forward. In rural places, the risk is more clearly defined and the community more cohesive, therefore making decision-making on this issue less complex and divisive. Moreover, rural communities are generally more self-sufficient and confident in their ability to adapt, as well as more committed to staying and coping than urban dwellers, who often have higher expectations of assistance from local officials. Rural residents also have less political visibility than urban dwellers, who generally receive more attention during and after flood events. Rural communities’ self-sufficiency and high coping capacity may work against them by giving officials the perception that they can deal with issues themselves and do not need external help. There is also an issue of dependency—on assistance, infrastructure, and resources. In urban locations, people have more of everything—more alternative routes to get to places, more services and support facilities, more shelters, and more visibility. In rural areas, many satellite villages are connected to the outside world by a single lifeline roadway, and critical facilities are located at substantial distances. In both rural and urban locations, face-to-face communication is considered the most effective. They both struggle with stormwater runoff and drainage issues, accessibility and limited evacuation options, and similar barriers to adaptation such as limited personnel and resources to address the problem on the municipal level. In rural locations, environmental and sociodemographic changes are more easily observable, such as younger people

moving out, retirees moving in, stores closing, and school enrollment decreasing. Still, not all rural locations are the same; just like the urban neighborhoods, they have their own unique cultures and risk perceptions that drive their adaptation decision-making.

5. Conclusions

In some communities, flood-response strategies are designed as unilateral and static and often do not reflect the dynamic and ever-changing circumstances on the ground, affecting the risk propagation and effectiveness of adaptation. The responses to coastal flooding should be more efficiently aligned with the constantly evolving local context that defines the success of individual interventions. This study revealed that many officials still tend to favor hazard mitigation over adaptation and focus on the problem itself and targeted solutions. It also highlighted the need for more transparency and accountability regarding risks, impacts, disclosure of repetitive damages, and effectiveness of different response options. Respondents emphasized some ethical considerations, such as who should get priority in financial and technical assistance; which communities, roads, and households are more valuable and worth protecting; and which factors will drive this decision-making. The rural versus urban typology in this study also brought up the issue of the scale and extent of impacts on individual localities. For example, in a rural village or town, a single event can virtually destroy the whole location, including its sociocultural fabric, while in an urban area the same impacts would merely affect 10% of the area. In rural areas, the social memory of events is present for longer and becomes an important part of the community history and identity, often being used as a reference in local knowledge driving the dialogue on flood responses. Many rural communities are experiencing significant sociodemographic and economic changes that may disrupt their traditional methods of knowledge sharing and social cohesion that contributed to their higher coping capacity and resilience. Finding a contextualized means of preserving and propagating social memory of events may help improve risk perceptions, participation in collective action, and support for policy changes needed for adaptation. Rural municipalities are also generally more self-sufficient and willing to experiment and improvise with limited resources to address emerging coastal challenges.

The cultural dimensions of communities are always evolving due to external stimuli, such as changes in the natural environment, population shifts, or technological advances—a process that will likely be exacerbated by climate change in a significant and permanent manner, even potentially leading to major societal transformation or loss of cultures (Adger et al., 2009). This may lead to a loss of valuable local knowledge on mental aptitude and hazard preparedness, responses communities used to adapt, and why they could not keep up with the pace of change that ultimately led to their demise. Therefore, local knowledge and stories about coping with and surviving major disturbances like natural or technological disasters should be collected and documented using qualitative social science methods and translated into the contemporary context. The translation is important to ensure that this information is relevant to the extent and severity of anticipated climate change impacts, especially in developed countries where people tend to express general concerns about changes but are mostly detached from space (not happening here) and time (not happening yet) (Adger et al., 2009). For example, historically, many communities used to move away from a hazard to a new, safer location (e.g., from lower to higher ground or from an island to the mainland). Today, this may not be as easily achievable due to stricter land use regulations and property ownership policies, and higher legal and other costs associated with moving. However, this knowledge and these experiences can still be used to inform development of new relocation support mechanisms and programs. In addition to translation of local knowledge into current contexts, it is also important to integrate it into a learning process as input for community-based adaptation that can serve as a foundation for development of synergistic adaptation activities (Huq and Reid, 2007).

