Coastal Climate Change Response: An Analysis of the Use of Technology by Governments, Nonprofits, and Private Businesses in Coastal Climate Adaptation

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Introduction

In the fall of 2024, two major hurricanes made landfall in the southeastern United States, causing destruction and major flooding even in mountainous areas far from the coast. Devastating floods ripped through the mountains of western North Carolina, bringing rivers to some of the highest levels ever seen while razing entire towns in areas where flooding could never have been anticipated (Cohen, 2024). Throughout the entire southeast, students were forced home from school, with thousands still unable to return to school due to flood damage; this has disproportionally affected low-income students, who often live in areas most susceptible to damage and whose parents rely on school for childcare while working (Closson & Sandoval, 2024). For months, people in Florida were forced to recover and rebuild after Hurricane Milton tore across the coast a mere two weeks after Hurricane Helene; the compounding effects of these two storms were exponentially worse than if they had occurred separately, with already damaged infrastructure often impeding rescue efforts (Fortin & Mayorquín, 2024).

These catastrophic events highlight an urgent and growing challenge: despite broad consensus on the necessity of climate adaptation, pathways toward effective implementation remain contested, fragmented, and often unequal. Although technologies such as GIS vulnerability mapping, real-time flood monitoring applications, and nature-based infrastructure are available, they frequently exist in isolation, undermining their potential to provide comprehensive protection, particularly for socially vulnerable populations (Whitney, 2010; Haverkamp, 2017). Thus, the central challenge facing coastal communities today is not a lack of technological solutions, but rather the persistent fragmentation among governmental, nonprofit, and private-sector adaptation efforts. While some believe technological innovations alone are

sufficient to address climate change, this research shows that without integrated, cross-sector collaboration, these tools will remain inadequate.

This paper employs a comparative analysis of two distinct coastal regions, King County, Washington, and Coastal Virginia, to explore how governments, nonprofits, and private businesses currently utilize technology for climate adaptation. By examining the successes and limitations in each region, this research addresses the challenge of how technological tools and cross-sector collaboration can be better aligned and integrated to enhance climate resilience in coastal communities. Through identifying successful practices and persistent barriers, the analysis points toward recommendations for improved regulatory frameworks, sustainable funding mechanisms, and formalized collaborative structures. These insights are valuable not only for stakeholders in the studied regions but also for policymakers and communities across the country working to build more cohesive, equitable, and effective adaptation strategies.

Background and Context

Coastal communities across the United States face increasingly urgent threats from climate change, including sea-level rise, intensified storms, recurrent flooding, and coastal erosion. These hazards endanger public safety and infrastructure while also exposing deep social and political vulnerabilities. Approximately 40% of the U.S. population resides in coastal areas vulnerable to these impacts, underscoring the extensive need for effective climate adaptation (NOAA, 2020).

Adaptation is inherently complex, involving multiple sectors with varying capacities, incentives, and resources. Governments manage critical infrastructure, establish and enforce

environmental and zoning regulations, and lead emergency response. Nonprofit organizations frequently bridge institutional gaps through community engagement, education, and advocacy. Private businesses contribute essential innovation, financial capital, and technical expertise, including risk assessment software, sustainable materials, and advanced modeling technologies (Virginia Sea Grant, 2023; RISE, 2023).

However, despite each sector's critical role, their efforts often remain fragmented. Each tends to operate within its own institutional priorities and constraints, resulting in a fragmented landscape marked by redundancy, inefficiency, and unequal protection, especially for marginalized communities (Whitney, 2010; Haverkamp, 2017). When collaboration occurs, it is typically informal, limited in scale, and constrained by misaligned goals or competing resources.

Methods

This study employs a qualitative comparative case study approach to examine how governments, nonprofit organizations, and private businesses utilize climate adaptation technologies in two coastal regions of the United States: King County, Washington, and Coastal Virginia. These locations were chosen for their developed climate action plans and their geographic distance, providing a perspective from each US coast. The primary data source for this research was a comprehensive literature review, which included academic articles, government reports, nonprofit publications, and case studies focused on climate adaptation strategies and technologies.