In rural areas, institutional governance could be improved by building stronger synergies between the formal governance structures in the administrative hubs and informal decision-making in rural satellite communities, as well as by building trust between all stakeholders. As suggested in the interviews, this could be achieved by the frequent physical presence of local officials in the peripheral communities and/or by inclusion of stakeholders from rural fringes in the policy-making process via participation on advisory boards, committees, or the city council. The local officials should create opportunities for learning about the self-sufficiency and coping skills used by local people that could inform the development of adaptive activities in other locations. The urban areas generally have more mechanisms that support stakeholders' participation in the policy process but do not necessarily ensure a broad representation of all affected parties, especially vulnerable populations. Urban residents tend to have different expectations of government and their role and responsibilities in risk reduction. The reliance on local officials and their ability to drive adaptation may maintain the status quo among the residents and dilute their personal responsibility for preparedness and adaptation. Therefore, local governments should establish an open dialogue with their constituents on uncertainties related to coastal hazards and on a range of possible outcomes using a language meaningful to all constituents. The relevance of information can be emphasized by putting it in the context of one's mortgage, workforce, impacts on real-estate values, and other community milestones. In the context of European Union flood risk reduction, Hegger et al. (2014) propose that required Flood Risk Management Strategies be applied simultaneously to all flood risk areas, linked together, and aligned to provide cohesive coverage that will result in resilient urban agglomeration. Similarly, the interviews highlight the importance of a customized granular approach to adaptation but also indicate that transitions between the places of differentiated flood risk and social vulnerability should be addressed to provide continuous protection. Birkmann and Garschagen (2010) call for a paradigm shift that would redirect attention from physical interventions to improvement in planning approaches and governance structures that could support adaptation, as well as synchronize the discourse on adaptation with sustainable development goals.

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Appendix A. Supplementary data

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References

- Abel, N., Gorddard, R., Harman, B., Leitch, A., Langridge, J., Ryan, A., Heyenga, S., 2011. Sea level rise, coastal development and planned retreat: analytical framework, governance principles and an Australian case study. *Environ. Sci. Policy* 14 (3), 279–288. <https://doi.org/10.1016/j.envsci.2010.12.002>.
- Adger, W.N., Dessai, S., Goulden, M., Hulme, M., Lorenzoni, L., Nelson, D.R., Naess, L.O., Wolf, J., Wreford, A., 2009. Are there social limits to adaptation to climate change? *Clim. Change* 93 (3–4), 335–354.
- Alexander, K.S., Ryan A., Measham T.G., 2011. Managed retreat of coastal communities: Understanding response to projected sea level rise. *Socio- Economics and the Environment in Discussion*, SCIRO Working Paper Series 2011-01, Canberra, Australia.
- Bierbaum, R., Smith, J.B., Lee, A., Blair, M., Carter, L., Chapin, F.S., Wasley, E., 2013. A comprehensive review of climate adaptation in the United States: more than before, but less than needed. *Mitig. Adapt. Strat. Glob. Change* 18 (3), 361–406.
- Birkland, A.T., 2001. Scientists and Coastal Hazards: Opportunities for Participation and Policy Change. *Environ. Geosci.* 8 (1), 61–67.
- Boesch, D.F., Atkinson, L.P., Boicourt, W.C., Boon, J.D., Cahoon, D.R., Dalrymple, R.A., Ezer, T., Horton, B.P., Johnson, Z.P., Kopp, R.E., Li, M., Moss, R.H., Parris, A., Sommerfield, C.K., 2013. Updating Maryland's Sea-level Rise Projections. Special Report of the Scientific and Technical Working Group to the Maryland Climate Change Commission, 22 pp. University of Maryland Center for Environmental Science, Cambridge, MD.