Relevant documents were identified through targeted searches on platforms such as Google Scholar, JSTOR, and official government and nonprofit websites. Search terms included

combinations of “climate change,” “adaptation,” “technology,” “King County,” “Coastal Virginia,” “nonprofit,” “government,” “private sector,” and related keywords. Sources were selected based on their depth of analysis, relevance to sector-specific adaptation efforts, and emphasis on the real-world application of technological tools. I analyzed the collected data to identify recurring themes and patterns related to technology use, sector-specific approaches, and the integration of technological tools in climate adaptation strategies. This process involved close reading, note-taking, and cross-referencing between sources to ensure a comprehensive understanding of the subject matter.

While this study draws from a diverse set of documents, it is limited by its reliance on secondary data. The absence of direct interviews or fieldwork may constrain insights into local stakeholder perspectives or recent developments. Nonetheless, the findings provide a robust foundation for understanding the institutional dynamics shaping climate adaptation efforts in the two regions.

Sectoral Contributions to Climate Adaptation

Climate adaptation is a complex multi-actor process, requiring active participation from governments, nonprofit organizations, and private businesses. Each sector brings different capacities, priorities, and technologies to the table. Understanding how these sectors engage with adaptation and how their contributions differ offers insight into both the strengths and limitations of current approaches. This section examines how each sector has applied technological tools in the distinct contexts of King County, Washington, and Coastal Virginia.

Government

Governments at the local, state, and federal levels have historically played a central role in climate adaptation due to their regulatory authority, access to funding, and responsibility for public infrastructure and safety. In both King County and Coastal Virginia, government entities have led the development and deployment of large-scale adaptation technologies, particularly those related to infrastructure planning, environmental monitoring, and hazard mitigation.

In King County, the government has prioritized long-term resilience through predictive modeling and integrated planning. Geographic Information Systems (GIS) have been widely employed to map vulnerabilities, model sea-level rise, and guide infrastructure investment (Saavedra & Budd, 2009). Climate models are equally pivotal, with downscaled climate projections used to assess regional risks, including temperature fluctuations, precipitation changes, and sea-level rise (King County, 2023). These models inform adaptation strategies at local, regional, and state levels, allowing King County to prioritize equity in decision-making and target adaptation resources more effectively.

In Coastal Virginia, where sea-level rise and recurrent flooding are more immediately visible, governments have invested heavily in real-time monitoring systems. One of the most prominent initiatives is StormSense, a sensor network that integrates Internet of Things (IoT) technology with cloud computing to deliver real-time flood data across several municipalities (VIMS, 2023). This system enhances emergency preparedness and allows for timely, localized flood warnings. Governments in Coastal Virginia have also prioritized infrastructure upgrades, including smart stormwater systems and automated tide gates, to prevent backflow and reduce flood damage in vulnerable areas (Saitgalina et al., 2023).

However, both regions face structural barriers that limit the effectiveness of government-led adaptation. Policy fragmentation, overlapping jurisdictions, and inconsistent funding streams are frequently cited as obstacles to implementing and sustaining technology-based adaptation strategies (Eghdami et al., 2023). In Coastal Virginia in particular, the complexity of coordinating among state agencies, county governments, and municipal authorities creates delays and inefficiencies. Although King County has made progress in integrating federal and state climate guidance into local planning, fragmentation still limits comprehensive action.

Nonprofit Organizations

Nonprofits serve as essential intermediaries between formal institutions and local communities. Their adaptation strategies often emphasize public engagement, environmental justice, and the democratization of scientific knowledge. Nonprofits frequently fill the gaps left by government initiatives, particularly in areas of education, advocacy, and implementation of nature-based solutions.

In King County, nonprofit organizations have played a key role in promoting equitable adaptation strategies. Many nonprofits have adopted GIS and social vulnerability mapping to advocate for marginalized communities disproportionately affected by climate impacts (Whitney, 2010). These organizations work closely with local agencies and research institutions to ensure that climate adaptation efforts include community-driven priorities and reflect the lived realities of those most vulnerable.