- Bronen, R., 2015. Climate-induced community relocations: using integrated social-ecological assessments to foster adaptation and resilience. *Ecol. Soc.* 20 (3), 36. <https://doi.org/10.5751/ES-07801-200336>.
- Buijs, J., Boelens, L., Bormann, H., Restemeyer, B., Terpstra, T., van der Voorn, T., 2018. Adaptive planning for flood resilient areas: dealing with complexity in decision-making about multilayered flood risk management. AESOP conference paper, 16th meeting: Adaptive Planning for Spatial Transformation, Groningen, Netherlands.
- Collini, K., 2008. Coastal community resilience: an evaluation of resilience as a potential performance measure of the Coastal Zone Management Act. Final Report of the CSO Coastal Resilience Steering Committee.
- Cronin, V., Guthrie, P., 2011. Community-led resettlement: from a flood-affected slum to a new society in Pune, India. *Environ. Hazards* 10 (3–4), 310–326.
- ESLC, see Eastern Shore Land Conservancy, 2016. Kent County Climate Change and Sea Level Rise Vulnerability Report. Prepared by the Eastern Shore Land Conservancy Retrieved from http://www.eslc.org/wp-content/uploads/2015/02/Kent-County-Climate-Change-Adaptation-Report_final_Sept2016.pdf.
- FEMA, Federal Emergency Management Agency, n.d. Definitions. Retrieved from <https://www.fema.gov/national-flood-insurance-program/definitions>.
- Few, R., Brown, K., Tompkins, E.L., 2007. Public participation and climate change adaptation: avoiding the illusion of inclusion. *Clim. Policy* 7 (1), 46–59.
- Ezer, T., Atkinson, L.P., Corlett, W.B., Blanco, J.L., 2013. Gulf Stream's induced sea level rise and variability along the US mid-Atlantic coast. *J. Geophys. Res. Oceans* 118 (2), 685–697.
- Folger, P., Carter N.T., 2016. Sea-Level Rise and U.S. Coasts: Science and Policy Considerations. Congressional Research Service, Report 7-5700, Washington D.C.
- Frey, A., Olivera, F., Irish, J., Dunkin, L., Kaihatu, J., Ferreira, C., Edge, B., 2010. Potential impact of climate change on hurricane flooding inundation, population affected, and property damages. *J. Am. Water Resour. Assoc.* 46 (5), 1049–1059. <https://doi.org/10.1111/j.1752-1688.2010.00475.x>.
- Füssel, H.M., 2007. Adaptation planning for climate change: concepts, assessment approaches, and key lessons. *Sustain. Sci.* 2 (2), 265–275. <https://doi.org/10.1007/s11625-007-0032-y>.
- Gill, S.K., Wright, R., Titus, J.G., Kafalenos, R., Wright, K., 2009. Population, land use, and infrastructure. In: *Coastal Sensitivity to Sea-Level Rise: A Focus on the Mid-Atlantic Region*. A report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research. [J.G. Titus (lead author), K.E. Anderson, D.R. Cahoon, D.B. Gesch, S.K. Gill, B.T. Gutierrez, E.R. Thieler, and S.J. Williams (lead authors)]. U.S. Environmental Protection Agency, Washington DC, pp. 105–116.
- Godschalk, D.R., Brower, D.J., Beatley, T., 1989. Catastrophic coastal storms: hazard mitigation and development management. Duke University Press.
- Governor's Commission on Climate Change (GCCC), 2008. Final Report: A Climate Change Action Plan, Governor's Commission on Climate Change.
- Gutierrez, B.T., Williams, S.J., Thieler, E.R., 2009. Ocean coasts. *Coastal Sensitivity to Sea-Level Rise: A Focus on the Mid-Atlantic Region*, U.S. Climate Change Science Program, Synthesis and Assessment Product 4.1, 43–56.
- Haer, T., Kalnay, E., Kearney, M., Moll, H., 2013. Relative sea-level rise and the conterminous United States: consequences of potential land inundation in terms of population at risk and GDP loss. *Global Environ. Change* 23 (6), 1627–1636.