Coastal Virginia nonprofits have focused heavily on community engagement and participatory data collection. One of the most notable examples is the Sea Level Rise app,

developed by Wetlands Watch, which enables residents to document flooding in real-time through geotagged photographs and field observations (Wetlands Watch, 2023). This crowdsourced data has been used to improve flood models and inform municipal planning. Events such as “Catch the King”, the world’s largest crowdsourced flood-mapping initiative, demonstrate the ability of nonprofits to mobilize public participation and generate actionable, localized datasets (Wetlands Watch, 2023; Saitgalina et al., 2023).

Nonprofits in both regions have also been instrumental in implementing nature-based solutions. In Coastal Virginia, they provide technical assistance to property owners interested in installing living shorelines, which use natural materials like marsh grasses and oyster reefs to stabilize coastlines and reduce erosion (Saitgalina et al., 2023). These organizations use erosion modeling tools and GIS assessments to design site-specific interventions, often in partnership with local governments and universities.

Despite their innovation and local legitimacy, nonprofits face structural limitations. Their reliance on short-term grant funding undermines long-term project continuity and limits scalability (Eghdami et al., 2023). In Coastal Virginia, nonprofit-generated data is often underutilized in official planning processes, due in part to institutional biases that prioritize expert or agency-led data over community-generated knowledge (Haverkamp, 2017). In contrast, King County’s nonprofits benefit from more institutionalized partnerships with government agencies, allowing for deeper integration of their insights into official adaptation frameworks.

Private Businesses

The private sector contributes to climate adaptation through innovation, product development, and infrastructure resilience. Businesses also serve as early adopters of adaptation technologies, particularly when those technologies offer cost savings, competitive advantages, or protection of assets. However, their participation in broader resilience strategies often depends on clear economic incentives and regulatory signals.

In King County, businesses have focused on sustainability management and internal risk reduction. They deploy sustainability management software to monitor and reduce carbon footprints, tracking energy consumption, emissions, and resource use to support corporate sustainability goals (Poyar & Beller-Simms, 2010). In construction and real estate, advanced materials and engineering technologies enhance the resilience of buildings and infrastructure against climate impacts (Lowe et al., 2009).

Coastal Virginia's private sector is more visibly engaged in climate adaptation, particularly through partnerships with nonprofits and public agencies. Organizations like RISE Resilience Innovations provide funding and pilot opportunities for startups developing climate adaptation technologies, such as flood-resilient septic systems and concrete substitutes made from dredged sediment. Companies such as ReadyReef, Inc. produce prefabricated oyster reef structures for use in shoreline stabilization projects, supporting the region's push toward hybrid green-grey infrastructure solutions (RISE, 2023).

Despite these examples, private-sector engagement remains inconsistent. Many businesses are hesitant to invest in resilience technologies without clear financial returns or policy mandates (Eghdami et al., 2023). In both regions, most private-sector climate efforts are

either tied to internal risk mitigation or confined to well-funded pilot projects. Without sustained incentives, such as tax credits, public-private partnerships, or procurement guarantees, the private sector's role in climate adaptation will likely remain underdeveloped.

Fragmentation as a Structural Barrier

Despite the increasing sophistication of climate adaptation technologies and the distinct contributions made by governments, nonprofits, and private businesses, climate resilience efforts in both King County and Coastal Virginia remain limited by systemic fragmentation. This fragmentation manifests in overlapping jurisdictions, siloed data systems, inconsistent funding streams, and misaligned institutional incentives. While each sector brings important tools and perspectives to the adaptation process, the absence of a shared governance framework undermines their collective impact. As a result, even successful projects often remain isolated, limiting scalability and long-term effectiveness.

One of the most persistent sources of fragmentation is jurisdictional overlap. In Coastal Virginia, multiple municipalities, counties, and state agencies are responsible for different aspects of adaptation, leading to duplicated efforts and gaps in service delivery. This fragmentation is a key barrier to coordinated infrastructure development and policy implementation (Eghdami et al., 2023). For example, while one locality may invest in stormwater system upgrades, a neighboring jurisdiction might lack the capacity or mandate to maintain related infrastructure, reducing the overall efficacy of the investment. This lack of vertical and horizontal alignment complicates planning processes, delays project execution, and increases administrative burdens. King County, while more centralized in its climate governance,

is not immune to these challenges. Although the region has developed advanced predictive models and equity-focused planning frameworks, coordination across jurisdictions and internal agencies remains inconsistent (Whitney, 2010; King County, 2023). Differing timelines, reporting requirements, and planning frameworks across levels of government contribute to fragmented implementation.

Another form of fragmentation occurs through data silos. Although all three sectors rely heavily on technological tools such as GIS mapping, flood monitoring systems, and predictive analytics, these systems are often developed and managed independently. In both King County and Coastal Virginia, nonprofits and academic institutions have created valuable datasets, ranging from social vulnerability indices to crowdsourced flood maps, but these are not always incorporated into official government planning or private-sector decision-making (Haverkamp, 2017; Whitney, 2010; Wetlands Watch, 2023). The lack of common data standards, open-access platforms, or institutional agreements for data sharing prevents adaptation efforts from benefiting from a more comprehensive, integrated understanding of risk.

Funding structures further exacerbate fragmentation. Nonprofits often rely on short-term grants, which limit their ability to scale successful initiatives or maintain long-term community engagement (Eghdami et al., 2023). Businesses typically invest in resilience measures only when they perceive a clear return on investment or when incentivized by policy, leaving many innovative solutions without the support needed to achieve broader adoption. Meanwhile, government funding is frequently tied to narrow mandates or competitive grants that do not reward collaboration. These disconnected funding streams lead to fragmented resource allocation, where critical actors, particularly nonprofits, struggle to sustain their contributions despite demonstrated effectiveness.

Institutional incentives are also misaligned across sectors. Government agencies may prioritize regulatory compliance and risk minimization, while nonprofits focus on equity and public engagement, and private businesses pursue innovation and cost-efficiency. These divergent goals can result in miscommunication or even conflict when adaptation projects are designed or implemented. For example, in Coastal Virginia, nonprofits promoting nature-based shoreline stabilization have sometimes faced opposition from developers or local governments focused on traditional engineering solutions (Haverkamp, 2017; Saitgalina et al., 2023). Without a shared vision or mechanisms for collaboration, such conflicts undermine progress.

The consequences of fragmentation are particularly severe for frontline communities. In both King County and Coastal Virginia, socially vulnerable populations are often excluded from formal planning processes, even as they face the greatest risks from climate change. Often, government-led adaptation initiatives prioritize security and efficiency over democratic participation and local knowledge (Whitney, 2010; Haverkamp, 2017). This exclusion further entrenches inequity and leads to the implementation of adaptation strategies that do not reflect the lived experiences or needs of the most affected residents.

While each sector has demonstrated a capacity for innovation and leadership, their efforts remain disconnected in ways that limit both effectiveness and equity. Addressing this fragmentation is not merely a matter of administrative coordination; it is necessary for transforming isolated adaptation efforts into cohesive, scalable, and inclusive resilience strategies.

Integrating Lessons and Advancing Collaboration

The experiences of King County and Coastal Virginia demonstrate that while each region has achieved notable successes in climate adaptation, these successes have been uneven, isolated, and shaped by the capacities and constraints of their institutional contexts. Integrating lessons from these two case studies not only highlights best practices but also points toward a more unified, collaborative approach to climate resilience, one that transcends sectoral boundaries and enables a more strategic deployment of technological tools.

Complementary Strengths from Both Regions

King County's adaptation strategies are marked by long-term, data-driven planning, emphasizing climate modeling, GIS-based vulnerability mapping, and integration of social equity into policy frameworks. Its government agencies have made significant investments in infrastructure designed for future climate scenarios and have partnered effectively with academic institutions and community-based organizations to identify at-risk populations (Whitney, 2010; King County, 2023). The emphasis on downscaled climate projections and scenario planning has allowed King County to address both present risks and emerging vulnerabilities over time.

In contrast, Coastal Virginia has pioneered real-time, community-based monitoring and hybrid infrastructure solutions. Projects like StormSense demonstrate the region's ability to mobilize digital sensors, cloud computing, and citizen science to track flood conditions and deliver timely alerts (VIMS, 2023). Moreover, nonprofit-led initiatives such as the Sea Level Rise app and "Catch the King" reflect a strong commitment to public engagement and participatory data collection (Wetlands Watch, 2023). Coastal Virginia also excels in testing and

implementing nature-based solutions, such as living shorelines and oyster reef stabilization, through partnerships between nonprofits, private companies, and local governments (Saitgalina et al., 2023).