- Harvatt, J., Petts, J., Chilvers, J., 2011. Understanding household responses to natural hazards: flooding and sea-level rise comparisons. *J. Risk Res.* 14 (1), 63–83.
- Hauer, M.E., Evans, J.M., Mishra, D.R., 2016. Millions projected to be at risk from sea-level rise in the continental United States. *Nat. Clim. Change* 6 (7), 691.
- Hall, J.A., Gill, S., Obeysekera, J., Sweet, W., Knuuti, K., Marburger, J., 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. U.S. Department of Defense, Strategic Environmental Research and Development Program, pp. 224.
- Hegger, D.L.T., Driessen, P.P.J., Dieperink, C., Wiering, M., Raadgever, G.T., Van Rijswijk, H.F.M.W., 2014. Assessing stability and dynamics in flood risk governance: an empirically illustrated research approach. *Water Resour. Manage.* 28, 4127–4142. <https://doi.org/10.1007/s11269-014-0732-x>.
- Higbee, M., 2014. Integrating Hazard Mitigation and Climate Adaptation Planning: Case Studies and Lessons Learned For the 2015 San Diego County Multi-Jurisdictional Hazard Mitigation Plan Update. ICLEI-Local Governments for Sustainability and e San Diego Foundation's Climate Initiative.
- Holland, G., Bruyère, C.L., 2014. Recent intense hurricane response to global climate change. *Clim. Dyn.* 42 (3–4), 617–627.
- Horton, B.P., Engelhart, S.E., Hill, D.F., Kemp, A.C., Nikitina, D., Miller, K.G., Peltier, W.R., 2013. Influence of tidal-range change and sediment compaction on Holocene relative sea-level change in New Jersey, USA. *J. Quaternary Sci.* 28 (4), 403–411. <https://doi.org/10.1002/jqs.2634>.
- Hug, S., Reid, H., 2007. Community-Based Adaptation: An IIED Briefing. International Institute for Environment and Development, London, pp. 2.
- Karl, T.R., Melillo, J.M., Peterson, T.C., 2009. *Global Climate Change Impacts in the United States*. Cambridge University Press.
- Karegar, M.A., Dixon, T.H., Malservisi, R., Kusche, J., Engelhart, S.E., 2017. Nuisance Flooding and Relative Sea-Level Rise: the Importance of Present-Day Land Motion. *Sci. Rep.* 7 (1), 11197.
- Kates, R.W., Travis, W.R., Wilbanks, T.J., 2012. Transformational adaptation when incremental adaptations to climate change are insufficient. In: *Proceedings of the National Academy of Sciences*, 201115521.
- Keeney, R.L., McDaniels, T.L., 2001. A framework to guide thinking and analysis regarding climate change policies. *Risk Anal.* 21, 989–1000.
- Kim, H.S., Vecchi, G.A., Knutson, T.R., Anderson, W.G., Delworth, T.L., Rosati, A., et al., 2014. Tropical cyclone simulation and response to CO2 doubling in the GFDL CM2. Five high-resolution coupled climate model. *J. Clim.* 27 (21), 8034–8054.
- Klein, R.J., Eriksen, S.E., Naess, L.O., Hammill, A., Tanner, T.M., Robledo, C., O'Brien, K.L., 2007. Portfolio screening to support the mainstreaming of adaptation to climate change into development assistance. *Clim. Change* 84 (1), 23–44.
- Knutson, T.R., McBride, J.L., Chan, J., Emanuel, K., Holland, G., Landsea, C., et al., 2010. Tropical cyclones and climate change. *Nat. Geosci.* 3 (3), 157–163.
- Lempert, R.J., Groves, D.G., 2010. Identifying and evaluating robust adaptive policy responses to climate change for water management agencies in the American west. *Technol. Forecast. Soc. Chang.* 77 (6), 960–974.

- Lowlander Center, 2015. Resettlement as a resilience strategy and the case of Isle de Jean Charles. Version 1.0, October 2015, Louisiana.
- McFarlane, B.J., Walberg, E.J., 2010. Climate Change in Hampton Roads Impacts and Stakeholder Involvement. Hampton Roads Planning District Commission, Chesapeake, Virginia.
- Melillo, J.M., Richmond, T.C., Yohe, G.W., 2014. Climate Change Impacts in the United States: The Third National Climate Assessment. U.S. Global Change Research Program 841. <https://doi.org/10.7930/J0Z31WJ2>.
- NCA, see: National Climate Assessment, 2014. Rural communities. U.S. Global Change Research Program, Washington, D.C.
- Nakashima, D.J., Galloway McLean, K., Thulstrup, H.D., Ramos Castillo, A., Rubis, J.T., 2012. Weathering uncertainty: Traditional knowledge for climate change assessment and adaptation. UNESCO and UNU TKI, Paris.
- Nicholls, R.J., Cazenave, A., 2010. Sea-level rise and its impact on coastal zones. *Science* 328 (5985), 1517–1520.
- Nicholls, R.J., Tol, R.S., 2006. Impacts and responses to sea-level rise: a global analysis of the SRES scenarios over the twenty-first century. *Philos. Trans. R. Soc. A Math. Phys. Eng. Sci.* 364 (1841), 1073–1095.
- NOAA, 2014. Sea Level Rise and Nuisance Flood Frequency Changes around the United States. NOAA Technical Report NOS CO-OPS 073, Silver Spring, Maryland.
- Parris, A., Bromirski, P., Burkett, V., Cayan, D., Culver, M., Hall, J., Horton, R., Knuuti, K., Moss, R., Obeysekera, J., Sallenger, A., Weiss, J., 2012. Global Sea Level Rise Scenarios for the US National Climate Assessment. NOAA Tech Memo OAR CPO-1 37.
- Peek, L.A., Mileti, D.S., 2002. The history and future of disaster research. In: Bechtel, R.B., Churchmans, A. (Eds.), *Handbook of Environmental Psychology*. John Wiley, New York, pp. 511–524.
- Rialland, A., Wold, K.E., 2009. Future Studies. Foresight and Scenarios as basis for better strategic decisions, Trondheim.
- Sallenger Jr, A.H., Doran, K.S., Howd, P.A., 2012. Hotspot of accelerated sea-level rise on the Atlantic coast of North America. *Nat. Clim. Change* 2 (12), 884. <https://doi.org/10.1038/NCLIMATE1597>.
- Scott, A., Gilbert, A., Gelan A., 2007. The Urbarialland n-Rural Divide: Myth or Reality? Socio-Economic Research Group (SERG) Policy Brief 2, Carter C. (ed.), Macaulay Institute, UK.
- Siegrist, M., Gutscher, H., 2008. Natural hazards and motivation for mitigation behavior: People cannot predict the affect evoked by a severe flood. *Risk Anal.* 28 (3), 771–778.
- Spanger-Siegrfried, E., Fitzpatrick, M.F., Dahl, K., 2014. Encroaching tides: How sea level rise and tidal flooding threaten U.S. East and Gulf Coast communities over the next 30 years. Union of Concerned Scientists, Cambridge, MA.
- Stiles, S., 2012. The message matters: changing communication about climate in Virginia. *Coastal Serv.* 15 (4), 2–5.
- Strauss, B., Tebaldi, C., Ziemlinski, R., 2012. Surging Seas: Sea Level Rise, Storms & Global Warming's Threat to the US Coast. Climate Central.
- Sweet, W.V., Kopp R.E., Weaver C.P., Obeysekera J., Horton R.M., Thieler E.R., Zervas, C., 2017. Global and Regional Sea Level Rise Scenarios for the United States. NOAA Technical Report NOS CO-OPS 083. Center for Operational Oceanographic Products and Services, National Ocean Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Silver Spring, MD.
- Termeer, C.J., Dewulf, A., Biesbroek, G.R., 2017. Transformational change: governance interventions for climate change adaptation from a continuous change perspective. *J. Environ. Plann. Manage.* 60 (4), 558–576.