While King County's strength lies in predictive, institutionalized governance, Coastal Virginia's advantage is its responsiveness and grassroots innovation. These differing approaches are not mutually exclusive. Rather, they suggest that the most robust adaptation strategies would combine the anticipatory planning of King County with the community-driven flexibility and field experimentation found in Coastal Virginia.

Opportunities for Cross-Sector Integration

The complementarity of these two models underscores the importance of structured collaboration. Technologies such as GIS platforms, mobile apps, and environmental sensors are already in use across sectors, but their impact remains limited by institutional silos. Integrating these tools into shared platforms for data collection, analysis, and decision-making would improve both efficiency and equity. For example, predictive models developed in King County could be enhanced with real-time flood data from citizen science initiatives in Coastal Virginia, creating dynamic systems that adapt as conditions change.

Similarly, the collaborative models used by nonprofit organizations in Coastal Virginia, such as providing technical assistance to homeowners for installing living shorelines, could be replicated in regions like King County to expand the reach of green infrastructure. In both cases, cross-sector knowledge sharing is essential. Governments must be willing to incorporate

community-generated data into formal planning, while nonprofits and businesses need sustained funding and institutional support to participate in long-term projects (Eghdami et al., 2023).

Creating centralized data repositories, interoperability standards, and formalized cross-sector planning bodies could facilitate these forms of integration. Examples already exist in pilot form: in Coastal Virginia, public-private-nonprofit partnerships facilitated by organizations like RISE have supported innovation through competitive grants and field demonstrations (RISE, 2023). These programs could be expanded and adapted to other regions, providing a scalable model for inclusive and technologically advanced adaptation.

Toward a Collaborative Framework

Advancing a collaborative model of climate adaptation requires institutional reforms that align incentives and promote sustained engagement across sectors. One critical step is the design of funding mechanisms that reward joint initiatives. Currently, fragmented grant structures and procurement systems often pit organizations against each other, rather than fostering cooperation. Multi-sector funding programs, particularly those that prioritize community involvement and knowledge co-production, would enable more holistic planning and implementation (Eghdami et al., 2023; Haverkamp, 2017).

Governments also need to take on the role of conveners, not just regulators or funders. In both King County and Coastal Virginia, adaptation has been most effective when public agencies actively coordinate with nonprofits and businesses to design and deliver services. This coordination can be institutionalized through resilience collaboratives, advisory boards with

cross-sector representation, and formal partnerships that outline shared responsibilities and timelines.

Equity must also remain central to this collaborative model, as adaptation planning that prioritizes efficiency and control over community self-determination often risks reproducing social inequities (Haverkamp, 2017). Community-based organizations, particularly those representing frontline and historically marginalized populations, must be empowered to shape adaptation agendas, not just react to them. Tools like vulnerability mapping and participatory planning platforms can help democratize access to decision-making and ensure that technological innovation serves broader social goals.

Finally, private businesses must be encouraged to align their innovations with public adaptation objectives. Procurement incentives, tax credits, and regulatory flexibility can help de-risk private-sector investment in resilience technologies. Equally important is their involvement in collaborative forums where their expertise can contribute to solving shared problems, rather than operating in parallel to public efforts.

Adopting integrated data systems, shared planning frameworks, equitable governance, and aligned incentives can help overcome the fragmentation that currently limits adaptation success. The experiences of King County and Coastal Virginia demonstrate not only what is possible within each sector but also what is achievable when their strengths are deliberately brought together.

Conclusion

Climate adaptation in coastal regions is no longer a distant concern; it is an immediate necessity. The analysis of King County, Washington, and Coastal Virginia illustrates that while a broad array of climate adaptation technologies is already in use, the effectiveness of these tools is limited not by their technical capabilities but by the fragmented systems within which they are deployed. Governments, nonprofits, and private businesses all have the capacity to contribute significantly to climate resilience, and each sector brings distinct strengths: government agencies provide infrastructure, regulatory power, and large-scale planning; nonprofits specialize in local knowledge, community engagement, and grassroots implementation; and private businesses offer innovation, flexible capital, and risk-management expertise. When these sectors operate in isolation, however, even the most advanced technologies fail to produce lasting, equitable outcomes (Eghdami et al., 2023; Haverkamp, 2017; Saitgalina et al., 2023).