- Titus, J.G., Park, R.A., Leatherman, S.P., Weggel, J.R., Greene, M.S., Mausell, P.W., Yohe, G., 1991. Greenhouse effect and sea level rise: the cost of holding back the sea. *Coastal Manage.* 19, 171–204.
- Tompkins, F., DeConcini, C., 2014. Sea-level Rise and its Impact on Virginia. World Resources Institute, Washington, DC.
- USCGRP, see: United States Climate Change Science Program, 2009. Climate sensitivity to sea level rise: a focus on the Mid-Atlantic region, Washington D.C.
- USGCRP, see: United States Global Change Research Program, 2014. 3rd National Climate Assessment Report. Washington D.C.
- van der Voorn, T., Pahl-Wostl, C., Quist, J., 2012. Combining backcasting and adaptive management for climate adaptation in coastal regions: a methodology and a South African case study. *Futures* 44 (4), 346–364.
- van der Voorn, T., Quist, J., Pahl-Wostl, C., Haasnoot, M., 2017. Envisioning robust climate change adaptation futures for coastal regions: a comparative evaluation of cases in three continents. *Mitig. Adapt. Strat. Glob. Change* 22 (3), 519–546.
- Villarini, G., Vecchi, G.A., 2013. Projected increases in North Atlantic tropical cyclone intensity from CMIP5 models. *J. Clim.* 26 (10), 3231–3240.
- VIMS, see: Virginia Institute of Marine Science, 2013. Recurrent Flooding Study for Tidewater Virginia SJR 76. Senate Document No. 3, Commonwealth Of Virginia, Richmond.
- Zhong, L., Li, M., Foreman, M.G., 2008. Resonance and sea level variability in Chesapeake Bay. *Cont. Shelf Res.* 28, 2565–2573.
- Vignola, R., Leclerc, G., Morales, M., Gonzalez, J., 2017. Leadership for moving the climate change adaptation agenda from planning to action. *Curr. Opin. Environ. Sustain.* 26, 84–89.
- Vogel, J., Carney, K.M., Smith, J.B., Herrick, J., Stults, M., O'Grady, M. St., Juliana, A., Hosterman, H., Giangola, L., 2016. Climate Adaptation: The State of Practice in US Communities. Kresge Foundation.
- Wdowinski, S., Bray, R., Kirtman, B.P., Wu, Z., 2016. Increasing flooding hazard in coastal communities due to rising sea level: Case study of Miami Beach, Florida. *Ocean Coast. Manag.* 126, 1–8.
- Wilkins, J., 2011. Is Sea Level Rise Foreseeable? Does It Matter? *J. Land Use Environ. Law* 26 (2), 437–501.
- Wilson, C., Tansey, J., LeRoy, S., 2006. Integrating backcasting and decision analytic approaches to policy formulation: a conceptual framework. *Integrated Assess.* 6 (4).
- Williams, S.J., Gutierrez, B.T., Titus, J.G., Gill, S.K., Cahoon, D.R., Thieler, E.R., Anderson, K.E., FitzGerald, D., Burkett, V., Samenow, J., 2009. Sea-level rise and its effects on the coast. In: Coastal Sensitivity to Sea-Level Rise: A Focus on the Mid-Atlantic Region. A report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research. [J.G. Titus (coordinating lead author), K.E. Anderson, D.R. Cahoon, D.B. Gesch, S.K. Gill, B.T. Gutierrez, E.R. Thieler, and S.J. Williams (lead authors)]. U.S. Environmental Protection Agency, Washington DC, pp. 11-24.
- Willows, R., Reynard, N., Meadowcroft, I., Connell, R., 2003. Climate adaptation: risk, uncertainty and decision-making. Part 2. Climate Impacts Programme, Oxford, UK, pp. 41–87.
- Wise, R.M., Fazey, I., Smith, M.S., Park, S.E., Eakin, H.C., Van Garderen, E.A., Campbell, B., 2014. Reconceptualising adaptation to climate change as part of pathways of change and response. *Global Environ. Change* 28, 325–336.