In both King County and Coastal Virginia, there are compelling examples of technological adaptation. King County's integration of GIS, climate modeling, and equity mapping has positioned it as a national leader in proactive climate planning (Whitney, 2010; King County, 2023). Coastal Virginia, facing more acute and frequent flooding, has become a testing ground for real-time monitoring systems like StormSense and nature-based shoreline protection technologies such as living shorelines and oyster reef infrastructure (VIMS, 2023; Wetlands Watch, 2023; Saitgalina et al., 2023; RISE, 2023). These are not just technical achievements; they represent different approaches to risk and resilience. King County's forward-looking, data-driven strategy contrasts with Coastal Virginia's reactive, community-centered, and infrastructure-heavy approach. Each is shaped by its specific geographic, political, and social context (Eghdami et al., 2023; Haverkamp, 2017).

However, both regions illustrate a shared underlying problem: a lack of coordination across the sectors that make adaptation possible. When public agencies do not incorporate nonprofit-collected data into formal planning, when private innovations remain disconnected from public infrastructure needs, and when nonprofits are excluded from funding streams that support long-term implementation, the result is redundancy, inefficiency, and ultimately, greater vulnerability (Haverkamp, 2017; Eghdami et al., 2023; Saitgalina et al., 2023). Despite the clear necessity for collaboration, current institutional structures do not adequately incentivize or facilitate integrated planning.

This analysis challenges the notion that climate adaptation is primarily a technical problem waiting to be solved with better tools. That perspective, often embraced in techno-optimist policy discourse, obscures the deeply political, institutional, and social barriers that undermine adaptation efforts (Eghdami et al., 2023; Haverkamp, 2017). Technologies like flood sensors, predictive models, and sustainable building materials are only as useful as the systems into which they are embedded. Without mechanisms for data sharing, cross-sector communication, and collaborative governance, even the most advanced systems will underperform.

The prevailing notion that climate adaptation can be solved purely through technical innovation reflects a form of technological determinism that oversimplifies both the causes of vulnerability and the requirements for resilience. This perspective assumes that technologies, whether flood sensors, modeling tools, or sustainability software, carry intrinsic power to drive social change, and that their deployment alone will produce equitable outcomes. Such thinking disregards the deeply social nature of adaptation. Technologies do not act independently of the systems in which they are embedded. Their effectiveness is shaped by who controls them, who

has access to their outputs, and how their deployment aligns with political priorities and institutional capacities (Dafoe, 2015).

By focusing narrowly on the tools themselves, technological determinism diverts attention from the social choices that guide their use. It neglects the fact that adaptation technologies can reinforce existing inequalities if not integrated into inclusive governance structures. For example, data from flood sensors is only useful if incorporated into planning processes that reflect community needs; nature-based solutions require not just design expertise, but public trust and long-term stewardship. Without mechanisms for participatory planning, equitable funding, and cross-sector accountability, even the most advanced systems risk becoming isolated fixes rather than components of cohesive resilience strategies. Recognizing that technology is shaped by values, institutions, and power dynamics is essential to understanding why fragmentation persists (Feenberg, 2004).

The most urgent need, then, is to restructure how adaptation is organized and governed. This includes creating institutional frameworks that encourage information flow between sectors, funding models that reward collaboration, and planning processes that integrate both top-down scientific knowledge and bottom-up community insight. Governments must move beyond managing their own portfolios and act as conveners, bringing together nonprofits, businesses, and residents to co-create adaptation strategies (King County, 2023; Whitney, 2010). Nonprofits must be treated not as supplemental actors but as essential contributors whose work is grounded in the lived realities of the people most affected by climate change (Saitgalina et al., 2023; Haverkamp, 2017). Businesses, particularly those already engaged in climate-conscious innovation, should be incentivized to align their products and services with public resilience

goals through procurement partnerships, tax credits, and innovation grants (RISE, 2023; Virginia Sea Grant, 2023).

In short, this research reinforces the idea that climate resilience is a systems problem. No single sector can solve it alone. What is needed is not just better floodwalls or more accurate models, but a transformation in how knowledge, power, and responsibility are distributed among the actors shaping the climate future. The tools already exist; the next step is to build the relationships and institutional structures that will allow these tools to be used strategically, equitably, and in concert. Only then can coastal communities hope to withstand the accelerating threats posed by climate change and thrive in spite of them.

References

Cohen, L. (2024, October 1). Here's how Hurricane Helene brought "biblical devastation" to western North Carolina in a near "worst-case scenario". *CBS News*. https://www.cbsnews.com/news/hurricane-helene-biblical-devastation-north-carolina-near-worst-case-scenario/

Dafoe, A. (2015). On Technological Determinism: A Typology, Scope Conditions, and a Mechanism. *Science, Technology, & Human Values*, 40(6), 1047-1076. https://doi.org/10.1177/0162243915579283

Economics and demographics (2020). NOAA. https://coast.noaa.gov/states/fast-facts/economics-and-demographics.html.

Eghdami, S., Michel, V., Shafiee-Jood, M., & Louis, G. (2023). Gap analysis of climate adaptation policymaking in Coastal Virginia. *Frontiers in Climate*, 5. https://doi.org/10.3389/fclim.2023.1259337

Feenberg, A. (1992). Subversive rationalization: Technology, power, and democracy. *Inquiry*, 35(3–4), 301–322. https://doi.org/10.1080/00201749208602296

Fortin, J., & Mayorquín, O. (2024, October 13). Hurricane Milton: What we know about the damage and flooding in Florida. *The New York Times*. https://www.nytimes.com/2024/10/10/weather/hurricane-milton-damage-florida.html

Haverkamp, J. A. R. (2017). Politics, Values, and Reflexivity: The Case of Adaptation to Climate Change in Hampton Roads, Virginia. *Environment and Planning A*, 49(11), 2673-2692. https://journals.sagepub.com/doi/10.1177/0308518X17707525

King County Climate Action Team (eds.). (2023). *2023 Biennial Update of King County's 2020 Strategic Climate Action Plan.* https://your.kingcounty.gov/dnrp/climate/documents/2024/2401-13286w-SCAP-biennial-rpt.pdf

Lowe, A., Foster, J., & Winkelman, S. (2009). Ask the Climate Question: Adapting to Climate Change Impacts in Urban Regions. *Center for Clean Air Policy.* https://rosap.ntl.bts.gov/view/dot/17271

Poyar, K. A., & Beller-Simms, N. (2010). Early Responses to Climate Change: An Analysis of Seven U.S. State and Local Climate Adaptation Planning Initiatives. https://doi.org/10.1175/2010WCAS1047.1

RISE Resilience Innovations. (n. d.). RISE Resilience Innovations. https://riseresilience.org

Saavedra, C., & Budd, W. W. (2009). Climate change and environmental planning: Working to build community resilience and adaptive capacity in Washington State, USA. *Habitat International*, 33(3), 246–252. https://doi.org/10.1016/j.habitatint.2008.10.004

Saitgalina, M., Yusuf, J.-E. (Wie), & Covi, M. (2023). Shoreline Management and Coastal Resilience in Virginia: Analysis of the Roles of Environmental Nonprofit Organizations in Encouraging Living Shorelines. *Coastal Management*, 51(3), 172–185. https://doi.org/10.1080/08920753.2023.2199790

StormSense. (n. d). Virginia Institute of Marine Science. https://www.vims.edu/people/loftis_jd/StormSense/

Virginia Sea Grant. (November 2024). Virginia Sea Grant. https://vaseagrant.org/

Wetlands Watch. (n. d.). Wetlands Watch. https://www.wetlandswatch.org

Whitney, S. V. (2010). Seeking Sustainable and Inclusive Communities: A King County Case Study. *What Works Collaborative*. https://www.urban.org/sites/default/files/publication/28071/1001380-Seeking-Sustainable-and-Inclusive-Communities.PDF

Wolf, K. (2009). Adapting to Climate Change: Strategies from King County, Washington. *American Planning Association*. https://your.kingcounty.gov/dnrp/library/2009/kcr2209.pdf